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REVIEW

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Deconstructing the complexity of measuring food security in South Africa: a systematic review and meta-analysis (2000–2024)

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Abstract

Background Measuring the non-observable nature of food security has remained complex mainly because of the construct's complexity and its continuously evolving nature. The main challenges in measuring food security involve determining what is to be measured and how it is measured. In South Africa, various approaches and indicators have led to divergent food security measurement outcomes, leading to inaccurate assessment, monitoring, and targeting of context-specific food security interventions. This study analyses food access, availability, and stability measurement metrics and proposes a clear food security measurement approach for South Africa. Comprehensive reviews of food security indices with a national scope and subsequent meta-analysis to determine these indicators' effect size, publication bias, and heterogeneity have not been adequately explored.

Methods A systematic review and meta-analysis using the PRISMA guidelines were used to select the analysed articles. A search strategy was used to retrieve literature from the Web of Science and Scopus Databases, yielding a total of 1155 articles. Rayyan 1.6 software was used for screening articles and duplicate removal, whilst the Newcastle-Ottawa scale was used to qualitatively assess the articles. Perplexity and Quill Bot Artificial Intelligence (AI) tools were used to enhance literature search and paraphrasing, respectively, to improve the validity and reliability of the review. The inclusion and exclusion criteria resulted in a final sample of 82 articles being eligible for analysis.

Results Most studies used Household Food Insecurity Access Score (HFIAS), ($n=45$), Household Dietary Diversity Score (HDDS) ($n=24$), Coping Strategy Index (CSI), ($n=13$), and the Household Hunger Score (HHS) ($n=4$). Few studies used a composite of indicators, while most studies used HFIAS alone. The indicators used provide very different estimates of the prevalence of food insecurity in South Africa. Limpopo and KwaZulu-Natal provinces had the most studies distributed across rural communities, while Cape Town City and Gauteng Province had the highest number of urban studies. Meta-analysis was done on HFIAS ($n=16$) and HDDS ($n=14$) indicators using a Forest plot and Funnel plot, and results showed limited heterogeneity and publication bias across the studies.

Conclusions More food security studies need to use longitudinal designs, composite indicators across different seasons, and along the urban, peri-urban, and rural settlement gradient, and panel data from national surveys. The routine national surveys need to adopt the full modules of indicators to allow for household and individual food security analysis in South Africa. We recommend the Agency Module, the Women Empowerment in Agriculture

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Index (WEAI), and the Women Empowerment in Livestock Index (WELI) to measure the sustainability and agency dimensions of food security.

Keywords Food access, Food availability, Food stability, Measurement indicators, Complexity, systematic review, Meta-analysis, South africa

Introduction

The Global agenda of achieving the Sustainable Development Goals (SDGs) of Zero Hunger (SDG1) and ending Poverty (SDG1) is well aligned with the African Union's (AU) Agenda 2063: The Africa We Want and the National Development Plan (NDP) for South Africa, which targets addressing poverty, inequality, and unemployment. To achieve these goals, policymakers need to monitor the prevalence of food insecurity using indicators that track broader trends and enable easy evaluation of food security policy initiatives and other interventions. This is critical for identifying underlying drivers and consequences and is vital to developing informative food security policies, strategies, and programs [1]. However, food security is challenging and complex to measure [2–4]. Although commendable efforts have been made by the South African government to address the food security situation since 1994, the agenda of household hunger and undernutrition remains a primary concern given the high levels of poverty, inequality, unemployment, and rapid urbanisation driven by climate change, pandemics, and recurring global economic recessions. Several studies have reported relatively high food insecurity among South Africans, including 45,5% [5], 61% [6]; and the General Household Survey (23%) [7]. This is against the assertion that South Africa is food secure at the national level. Furthermore, South Africa is experiencing a nutrition transition due to excessive consumption and reliance on cheap ultra-processed foods, high-calorie, oily, and high-sugar diets, and fewer fresh fruit and vegetable consumption (Ronquest-Ross et al. [8]). As a result, five of the leading causes of death in South Africa are linked to poor nutrition [5]. To address these challenges, food security interventions must rely on valid and reliable food access, availability, stability, and utilization measurements. However, the research community and development agencies have internationally recognized that no "perfect single measure captures all aspects of food insecurity" exists and that food insecurity is not a homogeneous condition easily measured in economic, energy-availability, or anthropometric terms (Hendriks et al. [9]). According to Hoddinott [10], there are about 450 food security indicators, and a nuanced analysis of these indicators shows that they do not all measure the same thing; instead, each focuses on one or more of the four key dimensions that are: availability, access, utilization or nutrition, and stability.

Background

The concept of food security

For purposes of this study, the author adopts the 1996 World Food Summit definition of food security, wherein food security is defined as "a situation that exists when all people, always, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life". Traditionally, the dimensions of food security were availability, stability, accessibility, and utilization. The World Food Committee introduced the agency's food security and sustainability dimensions, as expounded by the HLPE [11]. Darwood and Vuuren [12] define food availability as being concerned with the population's reliable and consistent supply and production situation. Accessibility is the economic and physical resources and the infrastructure necessary for the food to reach the consumer at the household or individual level. The dimension of food utilization is described in terms of the intake of adequate nutrient-dense food that can meet a population's physiological, sensory, and cultural needs [12]. The food stability dimension, introduced in 2009 during the World Food Summit, refers to the temporal dimension and pertains to the ability and resilience of a food system to survive natural or man-made disasters [13]. Food agency and sustainability were proposed as additional dimensions of food security, highlighting the importance of individuals having the ability to make choices and control their food systems. The agency food security dimension means that households, individuals, or communities can make decisions or strategic life choices about what foods they can eat, what foods they produce, and how that food is produced, processed, prepared, distributed, and consumed [14]. This implies that people can engage in processes that shape food system policies and governance to empower themselves. On the other hand, the food security dimension of sustainability in food systems is understood to foster long-term natural, social, and economic regeneration. This should ensure that the present and future generations do not have to compromise their food needs [14]. The six pillar food security dimensions are inextricably linked (See Fig. 1) with feedback relationships among the different pillars. Food availability enhances food access and utilization, while food stability influences access, availability, agency, sustainability, and utilization. The instability is usually in the form of shocks such as high food prices, the COVID-19 pandemic, climate change-induced hazards,

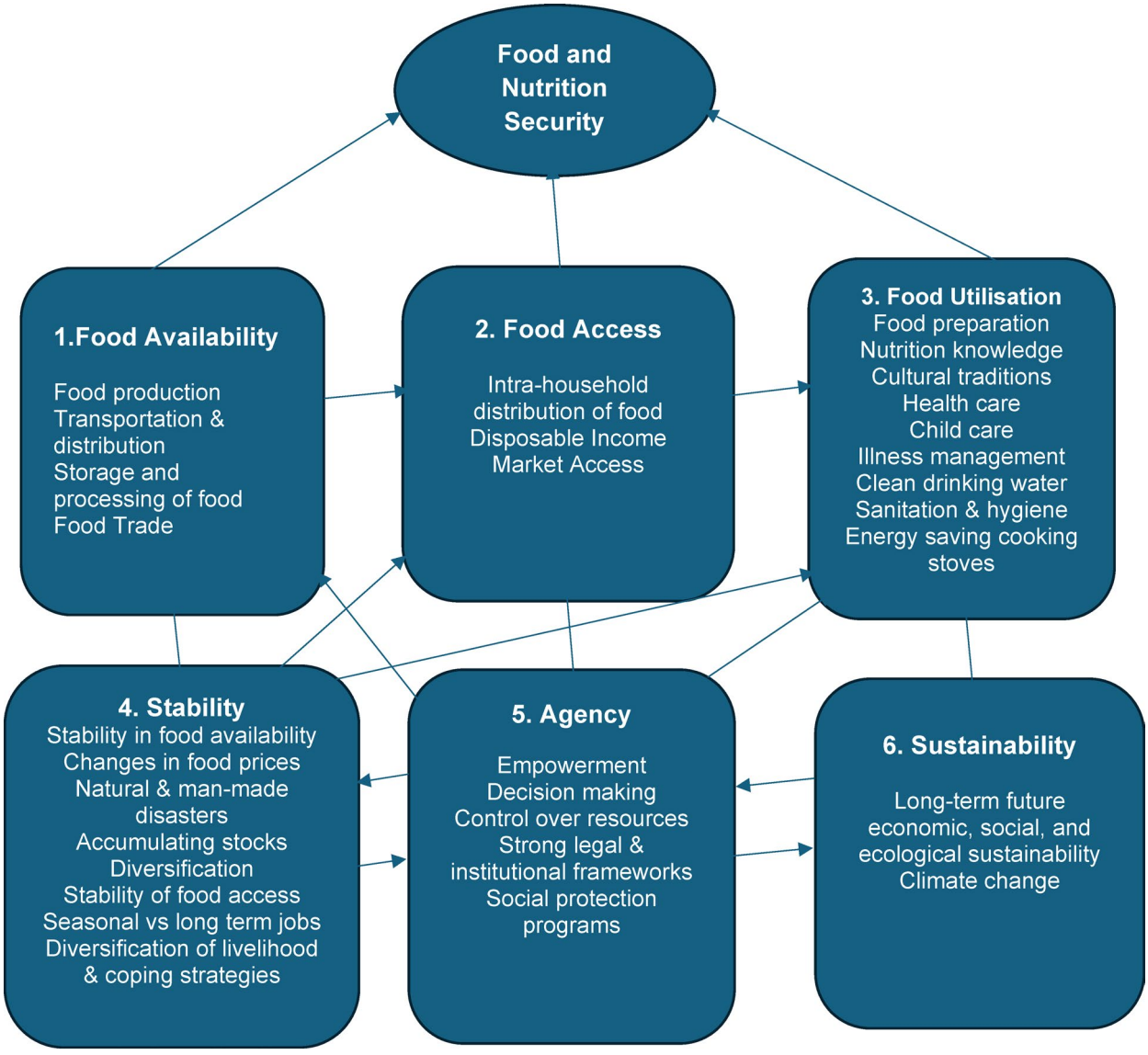

Fig. 1 Six-pillar multi-dimensional food security concept (Adopted & modified from Dawood & van Vuuren [12])

extreme events, political instability, and global economic recessions.

Food security measurement

Because there is no agreed or standard measure of food insecurity internationally [15] and in South Africa [9, 16], it is not easy to establish a relationship between food security and nutrition indicators Food security indicators or metrics have been divided into direct indicators, which measure the experience of food insecurity (for example, food consumption surveys, household perceptions of food insecurity or hunger, and food frequency measurements). Direct indicators are best measured by observing households over time and interviewing household members in-depth [17], for example, HFIAS, HHS, and FCS, while indirect household food security indicators are used where access to such information is unavailable or too costly to collect. Indirect indicators include dietary diversity, storage estimates at critical times of the year, subsistence potential for largely agrarian households (ratio of dietary energy requirement and food availability), and nutritional assessments (anthropometric measurements. The dynamic nature of food security dimensions, which continually evolves, makes it challenging to rely on a single measure or index due to contextual differences across countries, provinces, districts, municipalities, cultures, and households. Given the complexity of food security and the range of factors involved, as well as security measurement, it is appreciably complex, extensive, and expensive [9]. Therefore, there is a need to deconstruct this complexity to facilitate

comprehensive, reliable, and valid food insecurity estimates. Data and resource availability often limit the variables in measuring and monitoring regional household food security. The complexity around linking the household food security indicators to individual households is a huge impediment, especially linking household food security and individual nutrition outcomes.

Various routine national studies that include the General Household Survey (GHS), the National Food Consumption Survey (NFCS), the National Income Dynamics Survey (NIDS), the South African Social Attitudes Survey (SASAS), and the Labour Force Survey (LFS), have been implemented in South Africa with modules to measure food insecurity and household hunger prevalence. The other surveys that have food security modules include the Food Insecurity and Vulnerability Information and Mapping System (FIVIMS), and the Income and Expenditure Survey (IES) [9]. These surveys use different metrics and are also done at different times. Therefore, they have yielded divergent food security measurement results, sometimes conflicting with other smaller provincial and municipality-based studies. For example, the General Household Survey 2007 indicated that 10.6% and 12.2% of adults and children were sometimes or always hungry. In stark contrast, the National Food Consumption Survey (NFCS) 2005 reported that 52% of households experience hunger (Labadarios et al. [18]). Although these studies were done in different time frames, they still provide extremely divergent figures in terms of hunger scores and food insecurity. In the South African National Health and Nutrition Examination (SANHANES) [5] study, about 54% of South African households reported experiencing either hunger or risk of hunger (Shisana et al. [5]). Using the same HFIAS module, the GHS [7] and Simelane et al. [6] conducted national surveys in the same period and reported 23.1% and 17.5% severe food insecurity, respectively. There is a significant difference in the HFIAS estimates of the two studies despite using the same metric. In agreement with these reports, Aliber [19] postulated that these national food security and nutrition surveys (GHS and IES) are not designed to analyze household-level food security; hence, it is not possible to do a detailed analysis using their data to interrogate the association of agricultural productivity, dietary diversity, and nutrition in South Africa. These national studies also do not use complete modules of indicators such as the HFIAS, as evidenced in the GHS, which employs a shortened version of the HFIAS questions, resulting in an incomplete assessment of the food insecurity status of the household. These drawbacks compound the complexity of measuring food security, especially at the household and individual levels.

The emphasis on enhancing reliability and validity in measuring food security also stems from what Hendriks et al. [9] have argued: measuring such a complex and non-observable food security concept has remained challenging because of the construct's complexity and continuously evolving nature. The main challenges in measuring food security involve determining what is to be measured and how it is measured. Determining what is measured refers to the specific food security dimensions (access, availability, stability, utilization, agency, and sustainability) [9]. The how part relates to the methods, research design, unit of analysis, choice of indicators, and the associated recall period. To address these challenges, scholars and development agencies have proposed a variety of indicators (See Table 1) to measure food and nutrition security. Despite several studies using measurement indicators at different levels, this has remained a complex terrain. Another reason for the measurement complexity is the dynamic nature of the definition of food security, which has evolved; hence, the indicators and methodologies used have also changed. Since adding the two pillars of agency and sustainability, no studies have explored how all six dimensions can be comprehensively measured to reflect the food security status of households in South Africa and beyond. Hendriks et al. [9] argue that to target food security, interventions effectively, there is a need to comprehensively analyse food insecurity experiences, the drivers, and the associated outcomes to provide a clear picture of the compound effect of the problem. This would enable effective planning through predictive modelling and provide baseline information that assists in designing intervention strategies and programs, particularly during shocks such as COVID-19, extreme weather events, and economic recessions.

Table 1 summarizes everyday food and nutrition security indicators or metrics that researchers, development agencies, and policymakers use. These include the Household Dietary Diversity Score (HDDS) [20]' which measures dietary quality. The Food Consumption Score (FCS) developed by the World Food Programme (WFP) in 2006 is an indicator of dietary quantity and quality (diversity). The CAF is derived from the Household Food Insecurity Access Scale (HFIAS) [21]. The Coping Strategies Index (CSI) was calculated following the method of Maxwell et al. [22]. The higher the CSI, the more food insecure the household was. The Household Hunger Scale (HHS) estimates the proportion of households experiencing three levels of severity of hunger: little or no household hunger [23]. Self-reported experience of hunger (EoH) and modified complex access to food (mCAF) questions are traditionally used to estimate the incidence of experiences of hunger (self-reported) among adults and children in households during the preceding 12 months. The EoH and CAF are based on questions typically included in the South African General Household Survey (GHS). The Household Economy Approach

Table 1 Food security indicators commonly used in food and nutrition security measurement in South Africa

Indicator/metric/	Dimension	Level of analysis	Description and measurement scale	Recall period
Household Food Insecurity Access Score (HFIAS)	Access	Household	HFIAS can be used to assess the prevalence of household food insecurity in a population and changes in food insecurity over time. The total HFIAS can range from 0 to 27, indicating the degree of insecure food access. As a categorical variable, households are categorized as food secure, mildly food insecure, moderately food insecure, or severely food insecure	30 days
Food Insecurity Experience Scale (FIES)	Access	Individual	The FIES is an outcome of the Voices of the Hungry project. It is built up from a series of yes-no responses to a relatively short series of questions and then converted into a FIES scale using item response theory. It was designed and validated specifically for individual-level data collection.	12 Months
Household Hunger Scale (HHS)	Access Availability	Household	It is used to estimate the proportion of households experiencing three levels of severity of hunger: little or no household hunger (HHS score 0–1), moderate household hunger (HHS score 2–3), and severe household hunger (HHS score 4–6)	30 days
Household Meal Frequency Score (HMFS)	Availability Access	Household	The Household Meal Frequency Score (HMFS) is a proxy for food availability in a household.	
Household Dietary Diversity Score (HDDS)	Access Availability	Household	The Household Diversity Score (HDDS) measures dietary quality. It uses a 24-hour recall period for sixteen food groups without asking about the frequency of consumption. The dietary diversity score is the sum of the first fourteen scores classified as 1 for each food group is assigned a score of 1 (if consumed over the previous 24 hours) or 0 (if not consumed in the last 24 hours). The household score will range from 0 to 12 and is equal to the total number of food groups consumed by the household:	24 hours Or 7 days
Minimum Dietary Diversity for Women [MDD-W]	Access Utilization	Individual	This is measured individually for women between 15–49 years who have consumed five of the ten defined food groups. It is a proxy for micronutrient adequacy (Diet quality)	24 hours
Minimum Dietary Diversity [MDD]	Access Utilisation	Individual	It measures children between 6–23 months who have consumed at least five of the eight food groups in the previous day or night.	24 hours
Coping Strategy Index (CSI)	Access	Household	Assess what people do when they cannot access food. Responses to fifteen questions about the frequency of precautionary measures applied in the face of food shortages during the previous week were multiplied by the severity ranking for each strategy.4	7 days
The Food Consumption Score (FCS)	Access	Household	The FCS is the sum of the number of times a food group from the HDDS was eaten in the previous 7-day period, multiplied by the weight. The scores are then classified into three categories.	7 days
Community Childhood Hunger Identification Project (CCHIP)	Access Availability	Household Community	The CCHIP index defines hunger as the mental and physical condition resulting from insufficient food due to insufficient economic, family, or community resources.	12 months 30 days
The Months of Inadequate Household Food Provision (MIHFP)	Availability and access.	Household	This is a simple sum of the months a household reports experiencing hunger in the previous 12 months	12 Months
EoH and the mCAF	Access	Household Individual	Self-reported experience of hunger (EoH) and modified complex access to food (mCAF) questions were used to estimate the incidence of experiences of hunger (self-reported) among adults and children in households during the preceding 12 months.	12 Months
Low Energy Availability (LEA)	Access Availability	Household Individual	LEA is when the energy available by the household's food supplies is less than the sum of recommended energy intakes for each member. The numerator of the LEA calculation is the sum of the energy available in the food purchases reported by the household plus the energy consumed from food produced at home during 1 month. The denominator is the household sum of the daily recommended energy intakes for each member of the household member, multiplied by thirty to convert it to the same monthly time frame as the numerator. Households that scored <1 on this ratio were defined as having low energy availability.	30 days
Food Poverty (FP)	Access Utilization	Household	A household is said to be in Food Poverty (FP) when the amount of money it spends on food is not enough to purchase an essential diet that is nutritionally adequate. The numerator of this ratio is the sum of a household's reported food expenditure plus the estimated monetary value of the food it consumed from home production. The denominator is the cost of a nutritionally adequate food basket for a particular household.	

Table 1 (continued)

Indicator/metric/	Dimension	Level of analysis	Description and measurement scale	Recall period
Experience of Food Shortage Scale (EFSS)	Access Availability	Household	a tool used to measure household food security. It assesses the severity and frequency of food shortages experienced by a household within a specific period, typically the past 12 months.	12 months
Anthropometric measurements	Utilisation	Individual	Assessing individual nutritional outcomes about individuals' height, weight, and body size. Calculations of z scores with cut-off points	N/A
HEA	Access, availability Stability	Community	The Household Economy Approach enables the development of a baseline picture of how households in a particular area survive in average years. This information is collected through focus groups from each wealth group in a community using a mix of qualitative and quantitative approaches.	N/A

(HEA) is another example of vulnerability assessment. However, it uses rapid assessment methods for a more detailed assessment of food aid needs of disaster or conflict-affected communities over a more extended period (Hendriks [24]).

The agency and sustainability dimensions have added more complexity to the measurement indicators of food security since this can lead to misestimation and misinterpretation [25]. However, very few studies have assessed whether expected household food security indicator results converge and whether these provide valid evidence, especially in the South African context, where food security measurement is influenced by the heterogeneity of climate, socio-cultural values, livelihood zones, settlement type, inequality, and varied economic advancement. As Maxwell et al. [3] argued that divergent findings can be produced by applying different food security measures to the same data set. To the best of the authors knowledge, no survey with a national scope has been conducted to assess all the dimensions of food insecurity in South Africa, particularly food utilization and access. However, some national surveys have included specific modules of food insecurity assessment, as argued by Aliber [19], for instance the General Household Survey (GHS) and the Income and Expenditure Survey (IES) are not designed for the analysis of household-level food security, it is not possible to do the kind of detailed analysis using their data that interrogates food availability, access, and stability at the household and individual levels in South Africa. Labadarios et al. [18] confirmed that no national survey has ever assessed all food security dimensions in South Africa. Because of these limitations, D'Haese et al. [26] postulate that there are no existing regularised ways of monitoring food security in South Africa since different methodologies, sample sizes, and sampling techniques are used, and aspects of food security are assessed. As a result, this is bound to provide divergent results, making it very complex to compare indicators across studies and develop a single food security estimate for South Africa. For example, the GHS [7] reported that 23.1% of the households nationally were found to have inadequate or severely inadequate food. In comparison, Simelane et al. [3] reported a severe food insecurity category of 17.5% and 46% mild or moderate food insecurity among South African households.

Although several reviews have been documented regarding food security in South Africa, many of them have been localized to provincial, district, and municipality levels. For example, Govender et al. [27] focused on KwaZulu-Natal (KZN) districts, and Styne et al. [28] focused on Cape Town and Johannesburg. None of the studies did a review with a national scope, which is mainly attributed to the fragmented and siloed approach of studies that do not link household and individual food and nutrition security indicators to present a concise national scope necessary for policy planning. Except for van Den Berg and Walsh [1], who documented a review of the food and nutrition security indicators, there is little to no evidence regarding measuring the agency and sustainability dimensions of food security. Again, van Den Berg and Walsh [1] do not conduct a meta-analysis to comprehensively analyze the indices and determine the effect size, heterogeneity, and publication bias. Their review also does not analyze the use of varying indicators, the spatial distribution of the studies across districts, nor a sensitive analysis of the indicators documented. These gaps have been adequately bridged in this review study. It is against this background that this systematic review and meta-analysis study is conducted to provide empirical evidence to shape future food security intervention policies, programs, strategies, and research funding models grounded on valid and reliable empirical evidence in South Africa. A broad research question was framed using the Population, Exposure, Comparator, and Outcome of interest (PECO) framework. The main research question, therefore, is: How and to what extent have food security and nutrition standard international measurement indicators been used to measure food availability, access, and stability among households in South Africa?. The objectives of the study were (i) to explore and analyse the food security indicators' frequency of use, and the temporal and spatial distribution of food security studies between 2000 and 2024 in South Africa (ii) to determine the effect size and heterogeneity of studies for selected

metrics on food access, availability, and stability using meta-analysis (iii) to propose measurement approaches for the recently introduced food security dimensions of agency and sustainability and recommend policy interventions to address bottlenecks in national food security and related routine surveys in the South African context.

Methods and procedures

Research approach and design

The study adopted a descriptive design using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The Population, Exposure, Comparator, and Outcome of interest (PECO) framework was used to develop the main research question for this systematic review. The PECO framework was adopted because it is useful in circumstances where the exposure aspect is not a planned intervention, for example, in environmental, agricultural, and occupational health domains. A scoping review was done in Google Scholar (scholar.google.com), Scopus, and ISI Web of Science for the paper's primary systematic review sections of titles and abstracts. Preliminary screening based on title and abstract reviewing was done using Rayyan 1.6 software to facilitate resolving the disputes amongst the three (3) independent collaborators and easy removal of duplicates. This was followed by a comprehensive full-text search in Web of Science (WoS) and Scopus databases by the three independent authors through the Human Sciences Research Council (HSRC)' online library catalogue. The search was done using a search strategy with the aid of the Perplexity artificial intelligence (AI) application. The search focused on primary research and panel data from South Africa that used standard international (SI) indicators to measure food access, availability, and stability dimensions. A similar comprehensive systematic review focusing on zero hunger studies conducted in the Scopus database by Otekunrin et al. [29] argues that Scopus is undoubtedly one of the most reliable databases, with an exhaustive collection of abstracts and citation databases linked to scholarly publications from various academic fields. In 2023, Scopus has over 90 million content records,17 million-plus author profiles, over 1.8 billion cited references, and over 7 thousand publishers across 240 disciplines. Further, Scopus is a widely trusted source for reliable and quality bibliometric searches. In addition, the ISI Web of Science database was also used to search for literature.

Search strategy

Since food security is an interdisciplinary domain involving agriculture, food security, climate change, nutrition, public health, disaster management, and anthropology, a scoping review was done to determine the availability of literature, search terms, and appropriate databases focusing on food security assessment or measurement. To enhance the validity and reliability of the search strategy, Artificial Intelligence (AI) tools were used to assist in searching, summarising, and extracting the information from the articles. The AI perplexity application was used to find research papers. The authors did a full-text reading of all documents retrieved and used Quilbot, an artificial intelligence application, to complement the paraphrasing done after the manual data extraction of relevant text by the authors using NVIVO Software 14.0. The search strings for this systematic review included the terms related to food security measurement and food security indicators, or metrics. As was similarly implemented in a systematic review by Manikas et al. [30] in a study focusing on food security measurement, the following search strings were developed and used in this study:

("food security" OR "food access" OR "food affordability" OR "food availability" OR "food utilization" OR "food stability" OR "nutrition security" OR "nutrition insecurity") AND ("measurement" OR "metrics" OR "indicators" OR "assessments" OR "scales" OR "index") AND ("South Africa").

The search in the Scopus database yielded 572 articles, and the initial screening using titles, abstracts, and keywords removed 393 irrelevant documents. A similar search in Web of Science (WoS) produced 583 documents, and the initial screening of the articles based on the titles and information from abstracts removed 484 irrelevant documents, leaving 99 articles (see Fig. 2). After searching, the articles were exported into Rayyan 1.6 software for screening and duplicate removal. The files searched were also exported and merged into an Excel spreadsheet format. After removing duplicates, the remaining articles were screened using the appropriate inclusion and exclusion criteria illustrated in the PRISMA diagram (See Fig. 2).

Inclusion and exclusion criteria

The first step involved the three independent collaborators reading the article title, keywords, and then the abstract to check for initial inclusion or exclusion. Finally, the full text was read to check the inclusion and exclusion criteria. The systematic review included published peer-reviewed articles, book chapters, conference proceedings, and short communications. Only literature that was written in the English language was consulted. Review papers, conceptualization papers, and policy papers were excluded from the analysis. Only articles that used standard food security indices were considered, while those that used proxy indicators for food security were discarded. Indicators of food access, food availability, and stability were considered in this review; those of the food utilization dimension indicators related to

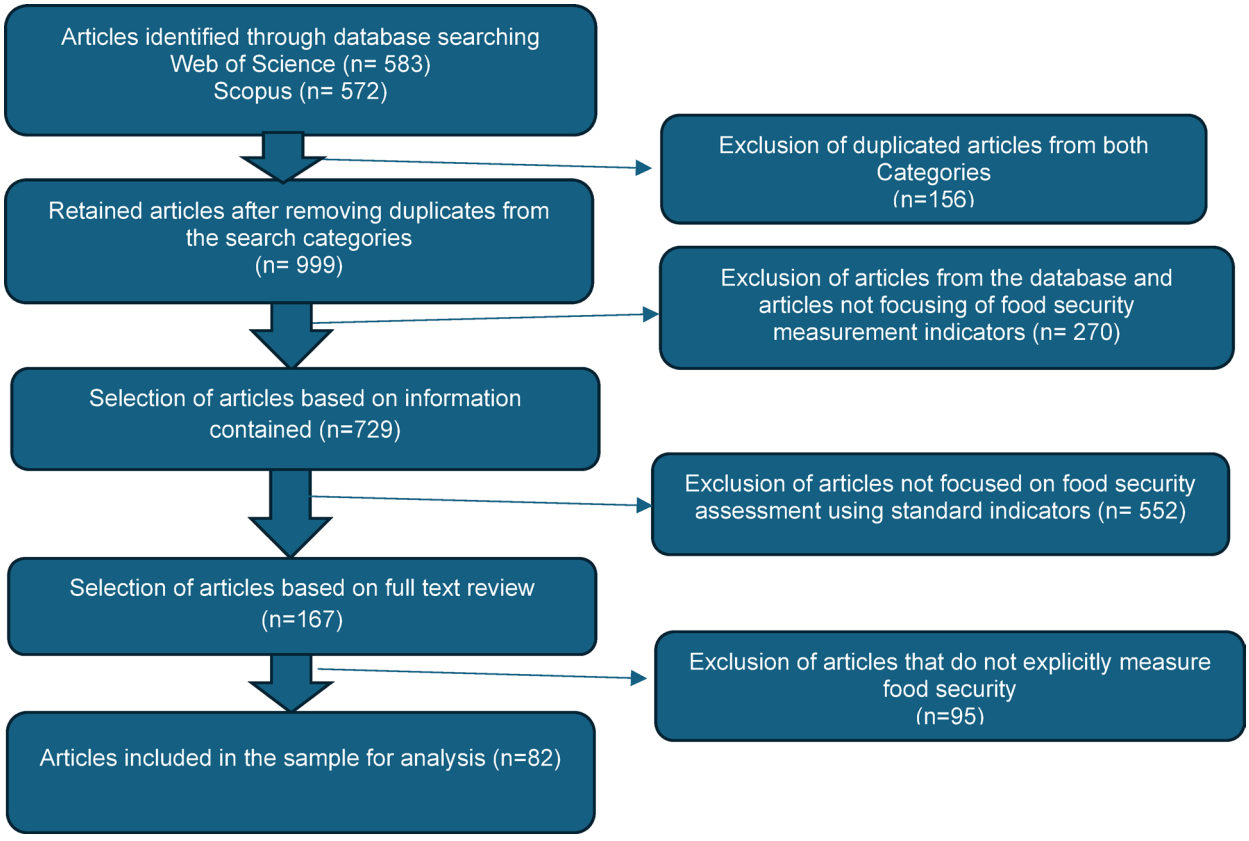

Fig. 2 Literature searching and screening criteria using the PRISMA guidelines

health and nutrition outcomes were excluded. In addition, grey literature and Master's and Doctoral theses were all excluded from the review because some of these documents are not easily accessible at their institutional repositories, and there are quality concerns, particularly given the limited peer review rigor aspect, which they are not subjected to. The search was done between February 2024 and finalised on 9th September 2024. Similarly, no agreed-upon indicators for the food security dimensions of agency and sustainability have been documented yet. Instead, this paper will propose plausible ways of quantifying these dimensions of food security.

Data extraction from the documents

Table 4 was developed to assist in extracting and presenting data from the documents. The extraction of the data was aided by Quillbot, an artificial intelligence application. The following data were extracted from eligible articles. The researcher tabulated the first author, year of publication, study name, food security indicators used, methodology, study design, total sample size, and the gender-specific number of participants and their ages. The mean, standard deviation (SD), and standard error (SE) of HFIAS and HDDS were also tabulated for meta-analysis.

Quality assessment and assurance of the review

The three independent collaborators searched for articles to eliminate bias with the assistance of Perplexity, an Artificial Intelligence (AI) tool. The review adopted the Newcastle-Ottawa scale as a quality assessment tool for scoring each study for inclusion. In this context, the tools focused primarily on the quality of the methodology, sample size, statistical analysis used, and how studies could be relatively compared with other studies. An online free Rayyan 1.6.0 software was used for preliminary screening of articles based on title and abstract, and resolving disagreements on the inclusion of articles among the three collaborators. This led to the thorough evaluation of the articles by three independent authors or collaborators. A discussion was used to tackle any disagreements among the collaborators before the final compilation of the database search results.

Statement on the use of artificial intelligence (AI) tools

The study was primarily based on the conceptualisation and independent execution by the authors, thereby guaranteeing the originality and responsible use of AI applications. Perplexity, an AI tool, was used to complement the search strings and strategy developed to enhance the accuracy of the search, which ensured that almost all

relevant literature that was missed by the search strings was included. Authors were primarily responsible for full-text reading and paraphrasing of all included articles. The NVIVO software was used to search for text related to the research question. Quill Bot, an AI tool, was also used to assist authors in paraphrasing the relevant text phrases to aid the synthesis of results, but this was done in such a way that it does not replace the traditional full-text reading and paraphrasing or data extraction using the data extraction tool developed by the authors.

Statistical analysis

The qualitative document analysis was done using NVIVO Software 14.0 assisted in extracting relevant text aligned to the research questions using text search queries. SPSS Software Version 29.0 was used to perform descriptive analysis and meta-analysis in which all standard errors (SEs) were first converted to standard deviations (SDs). Only two indicators, the HFIAS and HDDS, generated enough threshold data to enable meta-analysis. The meta-analysis was conducted separately for HFIAS and HDDS to generate forest plots and funnel plots, as well as the associated effect sizes, standard mean difference, and standard errors. Cochran's Q evaluated sources of between-study heterogeneity, and I square (I^2) tests. Fixed effect models were used to determine effect size, standard mean differences, and the associated standard errors. Since the heterogeneity among studies was minimal or moderate, as determined by Cochran's Q tests, subgroup analysis was not done during the meta-analysis analytical process.

Results

This review identified 18 commonly used standard food security indicators among studies on food access, availability, and stability between 2000 and 2024 in South Africa. Figure 3 depicts the number of studies that used indicators measuring food access, availability, and stability used by various studies from 2000 to 2024. The data extracted from the 82 articles reviewed are presented in

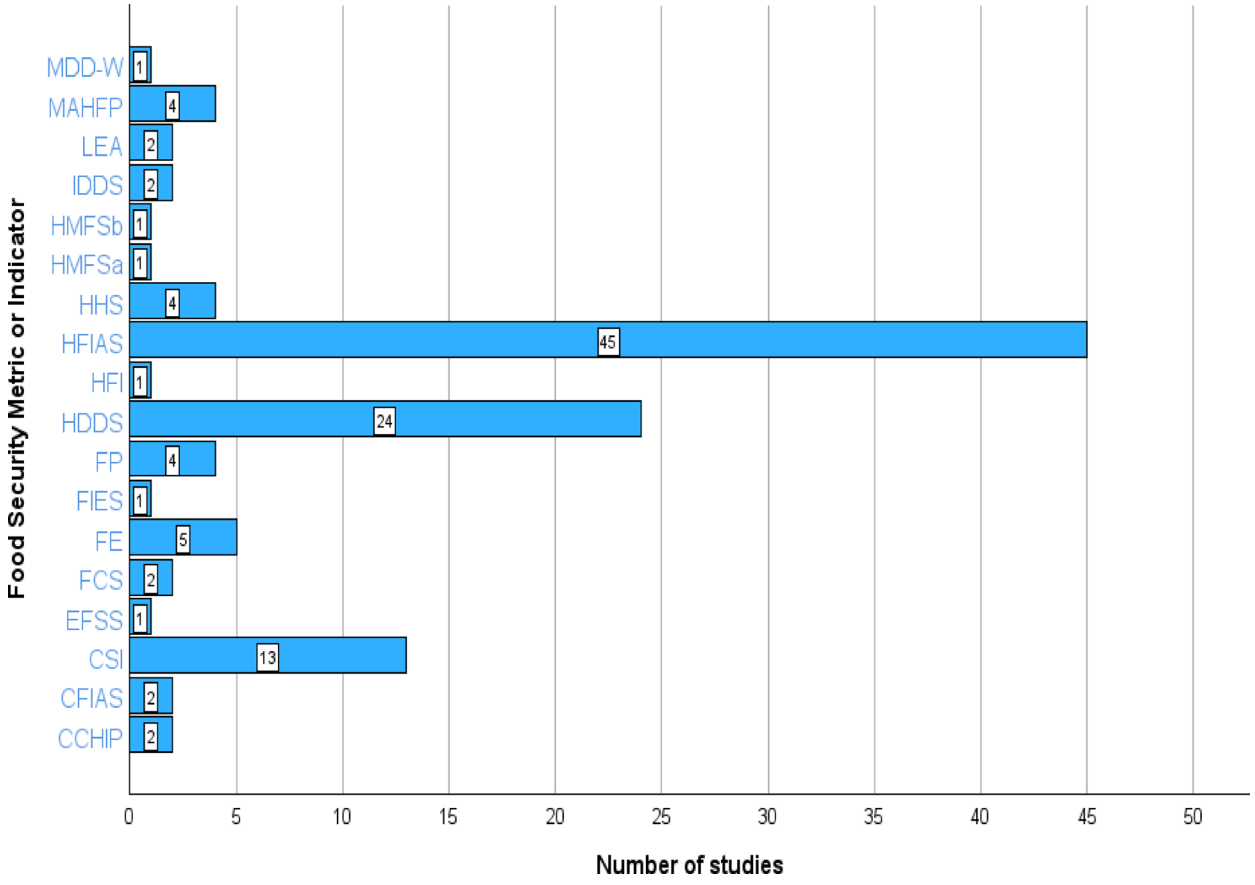

Fig. 3 The Frequency of different metrics (indicators)used to measure food security in South Africa. ***KEY: HFIAS -Household Food Insecurity Access Score; HHS-Household Hunger Score; FCS - Food Consumption Score; CSI-Coping Strategy Index; FE-Food Expenditure; HDDS-Household Dietary Diversity Score; FIES-Food Insecurity Experience Scale; CCHIP- Community Childhood Hunger Identification Project; MDD-W- Minimum Dietary Diversity Index for Women; LEA – Low Energy Availability; FP- Food Poverty, MAHFP- Months of Inadequate Household Food Provisioning; IDDS -Individual Dietary Diversity Score; HMFSa- Household Meal Frequency Score (HMFS) & HMSFb – Household Meal Frequency Score; CFIAS -Children's Food Insecurity Access Scale; HFI – Household Food Intake Scale; EFSS- Experience of Food Shortage Scale**

Table 4, which depicts the authors, indicators used, study areas, research approaches, and methods, and a summary of the findings.

It emerged that HFIAS is the most widely used indicator for measuring food access in South Africa, with 45 studies (See Fig. 3) reported to have used it. Most studies used this indicator as a stand-alone measure of food insecurity, while the HDDS was the second most frequently used indicator, with 24 studies. The Coping Strategy Index (CSI), Food Expenditure (FE), Household Hunger Score (HHS), Food Poverty (FP), and the Months of Inadequate Household Food Provisioning (MAHFP) followed in terms of frequency of use in that order (See Fig. 3). The high frequency of use of HFIAS is mainly because it provides a straightforward measure of self-reported food insecurity at the household level. Few studies used the Household Food Insecurity Access Prevalence (HFIAP).

Spatial distribution of food security measurement studies

Most food security studies implemented to measure food access, availability, and stability using standard indicators were done in parts of Limpopo, Gauteng, KZN, and Western Cape Provinces. On the other hand, very few studies of this nature have been done in the Free State, Northern Cape, Eastern Cape, North-West, Western Cape, and Mpumalanga Provinces (See Fig. 4). In the Western Cape, most of the studies have concentrated in the City of Cape Town), which depicts the severity of food insecurity in townships such as Khayelitsha, Mitchells Plain, and Nyanga. Similarly, most studies in Gauteng Province were also focused on urban townships. Minimal studies have been done across peri-urban settings.

Types of studies and data sources used

Figure 5 shows the number of studies undertaken in various provinces and districts, as well as the sources of data used for measuring food access, availability, and stability across South Africa from 2000 to 2024. From the review,

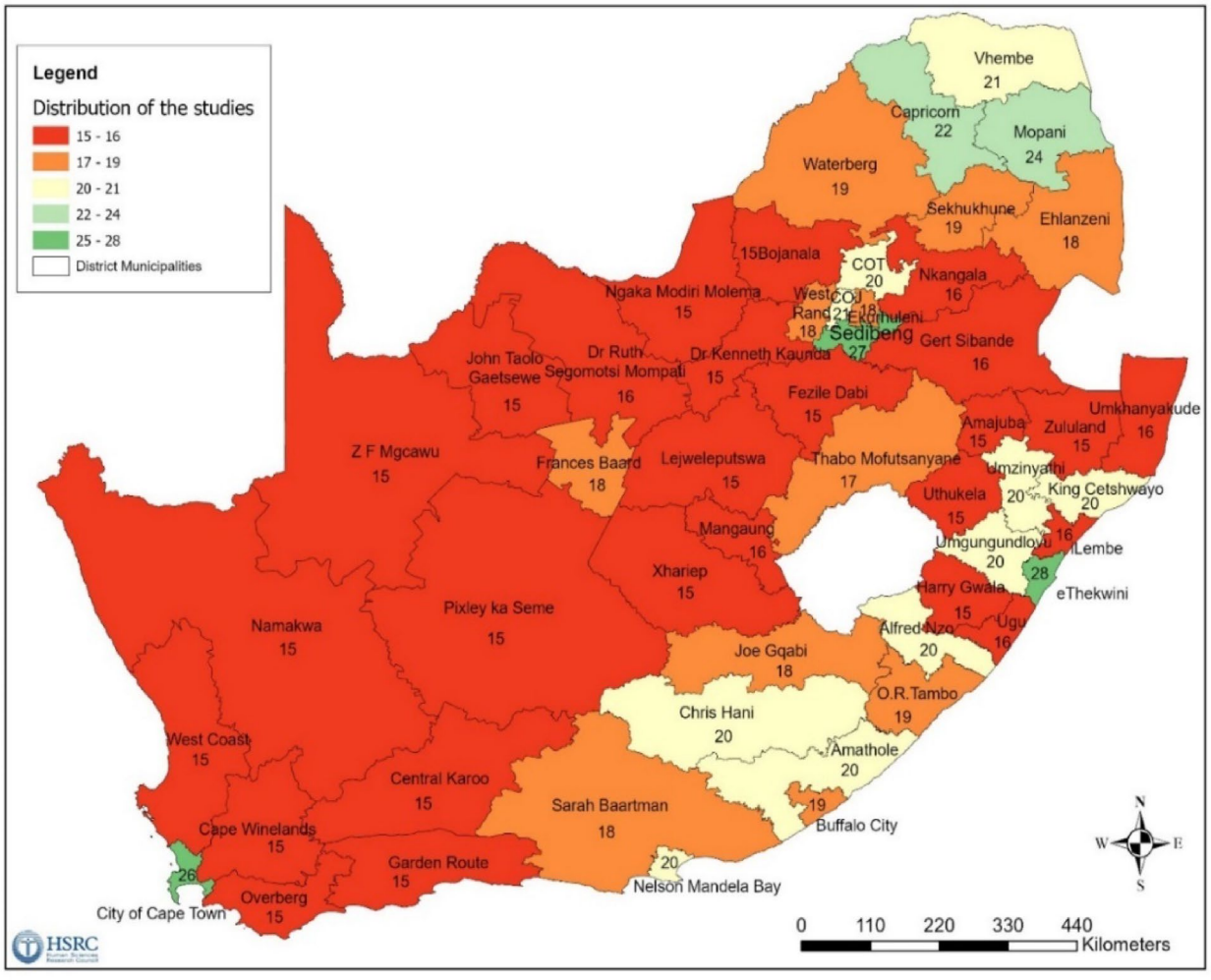

Fig. 4 Spatial distribution of studies that used food security measurement indicators in South Africa

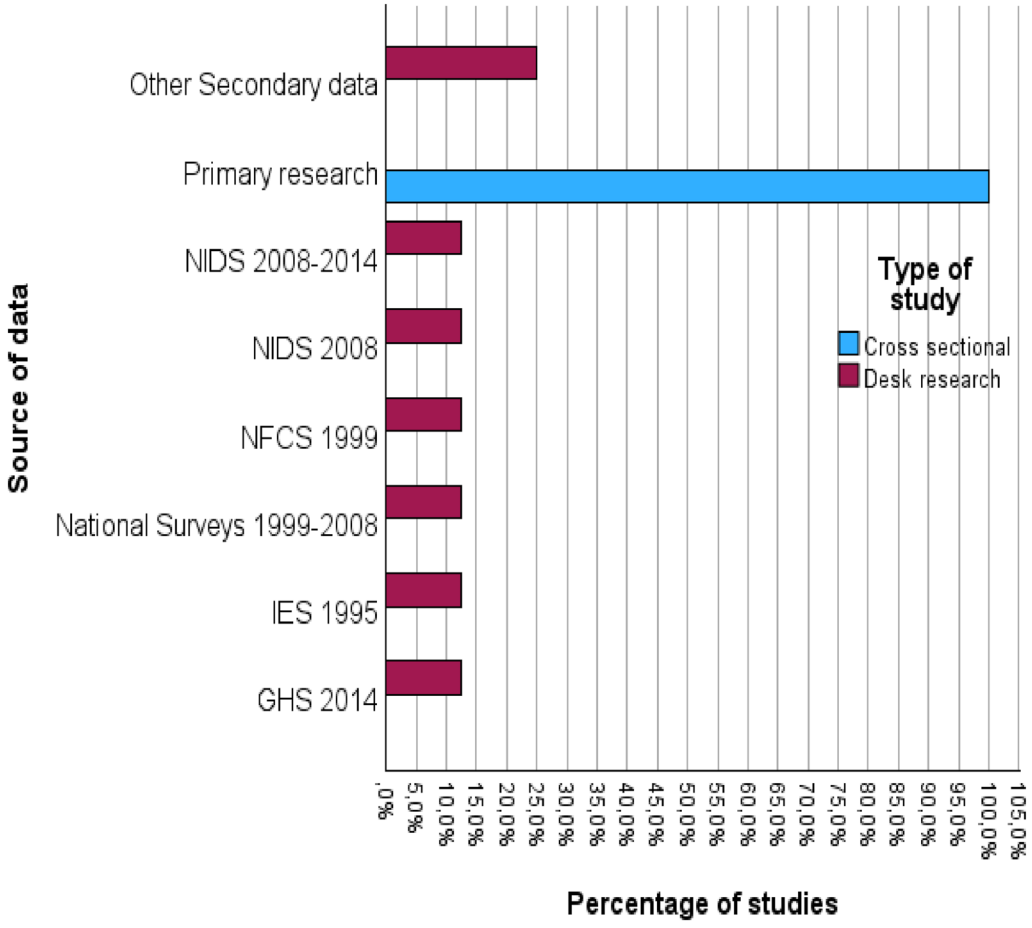

Fig. 5 Types of studies and sources of data used in measuring food security in South Africa.*Key: NFCS-National Food Consumption Survey; NIDS- National Income Dynamics Survey; IES- Income and Expenditure Survey; GHS-General Household Survey

the majority (89%) of the studies were cross-sectional studies. All cross-sectional studies were conducted using primary data collection, while very few studies (3%) used a desk research approach (see Fig. 5), from secondary and panel data generated from routine national surveys such as the General Household Survey (GHS) of 2014, the National Income Dynamics Survey (NIDS) of 2008–2014, and the Income and Expenditure Survey (IES) of 1995. Other secondary data sources from specific studies were also used, besides these national representative data sets.

Most studies were conducted in urban and rural settings, with Gauteng Province (GP) recording the highest number of studies in the urban setting (See Fig. 6). This is because most of the vulnerable food-insecure households in Gauteng are in urban township settings and there are no strict rural landscapes in Gauteng since the province is highly urbanized. KZN province, followed by the Limpopo Province, had the highest number of studies in the rural areas, a finding mainly attributable to the reliance on smallholder agriculture for food access and availability amongst the households in these two provinces. In the Free State, North West, and Northern Cape Provinces, there is minimal research activity involving food security measurement using standard indicators across all the settlement landscapes. Minimal food security measurement studies have been conducted in peri-urban settings across all provinces. This is despite the increased vulnerability to food insecurity of peri-urban households in the Free State province.

Temporal variation of food security measurement studies

The temporal variation of studies that used food security metrics indicates a gradual increase in studies from 2000 to 2011. There was a sharp decline in these studies in 2013 right through to 2015, followed by a sharp increase from 2015 to 2019 (See Fig. 7). A drastic decrease in the number of food security measurement studies is evident in 2020 due to the COVID-19 pandemic, which resulted in the unprecedented strict movement lockdown measures first instituted on 27th March 2020, leading to a complete halt in all research activities involving travelling to study sites. However, the general trend over the 2000–2024 period shows a steady increase in the number of food security studies using standard metrics to measure

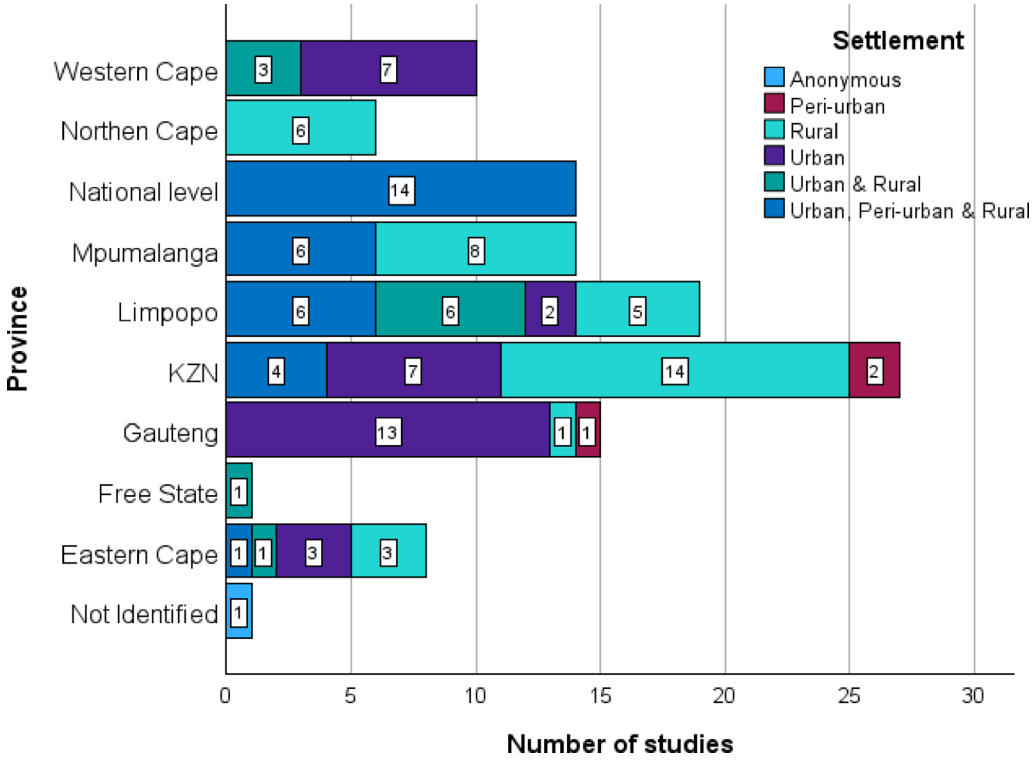

Fig. 6 Number of studies disaggregated by settlement type across the different provinces

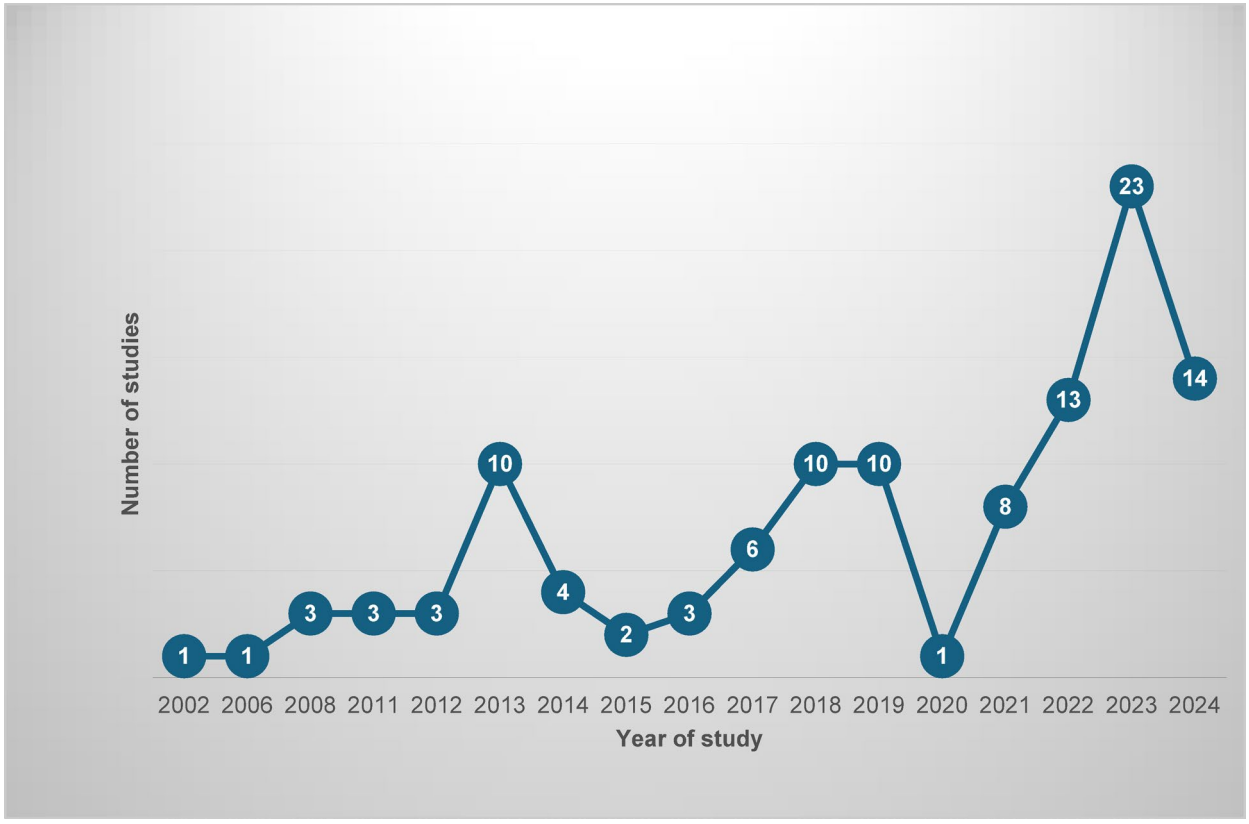

Fig. 7 Temporal variation of studies focusing on food security indicators in South Africa (2000–2024)

Table 2 Summary of HFIAS meta-analysis results used in food security measurement in South Africa

Effect size estimates						
	Effect size	Std. error	Z	Sig. (2-tailed)	95% Confidence interval	
					Lower	Upper
Overall	1,596	,2901	5,502	<,001	1,028	2,165

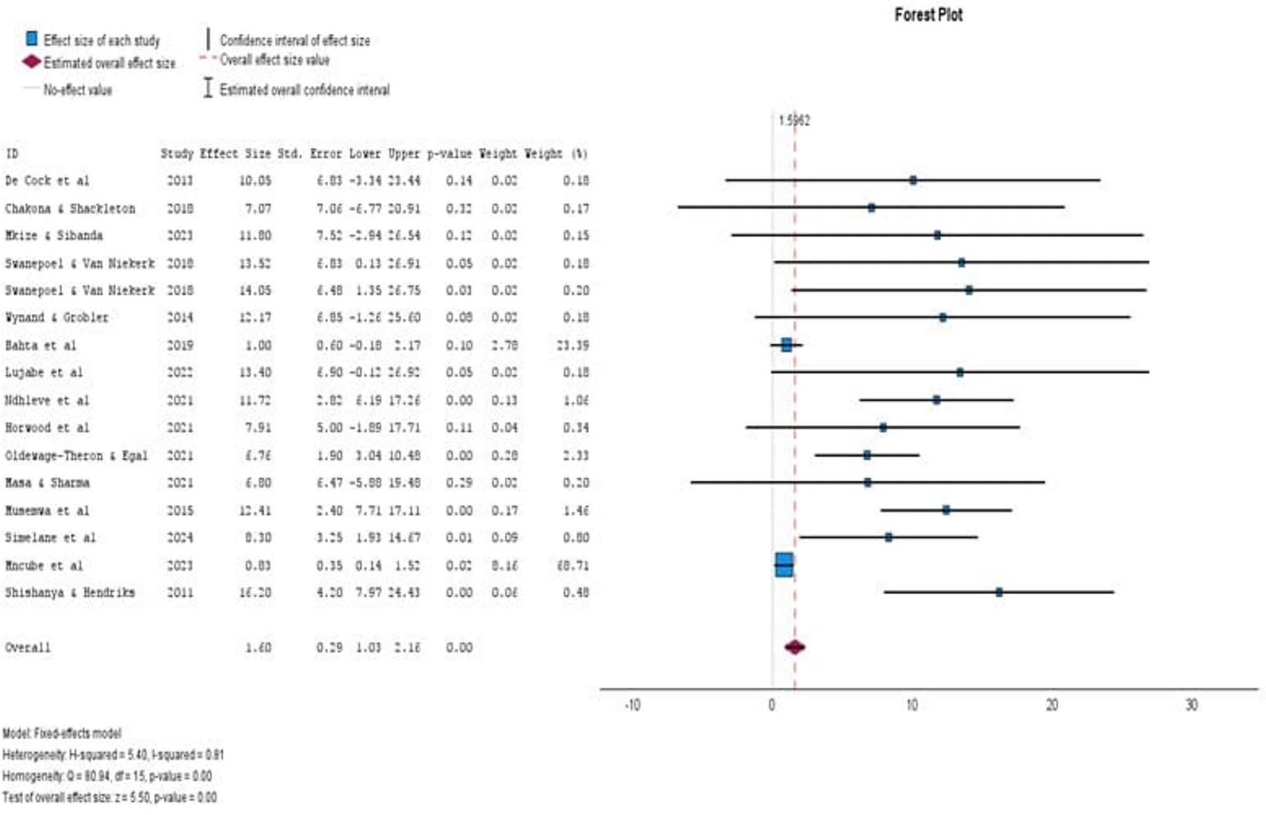

Fig. 8 Forest plot depicting effect sizes for selected HFIAS studies conducted in South Africa

food availability, access, and stability (See Fig. 7) from 2000 to 2024 (Table 2).

Meta-analysis of HFIAS and HDDS food security metrics

The meta-analysis results for the HFIAS metric show that the overall pooled effect size from the Forest plot is 1.5. (See Fig. 8). The studies are homogeneous since the I^2 (0.81) value is far less than 50%. However, the funnel plot for the HFIAS shows a relatively high publication bias, as shown in some studies (n = 4), which is outside the confidence interval limits. The forest plot also depicts that several studies [6, 31–34] were significant ($P < 0.05$) since their confidence limits did not encroach on the null point. Only [32, 35] had individual effect sizes below the pooled effect size of 1.5. These are the only two most precise studies identified from this study since they are close to the zero-standard error value within the funnel plot (See Fig. 9). The funnel plot also shows relatively high imprecision because of the distance of the distribution of the studies away from the x-axis (standard error). Meta-analysis results for HDDS show that the overall pooled effect size is 5.69, and the studies are homogeneous since the homogeneity test is less than 50%. The funnel plot for HDDS shows minimal publication bias since most of the studies, except two [36, 37], fell within the confidence limits of the funnel plot. The studies are also more precise in estimating the HDDS across the studies since most of the studies are closer to the zero standard error point within the funnel plot (See Fig. 10). There was very minimal heterogeneity for both metrics (HFIAS and HDDS) hence there was no subgroup analysis done (Table 3).

Discussion

The frequency of use of food security indicators in South Africa

The reliance on HFIAS as the primary and, in most instances, as the sole indicator of food insecurity measurement, as shown in most studies (n = 0.45), shows that much of the food insecurity estimates in South Africa

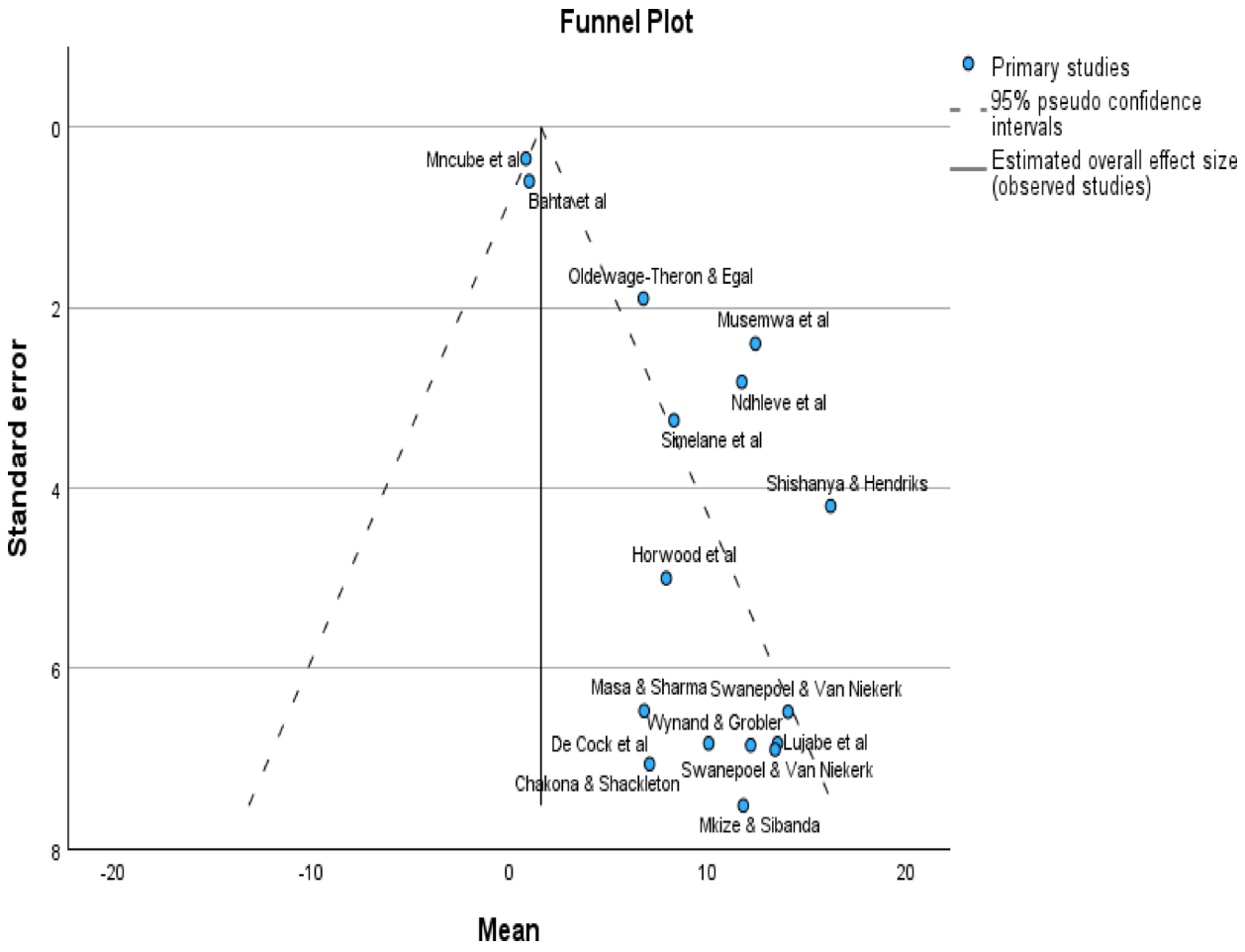

Fig. 9 A funnel plot depicting variability among selected HFIAS studies undertaken in South Africa

primarily rely on this metric. However, contrary to findings from the Global North, Sumsion et al. [38] postulate that the US Household Food Security Survey Module (HFSSM) and Food Insecurity Experience Scale (FIES) are two of the most used metrics of food insecurity in the United States (US). In stark contrast, the probable reason behind the extensive use of HFIAS in South Africa is that this indicator uses a household as a unit of analysis; it relies heavily on the reported experiences of the household caregiver and is therefore easy to measure. However, the HFIAS index may give a biased view of household food insecurity prevalence, especially consider the intra-household power disparities and food preparation and serve priorities that emanate from the different roles of the household members interviewed. This is similarly argued by Hendriks et al. [9] and Coates et al. [39] that adult men and women living in the same household may respond differently to household food security questions due to their divergent food-related roles and responsibilities. Although the HFIAS food continuum categories have standardized categories (Severe food insecurity, Mildly food insecure, Moderately food insecure, and Food secure) applicable across locations, they vary with different contexts, subject to varying age, level of income, culture, and other socio-economic factors. Because of this assertion, it is very difficult to make standardized HFIAS measurement outcome comparisons across communities, districts, municipalities, cultures, provinces, and livelihood zones. This is similarly buttressed by Hendriks et al. [9] that some of the items in the HFIAS questionnaire do not meet strict psychometric criteria for cultural invariance, meaning that it should not be used to make comparisons across diverse sociocultural countries and contexts. Despite these shortcomings, HFIAS remains the most helpful metric in population-level food policymaking, monitoring, and evaluation (M&E) of food access-related programs. The HFIAS indicator is also able to detect aspects of food insecurity involving decreased access to a sufficient quantity or quality of food. It also detects psychosocial manifestations of anxiety and uncertainty around food access, with negative implications for health and well-being. It is readily applicable to varying contexts, such as urban, peri-urban, and rural settlements. HFIAS is a relatively short module,

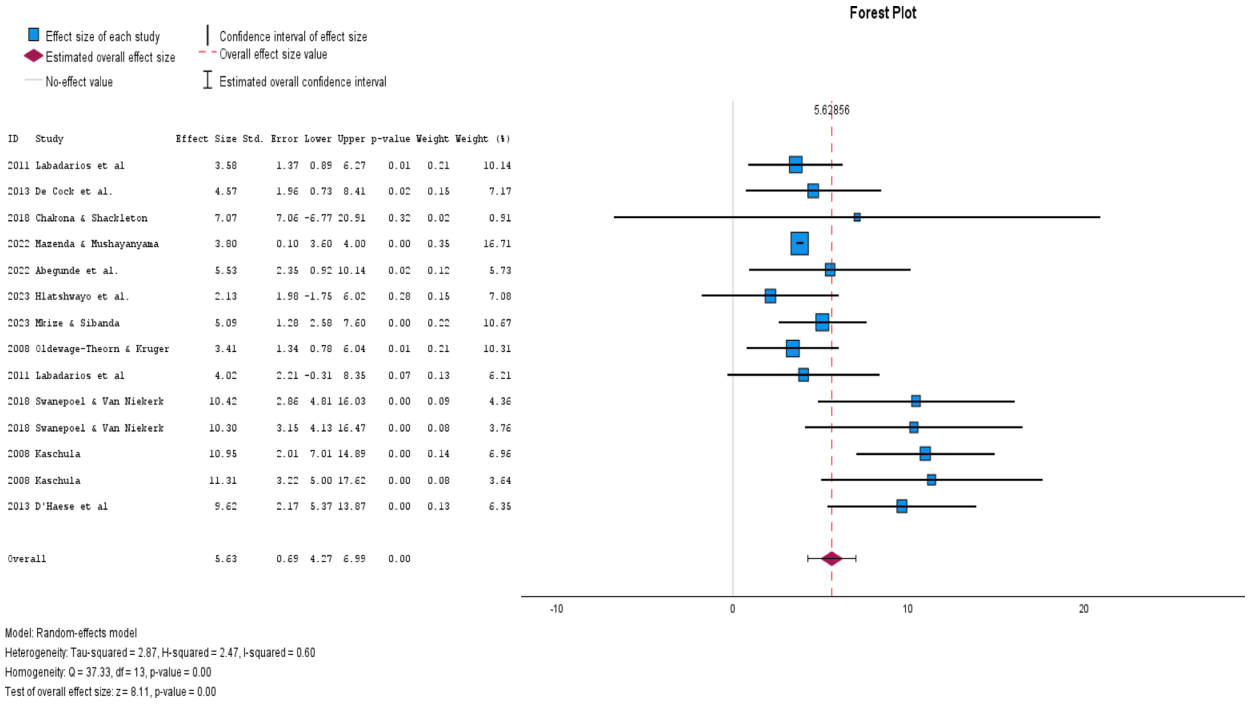

Fig. 10 Forest plot for HDDS among the selected studies conducted in South Africa (2000–2024)

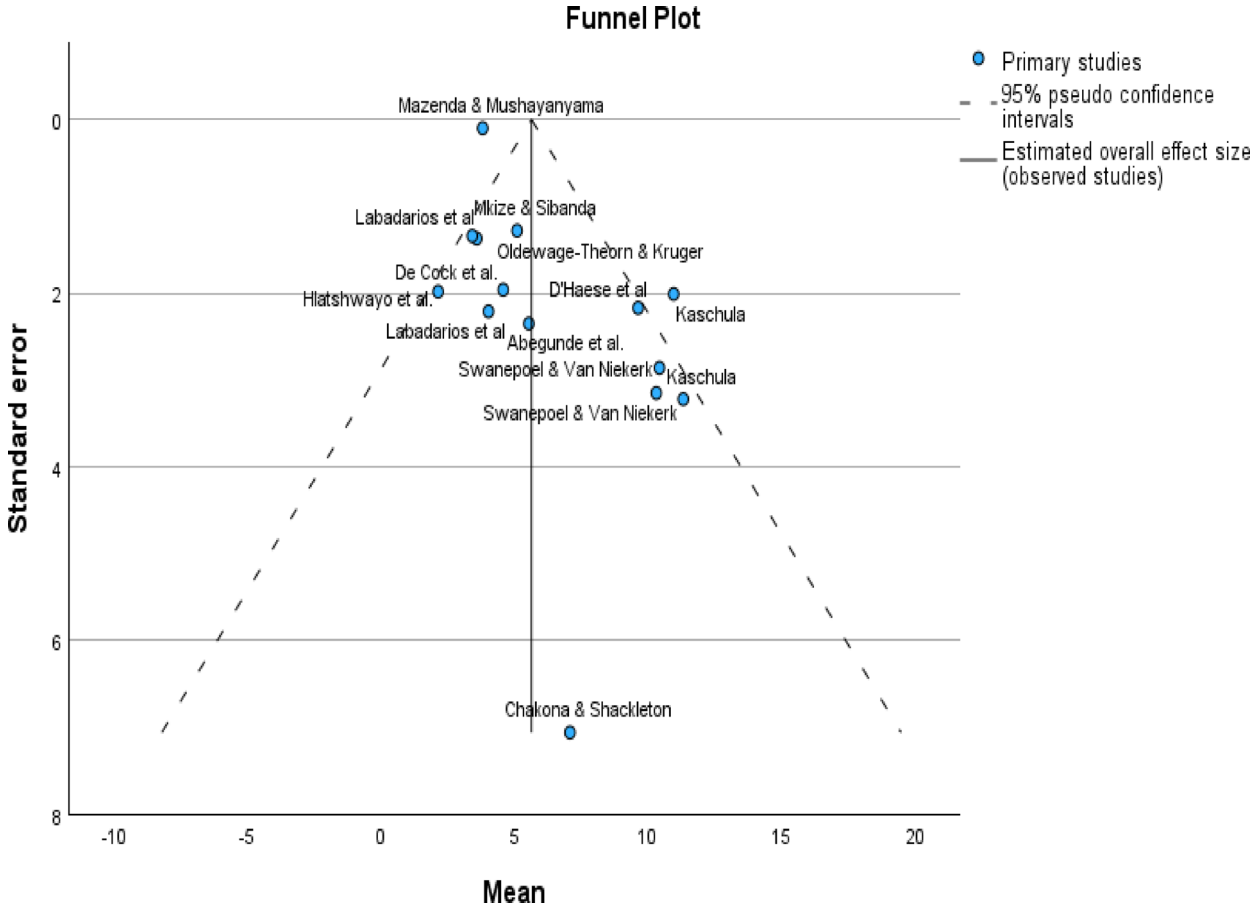

Fig. 11 A funnel plot depicting variability among selected HDDS studies undertaken in South Africa

Table 4 Summary findings from studies that used food access, availability, and stability indicators in South Africa between

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
1.Robb et al. [50] Sociodemographic Indicators, Household Food Security and Associations with Choline Intake in Pregnant Women: The NuEMI Study	HFIAS	Household	Free State,Bloemfontein	A cross-sectional study design was performed. All pregnant women attending the antenatal clinic at A consecutive convenience sample of 682 pregnant women in their second and third trimesters who provided written informed consent were included.	only 26.6% of participants were categorized as food secure, while 32.5% were classified asmoderately and 29.9% as severely food insecure. One in five participants (20.9%) indicated that in the past four weeks, there were times when no food was available in their households because of a lack of resources to obtain food.
2.Cele & Mudhara [51]. impacts of Crop Production and Value Chains on Household Food Insecurity in Kwazulu-Natal: An Ordered Probit Analysis	HFIAS	Household	KZN	A cross-sectional survey was conducted from July to September 2022 among 300 smallholder farmers in Swayimana in the uMgungundlovu District Municipality (UDM), under the Mshwati Local Municipality, and Umbumbulu in the eThekwini Metropolitan Municipality were studied.	Results show that 36% of the farmers were food secure, 33% were mildly food insecure, 22% were moderately food insecure, and 9% were severely food insecure.
3.Tyabashe-Phume et al. [52]. The relationship between food insecurity, the child support grant, and childcare arrangements	HHS	Household	Western Cape Cape Town (Township)	The study was designed using mixed methods. A hunger scale was administered to 120 participants, and in-depth interviews were conducted with 23 primary caregivers of children under 2 years of age.	About 19.2% were food insecure, and 80.8%) were food secure. while about 28.33% reported that in the past month, there had been instances when there was no food in the household because of the lack of resources to get food. About 22.5% reported having gone to sleep at night hungry because there was not enough food,
4.Rusere et al. [48] Patterns and trends in household food security in rural Mpumalanga Province, South Africa	HFIASHDDSCSIHMFSaHMFSbEFSS	Household	MpumalangaBushbuckridge	This was a longitudinal study in which data was collected cross-sectionally between April and June over five years, annually from 2010 to 2014 and again in 2019. At baseline, it included 587 households. Attrition has resulted in an uneven panel of 3260 observations reflecting 587 and 505 households annually.	81–92% had consumed three meals the previous day across the six study rounds. Few households (0–0.4%) had not eaten meals the last 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.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
5.Mbhenyane & Tambe [53]. The Influence of Household and Community Food Environments on Food Insecurity in Limpopo Province, South Africa.	HHS	Household	Limpopo	The study was conducted in the Limpopo Province of South Africa. For Village One, all 91 households were sampled, while for Village Two, 200 of the 645 households were sampled using systematic sampling.	This study's findings on household food security show that less than one-quarter (23.7%) of the surveyed households are food insecure, 39.4% are at risk, and 36.9% are experiencing hunger.
6. Gwacela et al [54]. Analysis of the Contribution of Home Gardens to Household Food Security in Limpopo Province, South Africa	HFIAS	Household	LimpopoLobowa, GanzankuluVenda	This study assessed the contributions of home gardens to food security in Limpopo Province. A total of 2043 rural households were selected using multistage stratified random sampling. 280 households participated in the study	Results showed that 46% of participants were food secure, 24% were severely food insecure, 17% were moderately, and 13% were mildly food insecure. Employment status and receiving any social relief had a negative association with household food security of home garden participants.
7.Nkinsi et al [55]. Food Insecurity at HIV Diagnosis **8**. Associated with Subsequent Viremia Amongst Adults Living with HIV in an Urban Township of South Africa	HFIAS	Household	UKZN,Umlazi	Secondary data from the cohort study of 2383 participants was used. The parent study participants were adults aged 18 or older who voluntarily presented for HIV testing at the iThembalabantu clinic in the Umlazi township of KwaZulu-Natal, South Africa, from September 2013 to April 2017.	The overall burden of food insecurity measured by the HFIAS in our cohort was low, accounting for 10.6%. Results also show that 84.9% were food secure, 3.6% were mildly food insecure, 4.3% were moderately, and 2.7% were severely food insecure.
9.Ngarava. [56]. Effectiveness of the indigent support policy on food insecurity in South Africa: Experiences from Matatiele Local Municipality	HFIAS	Household	Eastern CapeMatatiele Municipality	A cross-sectional survey study on 549 participants. The discriminatory selecting criteria and sampling frame comprise of households with water, energy and food insecurity, information of which is obtained from the Matatiele Spatial Development Framework Review	40.0% of the households are moderately food secure, while 32.0% are somehow food secure. Only 13% of the households are food safe, while 5% are extremely food insecure. A household that is a non-beneficiary of the indigent support policy has a higher HFIAS score of 0.226 compared to a household that is a beneficiary of the indigent support policy, indicating that the indigent policy has a positive impact on food security,

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
10.Ngarava [57]. Implications of land restitution as a Transformative Social Policy for Water-Energy-Food (WEF) insecurity in Magareng Local Municipality, South Africa	HFIAS	Household	Eastern Cape Greater Taung; Magareng Municipalities	A cross-sectional survey of 1184 households from Matatiele, Greater Taung, and Magareng Local Municipalities was done. The Household Water Insecurity Experience, Multidimensional Energy Poverty Index, and HFIAS were used to analyze water, energy, and food insecurity, respectively. In contrast, Propensity Score Matching was used to assess the impact of benefiting from land restitution on insecurities in these resources.	Benefiting from land restitution increased water and energy insecurities by 15.0% and 24.2%, respectively, while reducing food insecurity by 10.1%. Land restitution has improved the beneficiaries' food security status while reducing their water and energy security. A household that is a non-beneficiary of the indigent support policy has a higher HFIAS score of 0.226 compared to a household that is a beneficiary of the indigent support policy.
11.Hlatshwayo et al. [58] The determinants of crop productivity and its effect on food and nutrition security in rural communities of South Africa	HFIASHDDS	Household	Limpopo & Mpumalanga	Cross-sectional quantitative research was done on 1520 households selected using multi-stage stratified random sampling. Of these, 386 were crop producers, 176 were from Mpumalanga province, and 210 were from Limpopo province.	HFIAS results showed that most smallholder farmers were food insecure, with 78% of the farmers in each province found to be food insecure. HDDS showed that 50% of smallholder farmers in the overall sampled population had highly diverse diets. Only 50% of the smallholder farmers had high dietary diversity in each province.
12. Hlatshwayo et al[59]. Effect of market participation on the food and nutrition security status of the rural smallholder farmers: the case of Limpopo and Mpumalanga provinces, South Africa	FCSHDDS	Household	Limpopo & Mpumalanga Provinces	A sample of 1,520 participants was chosen from two provinces (Limpopo and Mpumalanga). The quantitative data were collected in four Mpumalanga districts and three Limpopo districts. The study used secondary data collected by the South African Vulnerability Assessment Committee in 2016	About 54% of smallholder farmers were within the acceptable diversified diets, while 30% and 16% were in the borderline and poor diets. 44% and 66% of the smallholder farmers consumed adequately diversified diets in Limpopo and Mpumalanga, respectively. About 14% of the respondents consumed poor diets. As for the HDDS, 57% of smallholder farmers consumed highly diverse diets, while 25 and 18% consumed medium and low-diverse diets.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
13. Ngidi et al. [60] Effect of Consumers' Acceptance of Indigenous Leafy Vegetables and Their Contribution to Household Food Security	HFIAS	Household	Limpopo&Mpumalanga	The study used secondary data collected by the South African Vulnerability Assessment Committee in 2016. A total of 1520 respondents were selected using a multistage sampling method in Limpopo and Mpumalanga provinces	HFIAS shows that 25% of households were food secure while 32% were mildly food insecure. About 33% of households were moderately food insecure, while 10% experienced severe food insecurity. These results show that most families experience food insecurity in Limpopo and Mpumalanga provinces.
14. Schoeman et al. [61] Prevalence of Poverty and Hunger at Cancer Diagnosis and Its Association with Malnutrition and Overall Survival in South Africa	HHS	Household	Anonymous	This cross-sectional study, nested in a prospective cohort study, recruited children newly diagnosed with cancer between three months and 15 years in five of 13 pediatric oncology units (POUs) in South Africa from October 2018 to December 2020. About 320 children and adolescents were enrolled during the study period	80% children lived in households with a high risk of food insecurity, with 37.2% living with hunger at home, 42.8% living with a risk of food insecurity, and a mere 20% living in households with food security. Most parents (71%) reported using a limited variety of foods to feed their children due to a lack of financial means. half-a-third (65.9%) of the households experienced a monthly shortage of funds for food, and most caregivers (56.6%) decreased their meal portions or skipped meals to be able to feed their families.
15.Mncube et al. [32] Addressing food insecurity in Richmond area of KwaZulu-Natal, South Africa: The role of cash transfers	HFIAS	Household	KZNRichmond	The study was conducted in the Richmond region, namely in Nkumane, St. Bernard's Mission, Nhlazuka, and Mpofana. 180 households (both beneficiaries and non-beneficiaries) participated in the study.	16.67% of the farmers in the sample were food secure, 40.74% had mild food insecurity, 33.33% had moderate food insecurity, and 9.26% had severe food insecurity. The average HFIAS score of the households was 7.21, indicating that most of the examined farmers experienced food security.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
16. Olawuyi & Mushunje [62] Access to special COVID-19 relief from distress grant and livelihood outcome of livestock farming households in Eastern Cape Province, South Africa	FIES	Household	Eastern Cape	This research used a dataset from the 1499 households captured in the 2021 South African General Household Survey to investigate whether access to extraordinary relief from influences on the livestock farming households' food security status in Eastern Cape Province of South Africa.	About 55.6% and 27.7% of the non-livestock farming households were found in the food break-even and surplus categories, respectively. A small proportion (10.1% and 6.6%, respectively) were also found in the transitory and chronic food insecurity situations. The results indicated that most (54.4%) livestock farming households were in the food break-even category. In comparison, close to one-fifth (24.0%) of the livestock farming beneficiary households were also found in the food surplus category. Transitory food insecurity (15.2%) and chronic food insecurity (6.4%) for livestock keepers
17. Nedzingahe et al. [63]. Associations among Food Systems, Food Environments, Food Choices, Food Security, and Nutrition Transition in Limpopo Province, South Africa: A Cross-Sectional Study.	HDDSHFIASCSI	Household	Limpopo ProvinceCapricorn, Mopane & Vhembe districts	A cross-sectional study investigated the influence of food systems and environments on households' food choices and nutrition transition in Limpopo province. A systematically selected sample of 429 households was used.	About 48.4% had a low DDS score (score of 4 to 7), and 19.2% had a medium score (score of 8 to 11). Households with an adequate score (12 to 13) were 0.2%, and those with an excellent score (14–17) were 24.3%. The mostly used coping strategies were relying on less preferred and less expensive foods (31.3%), reducing portion sizes (23.1%), and limiting portion size at mealtimes (22.4%). Average HFIAS score was 4 and almost half of the households were food secure, with only 4.0% of households experiencing severe food insecurity.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
18.Buhta & Musara [64] Diversity of Food Insecurity Coping Strategies among Livestock Farmers in Northern Cape Province of South Africa	HFIAS	Household	Northern Cape	A mixed methods approach was utilized on 217 smallholder livestock farmers in the Northern Cape province of South Africa. The Northern Cape Province, Frances Baard district municipality, and the four local municipalities, namely, Dikgatlong, Magareng, Phokwane, and Sol Plaatje, were purposively selected	Most households were relatively or mildly food secure. Pokwane and DiKgatlong households had moderate to high diversity and accounted for 9% and 15.6% of food-secure households, respectively. The contributions were reported as 11.55% and 11.9% for the mildly food-insecure category in the same diversity clusters and locations. Sol Platjiaa and Mgareng had low levels of coping strategies and diversity. Cases of severe food insecurity were approximately 4% and 1% of households reporting moderate to severe food insecurity, respectively
19. Jilajila et al. [65] An Analysis of the Prevalence and Factors Influencing Food Insecurity among University Students Participating in Alcohol Consumption in KwaZulu-Natal Province.	HFIAS	Household	KZN UKZNDUTUNIZULUMUT	Data were collected from 156 student respondents from the University of KwaZulu-Natal, Durban University of Technology, Mangosuthu University of Technology, and the University of Zululand.	1.79% reported themselves as food secure, while the remainder reported varying levels of food insecurity, with 17.31% of students being food insecure, 16.03% mildly food insecure, and 44.87% severely food insecure. On the other hand, a prevalence of 73.08% ($n = 114$) of alcohol consumption was found among the sampled students.
20. Bhebhe et al. [66] The Contribution of Trees and Green Spaces to Household Food Security in eThekwini Metro, KwaZulu-Natal	HFIAS	Household	KZNeThekwini	This study sought to investigate the contribution of trees and green spaces to household food security in eThekwini. A sample of 280 households met the inclusion criteria and consented to participate in this study by responding to questionnaires.	Results revealed that only 29% of the respondents were food secure, 36% were mildly food insecure, 27% were moderately, and 8% were severely food insecure. Non-cultivated green spaces, local trees, age, marital status, number of dependents, and monthly income positively correlated with food insecurity.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
21. Mazenda et al. [67]Household-level determinants of food security in the City of Tshwane, South Africa	HFIAS	Household	Gauteng Tshwane (Pretoria)	A sample comprising 775 households from the 7 regions of Tshwane was drawn through a primary field survey, and a total of 73 clusters were selected. Systematic household sample with an erratic start-up of 15 households per cluster	The study found that 39.2% of the households were food secure, 16.6% suffered from mild food insecurity, 12.1% were moderately, and 32.1% were severely food insecure. Food security was significantly more prevalent in male-headed households, households with younger members, households with educated heads, and employed households. Household size and income were also determinants of food security.
22. Chari et al. [68] Determinants of Food Access in Raymond Mhlaba Local Municipality, South Africa	HFIAS	Household	Eastern Cape Raymond Mhlaba Local Municipality	a comprehensive household survey of 117 households from Mavuso community within South Africa's Raymond Mhlaba Local Municipality (RMLM).	Outcomes disclosed that factors determining household food security status were age, education status, food gardening, indigenous knowledge, and remittances. Hence, to assist in boosting food security, the study recommends that priority be centered on the reflected vital institutional and socio-economic aspects that serve as a basis for advanced studies and proactive action on augmenting food security for sustainability
23. Harper et al. [49] Dietary diversity, food insecurityand the double burden of-malnutrition among children,adolescents and adults in South Africa: Findings from a national survey	HDDSHFIASFE	Household	National scope	The study utilized cross-sectional data from the South African National Income Dynamics Survey NIDS (2008). The SANIDS is a nationally representative panel survey of over 28,000 individuals in 7,300 households across South Africa. A stratified, two-stage cluster sample design was used to sample the households included in the first wave (2008).	The prevalence of low dietary diversity was only 3.9% in this sample, which likely contributed to the null finding. Medium nutritional diversity and food expenditure >60% of monthly spending were associated with stunting among the adolescent group. None of the experiential indicators (child hunger and household food insufficiency) were associated with stunting. Medium dietary diversity and child hunger were associated with wasting in children <5.years.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
24. Mkhize & Sibanda. [69] Food Insecurity in the Informal Settlements of Inanda Households Living with Children under 60 Months in Ethekwini Municipality	HFIASHDDS	Household	KZNeThekwiniInanda	This study assessed the food security status of households living with children under 60 months in the informal settlements. It employed a cross-sectional quantitative research approach, using a non-probability sampling method to obtain a sample size of 160 households with children under five.	HFIAS analysis showed that approximately 34%, 31%, and 28% were severely, mildly, and moderately food insecure, respectively. In contrast, approximately 8% of the informal households were food secure. The HDDS analysis revealed that approximately 77%) of the informal households had low dietary diversity (food insecure). Cereal, roots, and fatty foods were the main dietary components in the informal settlements of Inanda
25. Abegunde et al. [70] Effect of climate-smart agriculture on household food security in small-scale production systems: A micro-level analysis from South Africa	HDDSFCS	Household	KZNKing Cetshwayo District	The area was selected using a multi-stage sampling technique. Villages in the two selected municipalities were sampled using the villages recorded in both municipalities. A confidence level of 95 percent gave a sample size of 327 from 2160 small-scale farming households, comprising 720 households from Mthonjaneni and 1 440 from uMhlathuze.	About 38.2% of the households had high dietary diversity, 37.6% had medium dietary diversity and 24.2% experienced low dietary diversity. The mean HDDS was 5.53±2.35. Based on food consumption score, most of the sampled households in Mthonjaneni (80%), uMhlathuze (81%) and KCDM (80%) had acceptable food consumption score. Only 3 percent of the sampled households in Mthonjaneni and KCDM had inadequate food consumption, while 4 percent in uMhlathuze had inadequate food consumption.
26. Odelwag-Theron & Egal [34].Is food insecurity a problem among the elderly in Sharpeville, South Africa?	HFIASHDDS	Household	GautengSharpeville	This study considered 146 surviving participants from a cohort study that, at the baseline in 2004, included 368 free-living elderly people from a daycare center in Sharpeville, an urban settlement in the Gauteng province. All the respondents were homogeneous in age (≥60 years) and race (black) and state pensioners.	The HFIAS results show that 67% were food secure, 10% were moderately food insecure, 19% were mildly food insecure, and a paltry 4% were severely food insecure. The median HDDS for the total group was 7.5. This reflected high food variety (6–9 food groups). Although the HDDS was high, poor variety within the nine food groups was evident.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
27. Jesson et al. [71].Food insecurity and depression: A cross-sectional study of a multi-site urban youth cohort in Durban and Soweto, South Africa	HHS	Household	KZN (Durban) &Gauteng (Soweto)	A cross-sectional study was used, and 422 participants aged 16–24, living in Soweto or Durban and self-reporting an HIV-negative or unknown status, were enrolled in AYA-ZAZI. In Soweto, the study was conducted within the Perinatal HIV Research Unit (PHRU) between November 2014 and April 2015. In Durban, the cohort was based at the Match Research Unit (MRU), and study participants were enrolled between September 2015 and April 2016.	Overall, 18% were food insecure, with participants reporting moderate (12%) or severe (6%) hunger. The mean HHS score was 0.73 (SD 1.62). There were 23% of participants answered positively to the first question (no food to eat in your house because there was no money to get food), 14% to the second question (go to sleep at night hungry), and 11% to the third question (a whole day and night without eating anything). In this cross-sectional analysis, 18% of youth living in two South African urban settings were food insecure.
28. Horwood et al. [72].Addressing the interaction between food security, depression risk, and informalwork: Findings of a cross-sectional survey of informal women workers with young children in South Africa	HFIAS	Household	Clinics in Durban townships, KZN	A sample size of 192 women (96 with children aged < 1 year and 96 with children aged 12–35 months). A cross-sectional survey explored work setting and conditions, food security, and risk of depression among informal working women with young children (0–3 years). Household food security was scored on a scale of 0–27, where 27 is the most food insecure, using the established and validated scoring for this tool	Less than half of the women were designated as food secure (42.3%). Some participants experienced mild food insecurity (14.3%). Nearly 30% of participants had moderate food insecurity (27.2%). Further,16% of participants had severe food insecurity. 24.0% of participants with an income < R1 000 were severely food insecure, compared to 14.8% of participants with an income of R1 000–3 000 and 5.4% of participants with an income over R3 000.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
29. Clarke [73] Caregivers' Knowledge and Food Accessibility Contributes to Childhood Malnutrition: A Case Study of Dora Nginza Hospital	HFIAS	Household	Eastern Cape, Nelson Mandela Bay metro. Dora Nginza Hospital,	A cross-sectional study of a sample (n = 184) of caregiver-child pairs was used. The researcher and a trained research assistant completed a structured questionnaire that included socio-economic factors, health status, household food security, and caregiver knowledge.	The results also show that only 33.2% of households were food secure, 29.3% were at risk of hunger, and 37.5% experienced hunger. The prevalence of stunting, underweight, and wasting among children in the study was high.
30. Battersby [74]. Beyond the food desert: finding ways to speak about urban food security in South Africa	HFIASHDDSMAHFP	Household	Cape Town: Ocean View,Philippi)	A cross-sectional survey on 1060 households sampled in Cape Town. Food security	80% of the households were either moderately or severely food insecure Ocean View, Ward 34, Ward 95, and Kipplaat had 45%, 71%, 80%, and 69% severe food insecurity, respectively. 50% experienced food shortages in January and June, while the least was about 20% recorded in November and December. The mean household dietary diversity was 6.75 out of 12,9, which is not too limited.
31. Chwe Sabi et al. [75] Students' vulnerability and perceptions of food insecurity at the University of KwaZulu-Natal	HFIAS	Household	KZN,University of KwaZulu Natal (UKZN)	A cross-sectional quantitative survey was undertaken at UKZN. Participants were recruited on the five campuses to target 1% (n = 500) of full-time students from the sampling frame of 43,283 registered students in 2015. The 1% was arrived at using two sampling techniques, i.e., oversampling and quotasampling.	Vulnerability to severe FI was more prevalent among the NSFAS-sponsored students (n = 96), as 48.1% of these students had no food due to a lack of resources, 39.6% of them went to bed hungry, and nearly 28% of these stayed hungry for the whole day and night due to food insufficiency.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
32. Bahta et al. [35]. Does women's empowerment through policy intervention reduce food insecurity in South Africa?	HFIAS	Household	Gauteng, Johannesburg, Ekurhuleni, West Rand, and Sedibeng.	A multi-stage sampling was used, where the homestead food garden program was implemented. Four municipalities were selected using simple random sampling: Johannesburg, Ekurhuleni, West Rand, and Sedibeng. 23 participating and 49 non-participating women from Ekurhuleni and 19 participating and 17 non-participating women from Sedibeng were used in the analysis. Thus, 79 women participants and 128 non-participants were utilized in the analysis study.	average HFIAS index for the respondents was 1.401, suggesting a higher level of food insecurity among the women. The average average. 57% of the respondents were food insecure, while 43% were food secure. The mean HFIAS for the participants was 2.28, and that of the non-participants was 6.52, This demonstrates the severity of food insecurity among non-participants in the program.
33. Maziya et al. [76] What factors determine household food security among smallholder farmers? Insights from Msinga, KwaZulu-Natal, South Africa	HFIAS	Household	KZN,Msinga Local Municipality	Primary data was obtained from surveys in the Tugela Ferry irrigation scheme and the Machunwini area, where farmers practice dryland farming. structured questionnaire administered to 250 randomly selected farmers (irrigators and non-irrigators)	A high proportion (45% irrigators and 47% non-irrigators) of households in Msinga were moderately food insecure. Respectively, 8% and 6% of irrigators and non-irrigators were food secure. Non-irrigators had a high proportion (29%) of severely food insecure households compared to 23% of irrigators.
34. Napier et al. [77] Predictors of food insecurity and coping strategies of women asylum seekersand refugees in Durban, South Africa	HFIASCSIFSC	Household	KZNDurban city	A mixed method a cross-sectional survey assessed the prevalence of household food insecurity and the association between food insecurity and coping strategies among women asylum seekers and refugees in the city of Durban. Women (n=200) were selected as the study sample	Mean CSI was 50.6 ± 34.8 and ranged from 0.0 to 171.0. Only 8% of the women were food secure compared to 46.5%, 45.0%, and 0.5% who were mildly, moderately, and severely food insecure, respectively. Most households used all the coping strategies identified by the respondents except for sending young children to eat at the local refugee preschool (45.0%).

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
35. Oldegwage-Theorn & Kruger [78]. Dietary diversity and adequacy of women caregivers in a peri-urban informal settlement in South Africa	HDDS	Household	South Africa"X"Peri-Urban informal settlement	This integrated nutrition study investigated food and dietary intake variables in 357 randomly selected households (28%) in an informal settlement. In households where the grandmother was present, the mother and the grandmother (n=426) were interviewed for dietary intake and diversification data	individual food items consumed in 7 days was 40, indicating a medium variety. However, 0–8 food groups consumed the indicating an inferior variety. 3.3% of respondents did not consume any food items from the nutritious food groups during the 7 days, surviving only on tea with sugar. Only two people consumed the widest variety of eight foods, while many respondents (34.5%) consumed only three food items in 7 days.80.9%) consumed only 2–4 individual foods in 7 days indicating poor dietary diversity,
36. Devereux & Tavener-Smith [79]. Seasonal Food Insecurity among Farm Workers in the Northern Cape, South Africa	HFIASHDDSCSIMAHFP	Household	Northern Cape	A structured questionnaire was designed and administered to approximately 200 female farm workers in the Northern Cape province of South Africa in September 2017 and again (with modifications) in October 2018.	Dietary diversity (HDDS) was lower in winter than in summer but lowest in autumn. Almost 53 percent of the sample reported low dietary diversity in autumn, compared to 4.77 percent in summer. There were five months when it was relatively high (>20 percent). February and March, the summer harvest season, recorded the lowest prevalence (just 10 percent of the sample).
37. Msaki & Hendriks [80] Do Food Quality and Food Quantity Talk the Same?Lesson From Household Food Security Study inEmbo, South Africa	HFI	Household	KZNMbumbulu district (Embo)	A survey (n = 200) exploring food diversity, quality of foods, and their relation to food intake in Embo, a poor farming community in rural KZN, was carried out in November 2004 (period of insufficiency) and repeated in March 2005 (period of plenty). Household food intake strata were developed using matrices from the Household Food Intake Index and nutritional adequacy ratios.	Household Food Intake Index was found to be as efficientas the nutrient adequacy ratios in food intake and its relationship to diversity during the period of insufficiency (November 2004) compared to periods of plenty (March 2005). Starches were the most diverse food group in both rounds, at 6.80(7) and 8.67(9). varieties of starch foods for the first and second rounds, respectively.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
38. Msaki & Hendricks [81]. Measuring Household Food Security Using Food Intake Indicators in Rural Kwazulu Natal, South Africa	HDDS	Household	KZNMbumbula district	The study was done in KZN,in November 2004 and March 2005. Specifically, in Embo, and Mbumbula districts. Two consecutive household surveys (n = 200) were conducted in November 2004 and March 2005 with female household heads only.	Food diversity was almost equal among the household food intake strata in both rounds. In the first round (November 2004), households with moderate food intake did not fulfil energy, protein, iron, vitamin A, and E requirements. Still, they fulfilled energy and micronutrient requirements in the second round (March 2005). Cereals have been a key energy source and iron, while legumes were the key protein sources. Vegetables were key sources of iron and vitamin A. Fats were the major source of vitamin E in both rounds.
39. Musemwa et al [82]. Household food insecurity in the poorest province of South Africa: level, causes and coping strategies	HFIAS	Household	Eastern CapeAmatole and Chris Hani DistrictMunicipalities	For this study, households in Nkonkobe and Tsolwani Local Municipality under the Amatole and Chris Hani District Municipalities, respectively, were randomly selected. A sample of 70 and 80 households were randomly selected from Tsolwani and Nkonkobe local municipalities, respectively, using a multi-staged random technique.	The average HFIAS for the sample was 12.41 and ranged from 0 to 27 (higher scores implying greater food insecurity). Most (68 %) of the interviewed households were severely food insecure, whereas the moderately food-secure and mildly food-insecure households were 24%, 4%, and 4%, respectively.
40. Baiyegunhi et al. [83] Mopane worm (Imbrasia belina) and rural household food security in Limpopo province, South Africa	HFIAS	Household	LimpopoMopani district, Greater Giyani & Greater Letaba municipalities	Four villages within the Greater Giyani and Greater Letaba local municipalities were randomly selected for this study. These villages represent the wider rural population in Mopani district and Limpopo province. Household surveys and participatory groups interviews were conducted with a total of 120 households (by randomly selecting 30 respondent households per village).	Most of the sampled households (61.7 %) consume mopane worms at least 3 to 5 times a week, indicating their importance to household food security in the region. About 15.8 % of sampled households were food secure, while 9.1 %, 23.3 %, and 51.7 % were mildly, moderately, and severely food insecure, respectively. This shows that 84.1 % of the sampled households are affected by one or other form of food insecurity.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
41. Grobler [84]. Factors influencing urban household food insecurity in Low-income neighborhood in South Africa	HFIAS	Household	Gauteng, Vaal region, Bophelong & Sharpveile	The study was a cross-sectional design conducted in two low-income areas, Bophelong and Sharpeville, in the Vaal region. A sample of 580 households was interviewed.	Results show that households spending more on food depict a low HFIAS score. Employment status is also positively correlated with a lower HFIAS score, meaning employment influences food security. Also, as the household income increases, the HFIAS score decreases.
42. Sharaunga et al. [85] Effects of 'women empowerment' on household food security in rural KwaZulu-Natal province	HFIAS	Household	KZN, Msinga Local Municipality	This study uses the Household Food Insecurity Access Scale (HFIAS) to identify the food security status of 300 primary female-headed households in Msinga, municipality, KZN, South Africa.	Most female-headed households (43.0%) in the study area were severely food insecure, while a few (19.0%) were food secure. Food-secure households also had the highest proportion (30.4%) of primary female heads of households with formally employed husbands.
43. Shishanya & Mafongoya [86] Adaptation to climate change and the impacts on household food security among rural farmers in uMzinyathi District of Kwazulu-Natal, South Africa	HFIAS	Household	KZN, uMzinyathi	Quantitative data was collected in uMzinyathi District Municipality through a questionnaire among 200 households out of approximately 6500 households involved in subsistence agriculture. Sub-samples of 44, 54, 46, 35, and 21 households were randomly selected from five wards.	Of those assessed, 97 % were severely food insecure, and the remaining 3% were moderately food insecure. Householders who were vulnerable to climate change recorded high levels of food insecurity. Declines in prices of farm products increases in costs of farm inputs, and anxiety over the occurrence of livestock diseases exacerbated household food insecurity.
44. Roisin et al [87]. Adapting the Coping Strategies Index to measure food insecurity in the rural district of iLembe,South Africa	CSI	Household	KZNiLembe District	This study was done in district of iLembe, in KwaZulu-Natal. Four FGDs took place in March 2017, one in each of the four sub-districts of iLembe..	The overall CSI was 42, indicating moderate food insecurity among households. The high coping strategies were limiting portion size of meals, relying on less preferred and less expensive foods, and restricting consumption by adults for children to eat. The coping strategies with the highest severity score included going an entire day without eating, consuming seed stock, sending a child to eat elsewhere, and restricting food for working household members.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
45. Khumalo & Sibanda [88]. Does Urban and Peri-Urban Agriculture Contribute to Household Food Security? An Assessment of the Food Security Status of Households in Tongaat,eThekwini Municipality	HFIASHDDS	Household	KZNeThekwini Municipality	The study adopted a quantitative research approach. It was conducted in the Tongaat peri-urban area within the eThekwini Municipality of KwaZulu-Natal Province. A selection of a total sample size of 208 respondents (that is, 109 and 99 UPA and non-UPA practicing households, respectively)	Results from both groups (the UPA and non-UPA) show that nearly half (about 48%) of the households were above the mean HDDS level. A majority (66%) did not or rarely worried about food shortages (deemed food secure). However, a higher (72%) proportion of the UPA practicing households did not or rarely worry about food shortages when compared to their counterparts, the non-UPA practicing households (61%) in the same HFIAS category
46. Dunga & Dunga [89]. An analysis of household food security: a case study of townships in Gauteng, South Africa	HFIAS	Household	Gauteng Urban townships	The study used primary data collected from townships around Gauteng in South Africa using a well-structured questionnaire on 587 household heads.	About 40% of the households were severely food insecure, over 30% were moderately food insecure, less than 10 % were mildly, and 20% were food secure. A higher percentage (52%) of those indicated as unemployed were found to be severely food insecure, whereas 33% were found to be severely food insecure. On the opposite, 27% of those who were employed were food-secure, while for those who were unemployed, only 11% were food-secure
47. Jonah & May. [90] The nexus between urbanization and food insecurity in South Africa: Does the type of dwelling matter?	HFIASHDDS	Household	National scope	A quantitative cross-sectional analysis was done. It combines descriptive charts and tables to estimate two binary regression models using the nationally representative 2017 South Africa General Household Survey. After generating all the variables, the final sample contains 12,361 urban households.	Households in formal dwellings recorded lower levels of food insecurity.19%, 35%, and 50% of formal, semi-formal, and informal households are considered food insecure when measured by the HDD. This compares with 7%, 19%, and 27% for formal, semi-formal, and informal households considered food insecure when measured by HFIAS, respectively. Households headed by blacks and coloreds recorded the highest levels of food insecurity, 21.20% and 22.25%, respectively, for the HFAIS scale and 40.29% and 28.29% for the HDD measure.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
48. Grobler [91]. Food Insecure Household Coping Strategies: The Case of a Low-Income Neighborhood in South Africa	CSIHFIAS	Household	Gauteng, Vaal, Bophelong	A Cross-sectional quantitative survey method was used, and a random sample of 300 households was interviewed using the face-to-face method in September 2013.	The highest mean of 1.9 days is indicated for relying on less expensive food, followed by 1.7 days for buying necessities and 1.1 days for sticking to a budget. The lowest mean was recorded for members sent to beg (0.14 days), sending members to eat elsewhere (0.20 days), and maintaining a food garden (0.38 days). About 57% reported severe food insecurity, with 25% being moderately food insecure and only a paltry 9% being food secure.
49. Mazenda et al. [92] Cities, Poverty and Food: The role of municipalities in enhancing food security	HDDS	Household	Gauteng,Tshwane (Pretoria)	A cross-section design was employed in which a proportion of the City of Tshwane's food insecure households drawn from the Statistics, South Africa, Community Survey were enumerated based on their choice of various food groups measured by the HDDI. The data sample for this study consisted of 775 households from the seven regions of the City of Tshwane1 subdivided into clusters.	The average dietary diversity score was 0.4 and 0.3 for all poor households in the City of Tshwane. Thus, the households were classified as having shallow dietary diversity (Simpson Index >/= 0.3) and low dietary diversity (Simpson Index < 0.4). The most popular HDD food group was cereal-related food, adopted by 53% of the households. This is followed by eating vegetables (18%), oils and fatty foods (8%), and the consumption of milk and milk products (5%).

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
50. Zondi et al. [93] Impact of Market Participation of Indigenous Crops on Household Food Security of Smallholder Farmers of South Africa	HFIAS	Household	Limpopo &Mpumalanga	This study analyzed the impact of market participation of Indigenous crops on the household food security of smallholder farmers in the Limpopo and Mpumalanga provinces of South Africa. A sample size of 209 Indigenous crop producers was selected from 1520 smallholder farmers, with 911 from Limpopo and 609 from Mpumalanga. The study adopted a multi-stage stratified random sampling technique. The data were collected using both qualitative and quantitative research.	Most households were moderately food insecure (38%), while 35% were mildly food insecure. More worryingly, 12% of the households were found to be severely food insecure, indicating severe problems relating to access to food in those surveyed households.
51. Masa & Sharma [40]. Invariance of the HouseholdFood Insecurity Access Scale Across Different Groups of Adolescents and Young Adults	HFIAS	Household	National scope (South Africa)	We analyzed cross-sectional quantitative data from 1437 and 4165 young South Africans and Ghanaians, respectively. The South African sample was a subset of youth who participated in a youth employability and financial capability project implemented in all 9 South African provinces. The average number of youths recruited and enrolled per site was 43. 1437 youth were between 15 and 24 years old.	The South African data observed a high prevalence of food insecurity, with 83% of youth (n =1180) reporting inadequate food access. Among youth from food-insecure households, 58% experienced severe food insecurity, 23% moderate food insecurity, and 19% mild food insecurity. The mean HFIAS score was 6.80 (SD = 6.47). South African youth were older (mean age = 21.91, SD = 1.77).

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
52. Ndhlovu et al. [94] Impact of value chain participation on household food insecurity among smallholder vegetable farmers in Swayimane KwaZulu-Natal	HFIAS	Household	KZN, Swayimane	Data collection using a survey questionnaire to obtain data on farmer profiles, value chain participation, and food security status was done with 51 smallholder farmers participating in agricultural value chains, mainly as producers and traders in rural Swayimane under Gcumisa Traditional Authority.	HFIAP was part of the HFIAS methodology; 66.7% of the farmers in the sample were food secure, 17.65% were mildly food insecure, 7.84% were moderately food insecure, and 7.84% were severely food insecure. The average HFIAS score for the sample was 7.21, which indicates that most of the households were food secure because the higher the score, the more food insecure a household becomes
53. Akinboade [95]. Correlates of access to ICT and food security of the poor in South Africa's Soshanguve	HFIAS	Household	Pretoria (Tshwane), Soshanguve	A cross-sectional survey targeting a sample size of 300 households was done.	About 50.3% of households in Soshanguve are food secure, 12.3% are mildly food insecure, about the same proportion are moderately food insecure (12.3%), and 26.3% are severely food insecure. There is a positive relationship between a household's food security status and the undertaking of ICT-related transactions for food security purposes. Food insecure households fall short of using landline telephony, of which demand is low in the slum area, and online food purchases using computers.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
54. Kehoe et al. [96] Food insecurity, diet quality, and body composition: data fromthe Healthy Life Trajectories Initiative (HeLTI) pilot survey in urban Soweto, South Africa	CCHIPHDDSMDD-W	CommunityHouseholdIndividual	GautengSoweto	The study uses data from the Soweto Young. Women's Health Survey was the screening and baseline data collection tool for the HeLTI study in Soweto. Household-level data collection was conducted in participants' homes. The young women were invited for individual-level data collection at the South African Medical Research Council SAMRC)/Wits Developmental Pathways for Health Research Unit, located within the Chris Hani Baragwanath Academic Hospital in Soweto (the largest hospital in the southern hemisphere).	Women who were the most miniature food secure had the least diverse diets, with 46% of food insecure women consuming diets in the lowest tertile of dietary diversity compared with 39% of those who were food secure. Food insecurity was also associated with lower diet quality.
55. Ndhleve et al [33] Household Food Security status and determinants: The Case of Botswana and South Africa	HFIAP/HFIAS	Household	Eastern Cape, OR Tambo, Chris Hani & Buffalo City	A cross-sectional survey design was employed with a semi-structured questionnaire tool. In South Africa, data was collected from households in two District Municipalities, namely OR Tambo (662), Chris Hani (640), and one Metropolitan Municipality (255) that is Buffalo City, all located in the Eastern Cape Province, giving a total of 1557	68% of the surveyed households were severely food insecure. Most of these households were from OR Tambo District (30.4%) and Chris Hani District (24.7%). Disaggregated by race, coloreds, and Whites are more food secure than Black Africans. Relative to black Africans, Coloreds are −1.543 less food insecure or −0.865 less likely to be food insecure, while Whites are −2.688 less insecure or −1.179 less likely (odds) to be food insecure.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
56. Lujabe et al. [97] Exploring the Food (In)Security Status of Suburban Households and Its Determinants during COVID-19	HFIAS	Housheold	Eastern Cape Nelson Mandela Bay Municipality, Ward 60	A Community-Based Participatory Action Research (CBPAR) approach was employed as the optimal design for guiding the broader studyThe questionnaire was used to collect data from 170 randomly selected households.	The results show that 6.1% of households are food secure, 3.05% are mildly food insecure, 13.4% are moderately food insecure, and 77.4% are severely food insecure. The results also show that a significant unemployment rate, a reliance on social grants, and an absence of income seriously impact the extent of household food insecurity. The words "many households go to sleep without food" became the typical expression of most residents.
57. Shishanya & Hendriks [31]. The contribution of community gardens to food security in the Maphephetheni Uplands	HFIAS	Household	KZN,Maphephetheni Uplands	The study was conducted in the Maphephetheni uplands, a rural area of KwaZulu-Natal, approximately 80 km west of Durban in the Valley of a Thousand Hills. Between May and June 2006, 53 households active in community gardens in the Maphephetheni Uplands participated in this study.	The average HFIAS score was 16.2. About 47 households were severely food insecure. 89% of the participants were severely food insecure, 7% moderately food insecure, and 4% were mildly food secure. None were food secure; instead, most of them were anxious and uncertain about food availability. They frequently used negative strategies that erode the possibility of improving their food security in the future. Generally, as household incomes increased, HFIAS scores decreased. Recipients of social grants were more food insecure on the HFIAS scale. Community gardens did not contribute significantly to household food security for 53 households participating in community gardening.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
58. Waidler & Devereux [98]. Social grants, remittances, and food security: does the source of income matter?	HDDSFE	Household	National scope	For this analysis, we used the National Income Dynamic Survey (NIDS), South Africa's first nationally representative panel survey, following more than 28,000 individuals over time. The first round was conducted in 2008, and subsequent rounds were carried out in 2010, 2012, and 2014.	very few individuals had a DDI lower than 4. The regression shows that recipients of the Older Person's Grant and remittances had higher probabilities of having a higher DDI. For instance, an increase in 100 Rands of both per capita remittances and OPG increased the probability of having a DDI of 12 by 1 % point. Remittances were positively associated with the DDI;
59. Rose & Charlton. [46] Quantitative Indicators from a Food Expenditure Survey Can Be Used to Target the Food Insecure in South Africa	FPLEA	HouseholdIndividual	National scope	Secondary data from the 1995 Income and Expenditure Survey (IES) with n=28 704.	Results showed that 43% of households were in food poverty in October 1995, and 55% had low energy availability. These indicators classified households into four groups: food poverty only, low energy availability only, food insecurity on both measures, and food security.
60. Kaschula [99] Using People to Cope with the Hunger: Social Networksand Food Transfers Amongst HIV/AIDS Afflicted Households in KwaZulu-Natal, South Africa	CSI	Household	KZNKwaDlangezwa	The study was conducted between 2006 and 2007 within the tribal authority of KwaDlangezwa. They recruited 34 households with 3–5 HIV/AIDS proxies, 33 households with 1–2 proxies, and 33 households with no proxies. Once recruited, households were visited at quarterly (3-month) intervals for 12 months	Households participating in the study reported high levels of food insecurity. At the end of the 4 assessments, all surveyed households had employed restrictive strategies such as skipping meals, limiting portions, and going to sleep hungry. Not surprisingly, poorer households were more food insecure. The use of donated foods by households was widespread but more prevalent in poorer households
61. Labadarios et al. [18]. Food security in South Africa: A review of national surveys	CCHIP	CommunityHousehold	National scope, South Africa	A systematic search of national surveys that used the Community Childhood Hunger Identification Project index to measure food security (access, availability, and utilization) in South Africa over 10 years (1999–2008) was done.	Children had low mean scores for dietary diversity (3.58; standard deviation, SD: ± 1.37) and dietary variety (5.52; SD: ± 2.54). The NFCS scores showed that stunting in children decreased from 21.6% in 1999 to 18% in 2005.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
62. Labadarios et al. [100] How diverse is the diet of adult South Africans?	HDDS	Household	National scope,South Africa	A cross-sectional study of adults from all specified ages, provinces, geographic localities, and socio-economic strata in South Africa was used (n = 3287). Dietary data was collected using a face-validated 24-hour recall, which was not quantified. A dietary diversity score (DDS) was calculated by counting each of the 9 food groups. A DDS <4 was regarded as reflecting poor dietary diversity and poor food security.	The provinces with the highest prevalence of poor dietary diversity (DDS <4) were Limpopo (61.8%) and the Eastern Cape (59.6%). By contrast, only 15.7% of participants in Western Cape had a low score. Participants in tribal areas (63.9%) and informal urban areas (55.7%) were the worst affected. The most consumed food groups were cereals/roots, meat/fish, dairy, and vegetables other than vitamin A. Eggs, legumes, and vitamin A-rich fruit and vegetables were the least consumed. Overall, most South Africans consumed a diet low in dietary variety. The tribal and informal urban areas were worst affected; eggs, legumes, and vitamin A-rich fruits and vegetables were the least consumed.
63. Oldewage-Theron et al. [101] Poverty, household food insecurity and nutrition:Coping strategies in an informal settlement in theVaal Triangle, South Africa	CSI	Household	GautengJohannesburg Vaal Triangle	Pre-tested socio-demographic questionnaires were administered to 357 randomly selected caregivers and 149 children aged 9–13. A validated quantified food frequency questionnaire (QFFQ) and 24-h recall were used to measure dietary intake and food consumption patterns and the Cornell hunger scale to determine coping strategies.	Coping strategies that were employed by the female caregivers in the households were procuring and cooking a limited variety of foods (82.1% during the last 30 days and 74.7% during the last 5 days), maternal buffering by limiting the caregiver's intake to make food available for the children (84.7% during the last 30 days and 80% during the last 5 days), skipping of meals (81.6% during the last 30 days and 68.4% during the last 5 days), and limiting portion sizes (84.7% during the last 30 days and 75.8% during the last 5 days). Close to 78.4% of the children in the households (n=190) experienced hunger when going to sleep at night during the preceding 30 days and 73.7% during the last 5 days

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
64. Kaschula [37]. Wild foods and household food security responses to AIDS: evidence from South Africa	HDDS	Household	KZNMsunduzi district	The research was conducted in two sites in KZN province between June 2005 and July 2006 in the Msunduzi district, among the peri-urban settlements of KwaHaza, Mpophomeni, Okhalweni, and Nadi. FGDs and interviews were used to explore the use of natural resources influenced by changes in vulnerability, specifically shock events, poverty, and AIDS. HDDS from 227 households, combined with qualitative work, explored the association of household AIDS proxies (recent morbidity, mortality, and orphan fostering) with household food security and dietary composition.	Prevalence of wild foods in the 48 h HDDS was 50.2% in site 1 and 30.3% in site 2, with a mean of 40.3% across sites. Wild leafy vegetables were by far the most frequently consumed uncultivated foods within the 48-h reference period, of which most were naturalized weeds such as Amaranthus spp and *Bidens pilosa* (blackjack)
65. Oldewage-Theron& Kruger [102]Food Variety and Dietary Diversity as Indicators of the Dietary Adequacy and Health Status of an Elderly Population in Sharpeville, South Africa	HDDS	Household	GautengSharpeville	This cross-sectional, analytical study was a comprehensive health assessment focusing on the dietary quality of 170 randomly selected elderly respondents in Sharpeville, South Africa. The data collection methods included 169 (153 women and 16 men) sociodemographic and health questionnaires, 139 (113 women and 26 men) 24-hour dietary recalls, and 149 food frequency questionnaires (FFQ).	The low mean _ standard deviation (SD) dietary diversity score (3.41±1.34) and food variety score (4.77±2.2) compared with poverty parameters confirmed household food insecurity in this community. Although three (n= 99, 58.6%) or two (n= 49, 28.9%) daily meals were mostly consumed, these were mainly carbohydrate-based and nutrient-deficient. The cereal group (2.01±0.81) had the highest mean food variety score _SD, followed by dairy (0.62 ± 0.53) and flesh foods (0.40 ± 0.53). the results showed that food variety and dietary diversity scores give a good assessment of the adequacy of the diet,

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
66. Akinyi Oketch [103]. Too little, too late: Comparison of nutritional status and quality of life of nutrition care and support recipient and non-recipients among HIV-positive adults in KwaZulu-Natal, South Africa	HFIASHDDS	Household	KZNInformal semi-urban settlement (France)Sweetwaters (Rural)	In 2009, a household base cross-sectional study of HIV-positive adults, NCS recipients (n = 97), and non-recipients (n = 203) living in an informal semi-urban settlement (France) and rural area (Sweetwater's) in KwaZulu-Natal, South Africa. The participants were sampled from the support group service list. Individuals who were <18 years old, pregnant/lactating, bedridden, and having severe anxiety/depression were excluded. Of the 300 participants included in the study, 84% (n = 252) were females.	The prevalence of food insecurity measured by HFIAS was 70% (n = 210). DDS did not differ significantly between the two groups, where diets were predominantly cereals and fats/oils. Sugars and beverages were consumed by >50% of the participants in the medium and high DDS tertiles. In addition, vegetables and meat were consumed by >50% of participants in the high DDS tertiles.
67. Kirkland et al. [104]. Toward Improved Understanding of Food Security	HDDSCSI	Household	MpumalangaBushbuckridge	A cross-sectional study surveyed 290 households to develop detailed food security measures. HDDS and CSI were used as indicators of food security	About 91 percent of households indicated that the respondent skipped an entire day of food (*skipped a whole day*) and also reported reducing the amount of food served to men (reduce amt. men). Another example: 83% of households that reported running out of food (*run out*) also worried about having enough food (*worried*) in the last 30 days. These associations (and the others noted in Table 4 as statistically significant) indicate that many measures overlap significantly in identifying food-insecure households.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
68. De Cock et al. [42] Food security in rural areas of Limpopo Province, South Africa	HFIASHDDSMAHFPFELEAFP	Household	Limpopo province Mopani districtVhembe districtCapricorn districtWaterberg districtSekhukhune district	A two-stage stratified approach with quota sampling was used to collect household data in July/August 2011. Two municipalities were selected from each of the five municipal districts of the province based on cost and the municipality's location. Within each municipality, 60 households were surveyed, totalling 600 households (one household was dropped from the analysis)	Using HFIAS, 14.8 % of the people in the sample were food secure, 5.8 % were mildly food insecure, 26.4 % were moderately food insecure, and 53.1 % were severely food insecure and an average HDDS of 4.5 out of the nine food groups. Maize products had the highest frequency, with a mean consumption of 6.7 in 7 days. The largest share of food-secure households was in Sekhukhune, while the largest share of food-insecure households was in Waterberg. Maruleng, a municipality in the Mopani district, also had many severely food-insecure households (65%). Mopani district was the poorest district when average income levels ranged between 1 and 4 months, with the most significant number of households experiencing one (13.2 %) or two (10.2 %) months of hunger. Waterberg presented the highest average number of months (3.1) when people faced hunger. Households could provide themselves with adequate food for 10.28 months on average. Also, 538 households had an LEA<1, indicating that 90 % have an energy intake below their energy requirements. The LEA of households in Limpopo province was 0.57, and the average FP was 1.15. Of the 599 households, 437had an FP<1, meaning that their food expenditure is smaller than the price of an adequate food basket for the household

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
69. Ngidi & Hendriks [44].Coping with Food Insecurity in Rural South Africa: The Case of Jozini, KwaZulu-Natal	CSI	Household	KZNJozini	survey (n=138) was conducted in June 2013 (winter) as part of a multi-purpose study to assess the current rain-fed and irrigated production of food crops and its potential to meet all year-round nutritional requirements of rural poor people in Jozini. Quantitative data was collected through household surveys and qualitative data was collected through Focus Group Discussions (FGDs).	Five coping strategies were employed during severe situations. The most employed strategy was relying on help from friends or relatives for food. Three strategies were employed during moderately severe situations. The most used strategy was relying on less preferred or less expensive foods. Only one strategy was undertaken during the least severe situations, suggesting that communities view their hunger period coping strategies as not so good.
70. Hendriks et al. [9] What are we measuring? Comparison of household food security indicators in the Eastern Cape Province, South Africa	HFIASHDDSFCSHHSCSIMIHFPEoHmCAF	Household	Eastern Cape, KZN, Limpopo, North West	A cross-sectional survey was conducted. Data for this study were drawn from a survey of food consumption and production patterns in the poorest rural districts of four provinces. Two-panel surveys were conducted at each site—one in the drier and less agriculturally productive winter months and one in the summer months. This article reports on data from the OR Tambo district in the Eastern Cape sample, which was surveyed in October 2013 (summer) and July 2014 (winter). The paper compares food security indicators across the summer and winter seasons in the Eastern Cape Province.	The key findings suggest that food security and nutrition indicators must be used or linked to provide a clear understanding of South Africa's food security status.A key finding is that only anthropometric measurements are sensitive to different levels of food insecurity across seasons and areas.The results show that it is essential to use measures that reflect the situation according to reports of consumption and experience of hunger and measures that reflect the outcomes of food insecurity; that is, anthropometric measures. I

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
71. Kruger et al. [43] Food-coping strategy index applied to a community offarm-worker households in South Africa	CSI	Household	GautengOrange farm	A quantitative research approach was used, which included a cross-sectional survey throughout five seasonal periods. The total sample included 13 women from 13 households, consisting of only the women available for all five seasons of the study.	The FCS most employed during the different seasons include relying on less preferred food or cheap food and gathering wild food, which are the two most common strategies during all seasons. Consumption of seed stock mainly occurred during the early summer and the winter when food availability was poor. Portion sizes were reduced mainly in the winter and the late summer. Food was bought on credit mainly in the late summer and spring, when wild leafy vegetables are less available, and food crops cannot be harvested
72. Walsh & Van Rooyen [105] Household food security and hunger in rural and urban communities in the Free State Province, South Africa	CCHIP	CommunityHousehold	Free State	A cross-sectional descriptive study was undertaken in Free State Province. The rural study commenced in 2007 in three rural Free State areas, namely Trompsburg, Philippolis, and Springfontein, and the urban study commenced in 2009 in Mangaung. Asample of 886 households was studied in rural and urban Free State Province,	In urban households, 87.4% were classified as high-risk households. In urban areas, 81% of households reported a food shortage at the time of the survey, significantly more than in rural households, where 46% reported a current food shortage. As expected, nearly ¾ or more of households ran out of money to buy food. More urban households reported running out of money to buy food (88% urban 73% rural), relying on a limited number of foods to feed their children (67% urban; 29% rural), cutting on the size of meals or skipping meals (77% urban; 72% rural) and giving children less food than they wanted (62% urban; 21% rural). In 59% of urban and 18% of rural households the family reported that children complained of hunger.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
73. Swanepoel & Van Niekerk [106] The level of household food security of urban farming and non-farming households in the informal settlement area of the Cape Town metropole in South Africa	HFIASHDDSMAHFPFPEA	Household	Western CapeCape Town Metropolitan city	The study was conducted in the informal settlement areas of the Cape Town Metropole of the Western Cape in South Africa. Initiatives like urban household and community food gardens implemented by the Farmer Support and Development Division of the Western Cape Department of Agriculture. These were Gugulethu; Khayelitsha; Mitchells' Plain; Philippi, Kraaifontein & Bonteheuwel. the social and economic aspects of FS at the household level, and the identification of the factors influencing FS at the household level by including the four major FS components, namely food availability, food accessibility, food utilization, and food system stability. A total of 223 surveys were completed, and three were eliminated due to outlying values, resulting in 220 households that were analyzed.	HFIAS shows that 77.7% of households are severely food insecure. Regarding the food poverty lines, just over 50% earn more than US$ 2 per capita per day, while 20.9% of the households are below the critical point of US$ 1.25 per capita per day. The average household expenditure on food is R338.26, while 52.5% is spent on food (share of expenditure spent). Kraaifontein and Philippi also experience severe food insecurity, with levels over 80%. Gugulethu and Khayelitsha have the lowest levels of severe food insecurity, with 66.7% and 68.4%, respectively; Mitchells Plain (11.7) and Gugulethu (11.1) have the highest HDDS, while Bonteheuwel has a much lower HDDS of 9.3. This indicates that the Bonteheuwel area experiences higher levels of food insecurity. The highest values were calculated for the region between 8 and 12 on the HDDS, which was 61.3%. The average number of hungry months experienced by households in the Cape Town Metropole was 4.3 during the previous 12 months.
74. Shisana et al. [5] South African National Health and Nutrition Examination Survey (SANHANES-1)	CCHIP	Community Household	National	The primary objectives of the SANHANES-1 were to assess defined aspects of the health and nutritional status of South Africans concerning the prevalence of NCDs (specifically cardiovascular disease, diabetes and hypertension) and their risk factors (diet, physical activity and tobacco use)	CCHIP showed that 45.5% of the households in South Africa are food insecure.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
75. Chakona & Shackleton [107] Minimum Dietary Diversity Scores for Women Indicate Micronutrient Adequacy and Food Insecurity Status in South African Towns	MDD-W	Individual	KZNDundee; Harrsmith and Richards Bay towns	The present study considered the diets, dietary diversity, and food security of women aged 15–49 along the rural-urban continuum in three South African towns situated along an agroecological gradient. A 48-hour dietary recall was conducted across two seasons with 554 women from rural, peri-urban, and urban locations of Richards Bay, Dundee, and Harrismith.	The mean (sd) MDD-W for Richards Bay (3.78± 0.07) was significantly higher than at Dundee (3.21 ± 0.08) and Harrismith (3.36±0.07). Food security and MDD-W were significantly higher in urban locations than in peri-urban or rural ones. There was a lower dependence on food purchasing in Richards Bay compared to Dundee and Harrismith. Most women in Richards Bay practiced subsistence agriculture, produced a surplus for sale, and collected wild foods, improving dietary intake and food security. The peri-urban populations had limited dietary intake and were more food insecure because of high levels of poverty, unemployment, and lack of land.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
76. Chakona & Shackleton [41] Household food insecurity along an agro-ecological gradient influences children's nutritional status in South Africa	HFIASHDDS	Household	KZNDundee; Harrsmith and Richards Bay towns	A cross-sectional study (n=554) to examine household food insecurity, dietary diversity, and child nutritional status locally, which influences access to and ability to grow food in South Africa, and explore the links and associations between these and household socioeconomic status. The Household Dietary Diversity Scores (HDDS) and the Household Food Insecurity Access Scale (HFIAS) tools were used to measure household dietary diversity and food insecurity along the urban, peri-urban, and rural continuum. Only 183 individuals in Richards Bay, 173 in Dundee, and 198 in Harrismith agreed to participate in the interviews. Interviews were conducted twice with the same individual [pre-harvest period (October and November 2014) and post-harvest period (June 2015)]	The HFIAS was generally low in all towns, with a mean of 7.07 ±7.06 for the sample. About 36% of the households were food secure, 24% were mildly food insecure, 28% were moderately, and 12% were severely food insecure. The level of household food access was high in Richards Bay, with the lowest HFIAS score of 5.57± 6.98, and food access was low in Dundee, which had the highest HFIAS of 9.39±7.13. There was a significant difference in HFIAS along the agroecological gradient, with Dundee being more food insecure than the other two, which were not significantly different. Within sites, mean HFIAS ranged from 6.74 ± 6.21 to 9.45 ± 6.67 in the rural location, 5.49±6.89 to 11.37±7.19 in the peri-urban location, and 3.02±6.29 to 5.37±6.49 in the urban location. The lowest mean HFIAS was recorded in Richards Bay urban and the highest in Dundee's peri-urban location. The urban population in all three towns was more food secure than the rural and peri-urban populations.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
77. McLaren et al. [108] Food insecurity, social welfare, and low birth weight: Implications for childhood malnutrition in an urban Eastern Cape Province township	CCHIP	Community	Eastern Cape	The study's main objective was to describe malnutrition in the context of food insecurity, child support grant (CSG) and Low Birth Weight (LBW) history among children younger than 24 months from an underprivileged urban settlement in the Eastern Cape Province of SA. A cross-sectional design descriptive study was used to collect data from a non-probability sample of 400 young children. The Community Childhood Hunger Identification Project index and anthropometric measures were taken from children.	Of the sample, 9% were stunted, 1% were wasted, 16% were overweight, 23% were food secure, 47% were at risk of hunger, and 31% were classified as hungry. CSG holders and 'hungry' households' children had significantly lower mean height-for-age z-scores (HAZ) than non-CSG holders and food-secure households. Despite these apparent associations, when LBW is considered a covariate, it becomes apparent that neither the CSG nor CCHIP category is significantly related to anthropometric indicators. This study was limited to a township in the Eastern Cape province and used only one Food Security Indicator (CCHIP).
78. Megbowon & Mushunje [47] Assessment of food security among households in Eastern Cape Province, South Africa	HDDS	Household	Eastern Cape	This paper analyzes food security status and its determinants among households in the Eastern Cape Province. The analysis is based on the General Household Survey (GHS), which was conducted in 2014, where 3,033 households were sampled from the province	Although 61.7 percent of households in the study area have a high dietary diversity score, food groups giving micronutrients are less consumed as food groups having cereals (maize), beef, sugar, and oil mainly were consumed

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
79. Ntila et al [109] Assessment of the food and nutrition security status of weaned 7–12 months old children in rural and peri-urban communities of Gauteng and Limpopo provinces, South Africa	CFIASIDDS	HouseholdIndividual	Gauteng & Limpopo provinces	Quantitative and qualitative research methods were used to collect the data. The questionnaire was administered to 212 caregivers (106 in Lebowakgomo and 106 in Hammanskraal) recruited using purposive sampling. This study assessed the food and nutrition security status of children receiving complementary food in rural and peri-urban communities. The Children's Food Insecurity Access Scale (CFIAS) was used to assess the children's food security status (access). The Individual Dietary Diversity Score (IDDS) and the unquantified food consumption frequency survey were used as a proxy. Measure of the nutritional quality of the children's diets.	The findings showed that a large percentage of children were severely food-insecure, 87% and 78%, in rural and peri-urban areas, respectively. Additionally, Lebowakgomo children (23.6%) and Hammanskraal children (17.9%) were severely underweight. Nutrient-deficient complementary foods characterized children's diets in both study areas. Cheaper foods with a more prolonged stomach-filling effect, such as white maize meal and sugar, were the most purchased and used. Hence, the children consumed minimal foods rich in proteins, minerals, and vitamins, significantly increasing their risk of being malnourished.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
80.D'Haese et al.[26] Improving food security in the rural areas of11 KwaZulu-Natal province, South Africa: Too little, too slow.	HFIASHDDS	Household	KZN(North -Zululand & Mkhanyakude) (South - Ugu & Umgungundhlovu)	A survey was done in July and August 2010 in two districts in the south and two districts in the north. Nine municipalities were selected within these districts among the 29 poorest-performing municipalities in the province. A sample of 390 participating households was randomly selected from households that benefited from the 38 EFSP projects in these nine municipalities. Most households interviewed (92%) were involved in community gardens, 42% in a home gardening project, and 36% in a broiler project.	Across the full sample, only 5.6% of the population were food secure; about 55.4% are severely food insecure, 30.5% are moderately food insecure, and 6.9% are faced with mild food insecurity. The most affected district is Umgungundlovu, where about 70% of the respondents face food insecurity according to the HFIAS categories.
81. Steyn et al. [28] Has Food Security and Nutritional Status Improved in Children 1-<10 Years in Two Provinces of South Africa between 1999 (National Food Consumption Survey) and 2018 (Provincial Dietary Intake Study (PDIS)	CCHIP	CommunityHousehold	Gauteng &Western Cape	The 1999 National Food Consumption Survey in South Africa showed that food insecurity (hunger) was prevalent in households with children aged one to <10 years. A repeat of the survey in two provinces: Gauteng (GTG) and the Western Cape (WC) was undertaken in 2018	Results showed that in all domains (living areas) in GTG, food shortage prevalence decreased between 1999 and 2018, from 55.0% to 29.6% in urban informal areas, from 34.1% to 19.4% in urban formal areas and from 42.1% to 15.6% in rural areas. While the prevalence of food shortage in urban formal areas in the WC remained similar in 2018, the prevalence decreased from 81.8% to 35.7% in urban informal areas and from 38.3% to 20.6% in rural areas. all the responses to the CCHIP questions asked in 1999 improved significantly in 2018 in Gauteng; in some cases, by about 40–50%.

Table 4 (continued)

Authors & Title of study	Index	Unit of analysis	Province &Area of study	Research approach, methods, and study subjects considered in the study	Summary of findings reported
82. Simelane et al [6] National Food & Nutrition Security Survey Report (NFNSS, 2024)	HFIASHDDSFCSFPFECSIHEA	HouseholdIndividualCommunity	National Scope	A cross-sectional survey was conducted in nine provinces of South Africa. Data were collected at the household and individual levels using the food security continuum and the Household Economic Approach (HEA). A sample of 34757 households were interviewed	Results indicate that only 36.5% of households in South Africa are food secure whilst 17.5% were severely food insecure and 46% were mildly or moderately food secure. HHS score reported a 79.2% of households experienced little to no hunger whilst the FCS reflected that 18.6% of households consume poor diets and the HDDS reported a 80.8% of households that consumed acceptable combination group of diets.

making it easier to incorporate into other household surveys, as similarly done in the General Household Survey (GHS) since 2009 in South Africa. One weakness of this indicator is that it might under- or over-report food insecurity in the households [40]. Therefore, HFIAS needs to be used simultaneously with other food security indicators, for example, HDDS, CSI, and FCS. This is also buttressed by D'Hasse et al. [26], who argue that the HFIAS measurement alone will not give a complete picture of the food security and nutrition status of households and individuals and is prone to measurement errors. For this reason, additional measures that include dietary diversity, the number of months people felt hungry in a year, expenditure on food, and production diversity need to be used together with HFIAS. From the review, studies such as those by [6, 9, 26, 41, 42] used a composite of indicators to measure food security, hence providing a more reliable and valid estimate of food insecurity prevalence. Most studies in South Africa also used the Household Dietary Diversity Score (HDDS) as the most common indicator for food quantity and quality assessment. Only one study was identified to have used the FIES indicator to measure food insecurity in South Africa. The Food Expenditure metric (FE) was also among the most widely used indicators, though relatively reported in a few studies (n = 4).

The limited number of studies (n = 13) that used the CSI food security indicator points towards a need for more studies examining the effects of various shocks, particularly in this era of a polycrisis that South Africa is battling. This also points to the limited measurement of the food stability dimension, which is usually related to how various shocks, such as extreme weather events, high food prices, the COVID-19 pandemic, and global economic recessions, affect food supply chains and trade. Simelane et al. [6];43, 44, 9] and others used the CSI to investigate how households used various coping mechanisms to respond to household food security shocks in South Africa. Leroy et al. [45] also argue that CSI is a valuable metric in screening vulnerable households, targeting specific food security interventions, or as an early warning indicator before shocks. Most of the studies were largely cross-sectional (89%), with a few studies (3%) having a national scope reported to have used panel data from GHS, NIDS, IES, and NFCS. Examples of studies that used panel data include [18, 46, 47], among others. Some studies, such as Chakona and Shackleton [41], compared food security measurements across seasons in Kwa-Zulu Natal (KZN) Province, focusing on Dundee, Richards Bay, and Harrismith districts/municipalities. Similarly, Hendriks et al. [9] designed a study across the winter and summer seasons using a composite of food security indicators that included HFIAS, HDDS, and CSI in Limpopo, Eastern Cape, North West, and Limpopo

Table 3 Summary of HDDS meta-analysis results depicting effect size estimates

Effect size estimates						
	Effect size	Std. error	Z	Sig. (2-tailed)	95% Confidence interval	
					Lower	Upper
Overall	5,629	,6938	8,113	<,001	4,269	6,988

Provinces. This study was comprehensive since it focused on several provinces over two seasons. The methodological approach of measuring food security across seasons provides more nuances regarding food availability, particularly in rural and peri-urban communities that rely on rain-fed agriculture, primarily affected by seasonal rainfall patterns such as the recent El Niño phenomenon. This is echoed by Simelane et al. [6], who reported that in most provinces in South Africa, food availability disproportionately varied according to seasons, drawing evidence from the Household Economic Approach (HEA)'s seasonal calendars generated from community Focus Group Discussions (FGDs) during the National Food and Nutrition Security Survey (NFNSS) study.

Temporal and spatial distribution of food security measurement studies in South Africa

From the year 2000 to 2024, most of the studies focusing on food availability, access, and stability, making use of the food security indicators, were predominantly focused on Limpopo Province (Vhembe; Capricorn and Mopani districts); eThekwini Municipality in the KZN Province and the City of Cape Town in the Western Cape Province. This is mainly because in the early years of the millennium through to around the year 2010, food insecurity has been widely reported in Limpopo Province than in any other province, especially in the semi-arid districts of Mopani and Capricorn (See Fig. 4). In Provinces such as the Northern Cape, Northwest, Free State, and Mpumalanga there were minimal studies of this nature, indicating a massive gap in empirical evidence pointing toward food access, availability, and stability at the household and individual levels. The renewed interest in food security measurement through the newly introduced Sustainable Development Goals (SDGs) in 2015 that followed the end of the Millenium Development Goals (MDGs) era provided an impetus for generating empirical evidence towards the Zero hunger (SDG 2) indicators and the 2025 SDG nutrition targets hence the sharp increase in the number of studies reported in the year 2015 to 2019 (See Fig. 7). In addition, the introduction of the National Policy on Food and Nutrition Security, as well as the National Strategy for Household Food and Nutrition Security in 2013 for South Africa, to ensure the availability, accessibility, and affordability of safe and nutritious food at the national and household levels, provides a plausible explanation for the sharp increase of studies from 2015 to 2019. This followed a renewed focus and thrust on channeling resources and efforts for studies addressing the measurement of food access, availability, stability, and utilization across provincial governments. Evidence from the South African 2023 Science, Technology and Innovation (STI) report indicate that there was a huge increase in research and development (R&D) funding allocated to strategic priorities including food and nutrition security during the 2014 right through 2018 period, thereby justifying the increase in food security measurement studies. The low number of studies recorded in 2020 is attributed to the COVID-19 pandemic outbreak, which resulted in restricted movements and a shift in the focus on resources and efforts to tackle the pandemic. Only studies that did not require movements were undertaken through telephonic conversations and digital technology use during this period (March 2020–2022).

To comprehensively capture the temporal variation of food security in South Africa, this study suggests that more studies need to be done using cohort and longitudinal studies, like the one undertaken by Rusere et al. [48]. Spatial settlement variations must also consider the urban, peri-urban, and rural settlement continuum to the food insecurity variabilities that emanate from these settlement dynamics. To capture the effect of the settlement gradient on food security, Chakona and Shackleton [41] conducted a study in KZN, in Harrismith, Dundee, and Richards Bay, to determine food access, availability, and stability along the settlement gradient. However, this is only one of the few studies done at the micro-level and more studies of this nature need to be undertaken in other provinces and municipalities of South Africa. Very few studies, such as [9, 41], have used the assessment of food security across different seasons, which provides a comprehensive assessment of food security among different seasons, especially in communities whose food availability is premised on smallholder rainfed agriculture, which is seasonal. The systematic review results also depict a situation where most studies used only one indicator, the HFIAS, which was not very comprehensive in capturing the quality of food security perspectives required to guarantee individual and household food security. A few studies, such as [6, 9, 41, 42, 49], combined several indicators such as HFIAS, HDDS, CSI, FCI, and MAHFP in an to attempt to provide a valid and reliable food security assessment, although not all the critical indicators were incorporated. None of the studies investigated the food security dimensions of agency and

sustainability, including the possible ways of quantifying and accounting for them. There is a need for a nuanced analysis of proposed methods and metrics to measure agency and sustainability in the South African context. Paganini et al. [14] conducted a similar study in South Africa in the Cape Flats in Western Cape Province. They proposed the Agency Module (AM) to measure the agency's food security dimension.

The review shows that there are provinces with minimal coverage regarding food security assessment research in South Africa. Nevertheless, they appear to be the most affected by food insecurity, as reported by the GHS [7], where the Northern Cape had the highest (37.7%), followed by the North West (32.6%). Although slightly different, Simelane et al. [6] also report similar trends, where North West, Mpumalanga, Free State, and Northern Cape recorded severe food insecurity of 25%, 22%, 22%, and 21%, respectively. Figure 4 depicts minimal food security studies that have been done in the North West, Mpumalanga, Free State, and Northern Cape Provinces, yet evidence shows that they experience the highest severe food insecurity compared to other provinces. The limited methodological triangulation approach in most of the studies limits the validity and reliability of the food security results. By design, most of the studies used quantitative survey methods without getting the voices of participants' experiences through qualitative methodologies. To the best of the authors' knowledge, Simelane et al. [6], through the National Food and Nutrition Security Survey (NFNSS), adopted the SAVACC-commissioned methodological framework that used the Household Economic Approach (HEA) and the Food Security Continuum to measure food insecurity in South Africa. This is also important given that the additional qualitative food security dimensions (Agency and Sustainability) have been added to the food and nutrition security concept.

Conclusions

The study reveals substantial empirical evidence on food access, availability, and stability measurement using standard indicators for 2000–2024 in South Africa. The HFIAS indicator emerged as the most widely used metric ($n = 45$) for quantifying food insecurity among South African households, followed by the HDDS ($n = 24$). The least used indicators were MDD-W, HFI, FIES, and CFIAS. Most of the studies used HFIAS as the sole measurement indicator of food insecurity in their studies. In contrast, only nine studies used a composite of three or more indicators of food access, availability, and stability. None of the reviewed articles attempted to measure the food security dimensions of agency and sustainability, except for the Paganini et al. (2021) study conducted in Cape Town, South Africa, which was reported as gray literature; hence, it could not be identified from the databases searched. Most of the studies (89%) were cross-sectional by design. Few studies measured food insecurity across different seasons, except for only four. Another significant finding is that few studies measured food security following the urban-peri-urban and rural settlement gradient, except for only two studies. A few studies use secondary data from previous national studies, including the Income and Expenditure Survey (IES), NFCS, GHS, and NIDS. The rest of the studies were cross-sectional primary studies. Studies in South Africa need to adopt the full HFIAS module within routine national surveys such as the GHS, NIDS, and the IES, and restructure the surveys to allow household and individual analysis of food insecurity. There is a need to emphasize measuring the stability dimension, especially the use of the CSI index, given the polycrisis that South Africa is undergoing. This would allow various composite indicators to capture most of the food security dimensions comprehensively.

The spatial distribution of the studies across provinces and districts is not uniform since most studies are concentrated in KZN and Limpopo provinces, particularly in the rural settings of these two provinces. Most of the studies conducted in Gauteng and Western Cape provinces were done in Sedibeng and Cape Town, respectively. Minimal research has been done in the Free State, North West, Northern Cape, and Mpumalanga Provinces, yet recent reports argue that most of these areas are the most food-insecure hotspots in South Africa. The peak of studies measuring food access, availability, and stability was reached in 2016, and its all-time low was in 2020 during the COVID-19 pandemic. Meta-analysis of HFIAS studies ($n = 16$) showed high publication bias, as depicted by the funnel plot output. Most of the studies ($n = 6$) were significant, as depicted by the forest plot for HFIAS; however, a high number of the studies were outside the confidence interval limits of the funnel plot, indicating high imprecision. This is contrary to the meta-analysis output of the HDDS metric ($n = 14$), where most studies were close to the zero standard error point in the funnel plot, and they were all within the confidence limits except for only two studies, thereby indicating very little publication bias and high precision. This study provides several possible approaches for measuring food security dimensions of agency and sustainability and explaining emerging gaps for further study.

Proposed approaches for measuring agency and sustainability dimensions of food security

Attempts to measure agency and sustainability will require different indicators that capture a range of aspects of each of these dimensions to account for their complexity. An index to measure food agencies by Paganini et al. [14] used a mixed-methods and co-research approach in

a household survey conducted in marginalized communities in South Africa. Results from this study showed a statistically significant relationship between the FIES and the metric developed to measure food agencies. Paganini et al. [14] developed an Agency Module consisting of five domains, each with four sets of questions. The domains include (a) Diet sovereignty, (b) Food production, (c) Food processing, (d) Food distribution, and (e) Voice in food policies and governance. The agency module (AM) necessitates the computation of an index for the agency and sub-indices for each domain. However, measuring these qualitative and subjective aspects, such as voice in food policies and governance, is complex. This will vary according to context, especially the state governance structure and ideologies, which influence policy formulation and implementation. Benchmarking these results by comparing the measurement of these dimensions across countries and local government settings will be very difficult due to the heterogeneity in governance systems in Africa and at the global level.

Clapp et al. [110] propose the use of metrics that have included some aspects of agency at the individual and household scales, such as the Women's Empowerment in Agriculture Index (WEAI) and the Women's Empowerment in Livestock Index (WELI). These indices measure women's empowerment using several domains that enhance agency in farming and animal husbandry by profiling women's roles versus men, thereby measuring their decision-making power [111–114]. However, these aspects are difficult to comprehensively measure due to the qualitative nature and comparison across communities is difficult due to differences in religion, culture, and intra-household power dynamics. There is a need to find linkages between food and nutrition outcomes by incorporating the factors influencing the dynamic nature of food security, as argued by [114]. This is however complex and require exceptional data science as well as advanced statistical expertise to accomplish considering that household food security status and individual nutrition data require merging and alignment prior to analysis as similarly done during the study by Simelane et al. [6]. Concerning sustainability, Seekell et al. [115] have developed resilience indicators for food systems, incorporating biophysical capacity, production diversity, and socioeconomic access. The proposed methodology and metrics emphasize that increased attention to agroecology indicators could improve researchers' ability to determine food systems transformation towards ecological, social, and economic sustainability. Diet indicators have also been proposed to enhance sustainability. Donini et al. [116] proposed assessments of the sustainability of healthy diets that draw on 13 indicators using the Mediterranean diet model. Most scholars have proposed the use of the Sustainable Nutrition Security (SNS) framework that incorporates seven types of metrics, including ecosystem stability, food loss and waste reduction, and sociocultural well-being (which includes gender equity and community rights [117].

Emerging gaps and scope for further studies

To adequately measure food access, availability, and stability, there is a need to use a composite of indicators that report food security experiences and quantity, such as HFIAS, CSI, and HDDS, while measuring the food quality component using metrics such as FSC and MDD-W. A few studies did this to a lesser extent [6, 9, 26, 42]. More indicators, such as MDD-W, which provides food security measurement for vulnerable groups, such as women and children (MDD), need to be used in most studies to generate the necessary evidence to address inequality and limited access to nutritious diets at the household level. Only two studies identified in this study used these vital indicators (MDD and MDD-W) since they are used as proxy indicators for micronutrient adequacy, a critical dimension of food quality. More studies need to be done to investigate the effects of multiple shocks on food access, availability, and stability using indicators such as the CSI, especially during and after extreme climate events, economic recessions, civil unrest, pandemics like COVID-19, and other shocks. Another glaring research gap is the assessment of food security dimensions across different seasons, such as summer, autumn, winter, and spring, since food availability varies significantly between these seasons, as demonstrated by [9, 14]. As an avenue for further exploration, researchers could review the studies focusing on food utilization and subsequent meta-analysis and explore the relationship with food access, availability, and stability at the individual and household levels. This glaring and critical gap in the food security domain must provide enough evidence for government and development agencies' food and nutrition security interventions. There is limited use of secondary data, especially those data generated from surveys with a national scope, such as the annual GHS, NIDS, and NFCS. Not much data analysis has been done to determine the changing trends of food security metrics over time.

Most studies did not provide evidence of food insecurity measurement across the settlement continuum of urban, peri-urban, and rural landscapes. According to the 2024 HLPE Report, peri-urban households experience extreme vulnerability to income due to various shocks, unlike their rural and urban counterparts. Most of these studies' research designs are cross-sectional, with no standardized minimum threshold sample size, sampling strategy, or data collection approach. There is also an opportunity to disaggregate food security metrics according to racial groups, an aspect that most studies

have not adequately explored in South Africa. Most vulnerable and marginalized groups, such as migrants' food security, have not received enough attention, an aspect in which urbanization has been the primary driver, yet these groups have not been appropriately considered. Although the South African Vulnerability Assessment Committee (SAVAC) has made good progress in designing and recommending methodological frameworks for measuring food security, there is an urgent need to scientifically compile and test these methodologies for broader adoption by institutions and researchers. The evolving nature of the food security concept has added two more dimensions: sustainability and Agency (HLPE [11]). More qualitative measurement dimensions are needed in these newly included concepts. Although the Household Economic Approach (HEA) had previously been advocated through the SAVAC food security assessment methodological framework, it has not been widely used. Simelane et al. [6] used the HEA approach as a qualitative dimension of food security measurement, triangulating it with the quantitative survey. However, a more rigorous analysis of its methods must be scientifically done to make the results more valid and reliable. This comes against the backdrop that HEA has been designed primarily to rapidly assess livelihood activities in disaster-affected areas and regions. Finally, a similar study and analysis need to focus on the food utilization (nutrition) dimension to provide an overview of anthropometric and other related nutrition outcomes in South Africa.

Limitations of the study

The study was limited to the review of metrics measuring food security dimensions of access, availability, and stability. It did not consider the dimensions of food utilization, food sustainability, or food agency. Only studies that used at least one indicator measuring food access, availability, and stability were considered. The searched databases were limited to Google Scholar, Scopus, and Web of Science. Only peer-reviewed and published scientific articles, conference proceedings, and book chapters were considered, excluding grey literature, Master's, and Doctoral Theses. The search was conducted between February 2024 and finalized on 9th September 2024; hence, articles that became available online in 2024 after the search dates were not considered. Other databases that were not considered include PubMed, EBSCO, and others, mainly because most of their documents relate to the food utilization dimension, which was excluded in this review. The only studies that were considered for meta-analysis were the ones that presented their results with means, standard deviation, or standard errors. Unlike other indicators, only the studies that used the HFIAS and HDDS metrics generated enough threshold data to be considered for meta-analysis.

Supplementary Information

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Supplementary Material 1

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Author contributions

The corresponding author, Dr Blessing Masamha, conceptualized and designed the study protocol, developed the search strategy, led the literature search, led the document screening process and discussions, analyzed the data, drafted the manuscript, and addressed all the review comments.

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Data availability

All relevant data extracted from the databases and analyzed are available and ready for sharing. This data is provided in this submission as supplementary information. The data includes articles extracted from the Web of Science (WoS) and Scopus databases, and the list of studies with indicators used in food security measurement.

Declarations

Declaration of use of artificial intelligence tools

The study ensured the responsible use of AI tools. It used two artificial intelligence (AI) applications to enhance the search and to complement the paraphrasing of relevant text for synthesis. Perplexity was used to complement the search strategy that was developed, whilst the Quill Bot was used to complement paraphrasing after full-text reading and manual extraction of text phrases by the three independent authors.

Competing interests

The authors have nothing conflicting to declare.

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