Asian Journal of Agriculture and Rural Development
Volume 15, Issue 2 (2025): 309-338

The interplay and correlates of agricultural (Farm) and non-agricultural activities to food diversity – linkages to health expenditure

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Article History
Received: 14 March 2025
Revised: 5 June 2025
Accepted: 17 June 2025
Published: 19 June 2025

Keywords
Agricultural participation
Composite reliability
Consumption expenditure
Health expenditure
Partial least squares –SEM
Simpson's index.

ABSTRACT
Literature suggests that a varied and high-quality diet is essential for adequate nutrient intake and improved health outcomes. Despite this knowledge, and considering that agricultural participation can enhance food availability and diversity, populations continue to face challenges in achieving dietary diversity due to socioeconomic constraints among a plethora of factors. Understanding this relationship becomes particularly important for Lesotho, where such insights can inform strategies to promote dietary diversity, improve public health, and reduce healthcare costs. This study utilized data from the Household Budget Survey to examine how household food consumption patterns, socioeconomic factors, and agricultural participation influence food diversity and health-related costs. Using Partial Least Squares-Structural Equation Modeling (PLS-SEM), we analyzed the relationships between these variables to gain a nuanced understanding of their interplay. Results reveal that food diversity is shaped by multiple factors, including agricultural participation, which directly affects health outcomes. Household characteristics, such as income, household size, and education level of the household head, significantly predict both food diversity and health expenditure. These findings underscore that supporting agricultural engagement and promoting dietary diversity can be cost-effective strategies to improve nutrition and reduce healthcare costs in Lesotho. Policymakers should focus interventions in these areas.

Contribution/Originality: This paper examines the overlooked relationships between food diversity, socioeconomic factors, and health outcomes in Lesotho. It reveals how household characteristics influence food patterns and expenditures, showing that promoting dietary diversity can improve health and reduce costs in a developing context.

DOI: 10.55493/5005.v15i2.5419
ISSN(P): 2304-1455/ ISSN(E): 2224-4433

How to cite: Ramalebo, K., Chifurira, R., Zewotir, T., & Chinhamud, K. (2025). The interplay and correlates of agricultural (Farm) and non-agricultural activities to food diversity – linkages to health expenditure. *Asian Journal of Agriculture and Rural Development, 15*(2), 309–338.

1. INTRODUCTION

Food composition, dietary diversity, and individual consumption patterns exhibit variability over time, with household dynamics playing a significant role in this fluctuation. Research indicates that factors encompassing sociodemographic and socioeconomic dynamics affect the decisions regarding food choices within households, suggesting a complex interplay of determinants (Jackson, 1984; Mazenda & Mushayanyama, 2022; Shonkwiler, Lee, & Taylor, 1987; Thiele & Weiss, 2003). Extending on this, the availability and demand for specific food items can be shaped by diverse factors such as climate conditions, cultural norms, and economic circumstances, impacting the variety of foods consumed across different demographic groups. As household dynamics evolve, variations in income, wealth, and household size can significantly influence consumption patterns and outcomes related to food variety and dietary preferences. The ability of diverse diets to adapt to socioeconomic shifts and external influences reflects a nuanced relationship between lifestyle factors and dietary choices. This association aligns with existing literature that emphasizes the importance of product variety on nutritional intake and overall health outcomes, highlighting the potential role of diverse diets in mitigating chronic diseases (Vadiveloo, Dixon, Mijanovich, Elbel, & Parekh, 2014). However, it is important to note that increased food variety can stimulate appetite and potentially lead to excess energy intake and adiposity, particularly if the food choices primarily come from related food groups. On a positive note, research by Murphy et al. (2006) underscores the potential health benefits of a varied diet rich in low-energy-dense and nutrient-packed foods, thereby promoting healthy living and the overall well-being of individuals. Despite the promising prospects of diverse dietary patterns, concerns raised by Vadiveloo et al. (2014) emphasize the need for caution when incorporating less healthy items within varied diets, particularly in relation to hygiene practices. Nevertheless, the wealth of evidence supports the notion that embracing a diverse range of food groups offers substantial benefits, with household socioeconomic factors serving as crucial indicators in predicting dietary changes. The implications of food diversity extend beyond individual health, potentially influencing productivity levels, lifestyle choices, and consumer behaviors within the marketing landscape.

Building on a plethora of benefits linked to food diversity, a critical inquiry arises regarding the potential influence of consuming a range of foods on healthcare expenditure and the interplay of agricultural and non-agricultural activities in shaping this dynamic. This discussion holds particular significance in developing economies such as Lesotho, where healthcare spending has consistently accounted for almost 10 percent of the gross domestic product over a five-year period, underscoring the weighty burden of healthcare costs. This ties in with the unique population dynamics in Lesotho, characterized by an average household size of four persons, a predominantly young population, a strong reliance on agriculture as a primary livelihood, and moderate levels of inequality. At the same time, the provision of healthcare in Lesotho is predominantly government-driven, with additional support from donors for specific programs. This reliance on governmental and donor funding could signal the challenges faced in achieving universal health coverage, which could be exacerbated by competing financial demands, tight budget constraints, and the uncertainty of donor support, which ultimately exposes the health system of the country to vulnerabilities. A potential alternative that could warrant scientific investigation is the relationship between food consumption diversity (towards meeting basic nutrition) as well as healthcare costs further linking these with socioeconomic factors and agricultural participation. By examining this connection, we may uncover evidence that supports a more sustainable approach to healthcare financing, one that leverages household food diversity as a cost-effective strategy to reduce healthcare expenditure. Producing scientific evidence on this potential relationship is crucial for informing policy decisions and developing targeted interventions that can improve healthcare outcomes in Lesotho. To investigate this relationship, this study aims to evaluate the levels of food diversity in Lesotho and its influencing factors. Specifically, we will examine whether a higher food variety, quantified using Simpson's index or Berry's index, correlates with reduced health expenditure. Building on previous research conducted by Thiele and Weiss (2003) and Mazenda and Mushayanyama (2022), among others, this study aims to contribute to the existing body of knowledge by evaluating the influence of food diversity on healthcare costs as part of a comprehensive investigation into strategies to enhance healthcare sustainability in Lesotho.

2. FOOD COMPOSITION IN LESOTHO AND ITS RELEVANCE TO THIS STUDY

The food basket of Lesotho households exhibits characteristics typical of other developing economies. To gain a deeper understanding of the basket and its diversity within households, we rely on the food composition and grouping data from the Household Budget Surveys (HBS). HBS provides valuable information on household spending patterns, including food consumption, and offers a nuanced understanding of the living conditions of the study population. The survey, which is typically conducted by countries every five years, has been validated as a reliable proxy for dietary measures (Dary & Jariseta, 2012; Engle-Stone & Brown, 2015). In Lesotho, the HBS employs a seven-day recall questionnaire, also known as a diary, to gather detailed information on household food purchases among other consumption expenditures. This approach allows for a comprehensive analysis of food consumption patterns and habits within households. In particular, households self-record their daily consumption of purchased goods, their own produce, and services and these include food items as outlined in Table 1. Due to its broad scope in measuring household consumption, the survey is considered a reliable and key source of information on food acquisition and food consumption (Kristo, Sikalidis, & Uzun, 2021; Naska, Vasdekis, & Trichopoulou, 2001). As such, we argue that the HBS, with its robustness in measuring food consumption expenditure, is a reliable proxy for measuring food diversity, even in the Lesotho setting.

Table 1. Food groups in Lesotho as per the HBS grouping.

SN.	Food group	Food products
1	Bread and cereals	Bread, Breakfast cereals, Cake flour, Wheat meal/grain, Bread flour, Maize meal/Grain, Macaroni and Noodles, Rice, Samp, Meal rice, Sorghum meal/Grain, Malt, Others.
2	Meat	Beef, Mutton, offal, Pork, Dried, salted or smoked meat and edible meat offal, Other preserved or processed meat and meat preparations, Others.
3	Fish	Fish, Seafood, Dried, smoked or salted fish and seafood, Other preserved/processed fish and seafood products, Others.
4	Milk, cheese and eggs	Whole milk, Low-fat milk, Preserved milk, Sour milk, Yogurt, Cheese and curd, Eggs, Others.
5	Fruits	Apples, Bananas, Oranges, Peaches, Pears, Grapes, Apricots, Pineapples, Mangoes, Watermelons, Other Citrus fruits, Berries, Dried fruits, Others.
6	Vegetables	Dried beans, Green beans, Green peas, Cabbage, Spinach, Lettuce, Other leaf and stem vegetables, Beetroot, Carrots, Tomatoes, Onions, Pumpkins, Others.

The 2017/18 HBS in Lesotho provides valuable insights into the food consumption patterns in the country. The survey reveals that household spending tends to gravitate towards bread and cereals, meat, vegetables, milk, cheese, and eggs, which are the dominant food groups in the country. Notably, despite this concentration, the HBS list of food groups is comprehensive, covering a wide range of categories including fish and fruits (see Table 1). Furthermore, the HBS provides valuable insights into health expenditure, revealing the average monthly health spending of entire households. This information enables the identification of recurring health spending patterns, including frequent visits to healthcare providers, medication purchases, and other healthcare-related expenses. Regular monitoring of household expenditures is essential in highlighting potential financial hardships in meeting healthcare costs and identifying areas where households may require support to manage their expenses. The HBS in Lesotho, for example, measured health expenditures by considering various costs, including travel to seek health services, medication costs, payments for healthcare visits and medicines, laboratory tests, transportation, hospitalization, and overnight stays. These costs are a key aspect of health expenditures, as defined by the World Health Organization, which comprises formal and informal payments made at the time of receiving care, including preventive, curative, rehabilitative, palliative, or long-term care.

3. CONCEPTUAL FRAMEWORK

Household consumption expenditure patterns provide a comprehensive snapshot of national consumption habits; nonetheless, a nuanced examination reveals that food composition patterns and variety exhibit significant variation within households. This heterogeneity is influenced by a complex interplay of factors, including food preferences, demographic and socioeconomic factors, as well as coping mechanisms for poor households. In Lesotho, this complexity is particularly relevant, given the rural-urban divide that defines the country and the struggles of some households to access nutritious food. The literature suggests that this variation is not limited to national contexts, but rather extends to regional contexts, as studies have observed similar patterns of diversity and skewness in food consumption in other jurisdictions (Mazenda & Mushayanyama, 2022) low-income consumers in developed economies (Binkley, Eales, & Jekanowski, 2000) and even households in different regions of developed economies (Thiele & Weiss, 2003). This conceptual framework argues that food consumption and variety patterns are shaped by a constellation of factors, including agricultural participation, which may link well with nutrition and thereby lower health expenditures.

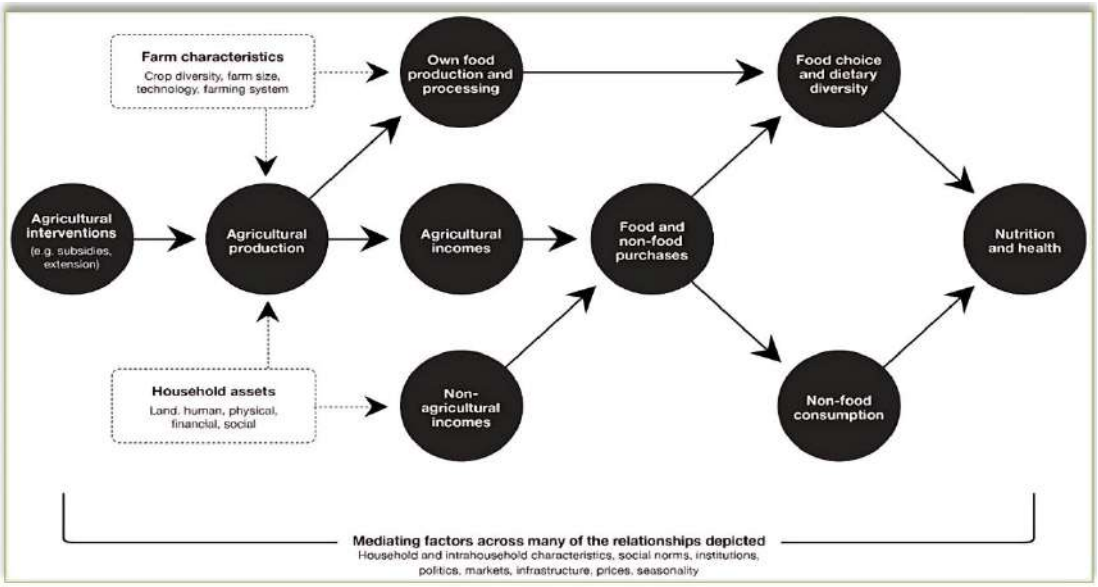

Figure 1. Relationship between agriculture, food purchases and dietary diversity.
Source: Bellon, Ntandou-Bouzitou, and Caracciolo (2016) and Kumar, Harris, and Rawat (2015).

In Figure 1, we illustrate the observed relationship between household activities, including agricultural participation, and their impact on food consumption, food variety, nutrition, and health outcomes (adopted from Bellon, Ntandou-Bouzitou, and Caracciolo (2016) and Kumar, Harris, and Rawat (2015). The figure highlights the connections between household activities, food variety, nutrition, and health outcomes, demonstrating that agricultural participation can also have a direct influence on food diversity and, subsequently, on health outcomes. Notably, some of these connections occur outside the household setting, such as agricultural interventions that can take the form of input subsidies from government and development partners. Additionally, environmental and climatic conditions, social atmosphere, political conditions, and economic contexts can also influence food variety (Warren, Hawkesworth, & Knai, 2015). These factors suggest a plausible ripple effect on food diversity, nutrition, and ultimately, health outcomes. For instance, by increasing food diversity through agricultural participation, households can reduce their reliance on processed and unhealthy foods, leading to improved nutritional outcomes and decreased health expenditures. To better understand these relationships, it is crucial to quantify the direction and magnitude of these interplay relationships to identify the most effective leverage points for policymakers.

4. STUDY AREA AND CONTEXT TO THE DATA COLLECTION

The interplay between agricultural and non-agricultural participation among households and their impact on food diversity and health expenditure has not been extensively explored within the context of Lesotho; this paper assesses this connection. The analysis utilizes three HBS rounds for 2002/03, 2010/11, and 2017/18, covering sample sizes of 5,992, 5,318, and 4,295 households, respectively. The analysis examines the consumption expenditure of these households relying on HBS food groupings, such as bread and cereals, meat, and fish, as well as sociodemographic characteristics like income, household size, and education of the household head. The paper then connects the related consumption expenditure to household food diversity and household expenditure on health to assess the differentials in their movements.

5. INSTRUMENTAL STUDY VARIABLES

Through an examination of demographic, socioeconomic, and agricultural participation variables, we aim to understand how they impact food consumption expenditure and healthcare spending. The inclusion of these variables in the variable selection allows us to explore their underlying relationships, which have been overlooked in the Lesotho context. Previous studies have shown that certain household characteristics, such as income, household size, and educational status, are important predictors of food diversity (Matita et al., 2021; Thiele & Weiss, 2003). For instance, educated individuals are likely to understand the benefits of consuming a variety of foods (Moon et al., 2002). These factors can influence household participation in agricultural and non-agricultural activities, which can, in turn, affect household spending on varied diets and health. Extending this plausible connection, similar studies have found that higher parental education levels are associated with diverse diets (Abdollahi et al., 2014). This could be explained by the notion that higher education levels are often linked to more favorable career prospects and remuneration, which can translate into more disposable income and better dietary understanding. At the same time, research further suggests that the economic status of the household head plays a significant role in shaping dietary patterns and health expenditure decisions. Households with economically active heads have greater access to a variety of nutritious foods, as shown by research (Kristo et al., 2021; Madzorera et al., 2021). The ability of the household to finance its needs, including spending on the right resources, is crucial for ensuring food diversity and enhancing diet quality. This is often the case because households with the necessary resources are more likely to have access to a wide range of nutrient-dense foods, which can improve health outcomes. Household size is another important instrumental variable that influences food diversity. Research has shown that as household size increases, there is a corresponding increase in the demand for a variety of foods (Leschewski, Weatherspoon, & Kuhns, 2017; Thiele & Weiss, 2003). Larger households may face resource scarcity challenges, which can drive the demand for a wider range of food options. In addition to these factors, geographical settings can also influence food diversity. To provide context, certain areas may encounter obstacles in food production and accessibility due to constraints such as limited water availability for irrigation, specific climatic conditions, various soil types, and geographical features that may hinder agricultural productivity.

These challenges can be further exacerbated by insufficient infrastructure, transportation facilities, and social amenities. The importance of considering local context in understanding and addressing issues related to dietary diversity and health expenditure is underscored by the findings of different studies. While research has shown that consumption patterns are converging in developed economies (Thiele & Weiss, 2003), significant differences in dietary diversity consumption have been observed across regions in developing countries (Anane, Nie, & Huang, 2021). Understanding the intricate structural relationships between household activities in agricultural and non-agricultural sectors, while also taking into account factors such as food diversity, health outcomes, and various contextual elements, is crucial for the development of effective strategies and targeted interventions designed to address the specific needs of diverse regions. These needs may involve implementing deliberate and aggressive measures to promote sustainable agricultural participation and practices, thereby enhancing access to diverse and nutritious food options. These could work towards improving overall well-being and quality of life in households in Lesotho.

6. METHODS

The study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore the relationships between variables in the dataset and the underlying structural connections in the model. Furthermore, within the

context of scrutinizing the food dietary diversity of the study population, we incorporated Simpson's Index as a rigorous means of evaluating the extent of food diversity inherent in the diets within households in Lesotho.

6.1. Simpson's Index

Simpson's Index is commonly used in ecological studies to measure diversity among species He and Hu (2005) and Morris et al. (2014) and has, in recent years, been crucial in profiling the food diversity status of households. In particular, in nutrition-related studies, the index captures the richness and evenness of food items consumed by food-insecure households. One such example of an application of this index is seen in Li (2012), applying the Constant Elasticity of Substitution approach to analyze household consumption and welfare implications in India. In a slightly different context, Theil and Finke (1983) assessed food diversity relative to per capita real income in 30 countries using the Herfindahl index and the Entropy index. This approach was further explored by Thiele and Weiss (2003), who utilised the Berry Index and the Entropy Index to assess the determinants of consumer demand for food diversity in Germany. Building on these methodologies, Mazenda and Mushayanyama (2022) recently used Simpson's Index to profile the dietary diversity status of food-insecure households living in the City of Tshwane in South Africa. This paper aligns with these approaches by using Simpson's Index to profile food diversity in households in Lesotho. The index floats between 0 and 1−1/n, with a limit value that approaches 1 as n (The number of foods) increases.

The Model:

Simpson's Index is expressed mathematically as follows:

$$(S) = 1 - (w_i)^2$$

Where w_i is the weight of the i^{th} food group. The value of the index returns "0" if only one single food group is consumed, while "1" suggests the consumption of all food groups.

6.2. Partial Least Squares Structural Equation Modelling

The PLS-SEM, the choice for this paper, examines the relationships among observed and latent variables. The selection of PLS-SEM is based on its capacity to estimate intricate models with numerous constructs and structural paths without imposing distributional assumptions on the data, as highlighted by Hair, Risher, Sarstedt, and Ringle (2019). The variables under study include a combination of categorical and continuous variables, rendering PLS-SEM a suitable methodological approach. Specifically, the observed variables consist of the historical engagement of households in selling agricultural items, household spending on agricultural products, and the household possession of agricultural items, collectively contributing to the latent variable of agricultural participation. Furthermore, health costs or spending is an observed variable, while health expenditure is its corresponding latent variable. Similarly, Simpson's Index is an observed variable connected to the latent variable of food diversity. In terms of socioeconomic variables, education level, economic activity, and household income are observed variables included in the model, with their respective latent variable being socioeconomic status.

The model path diagram, as displayed in Figure 2, illustrates the connections among agricultural participation, socioeconomic status, health expenditure, and food diversity. These linkages outline the hypothesized interplay and relationships between these key variables and latent constructs, shedding light on the dynamics at play within the model.

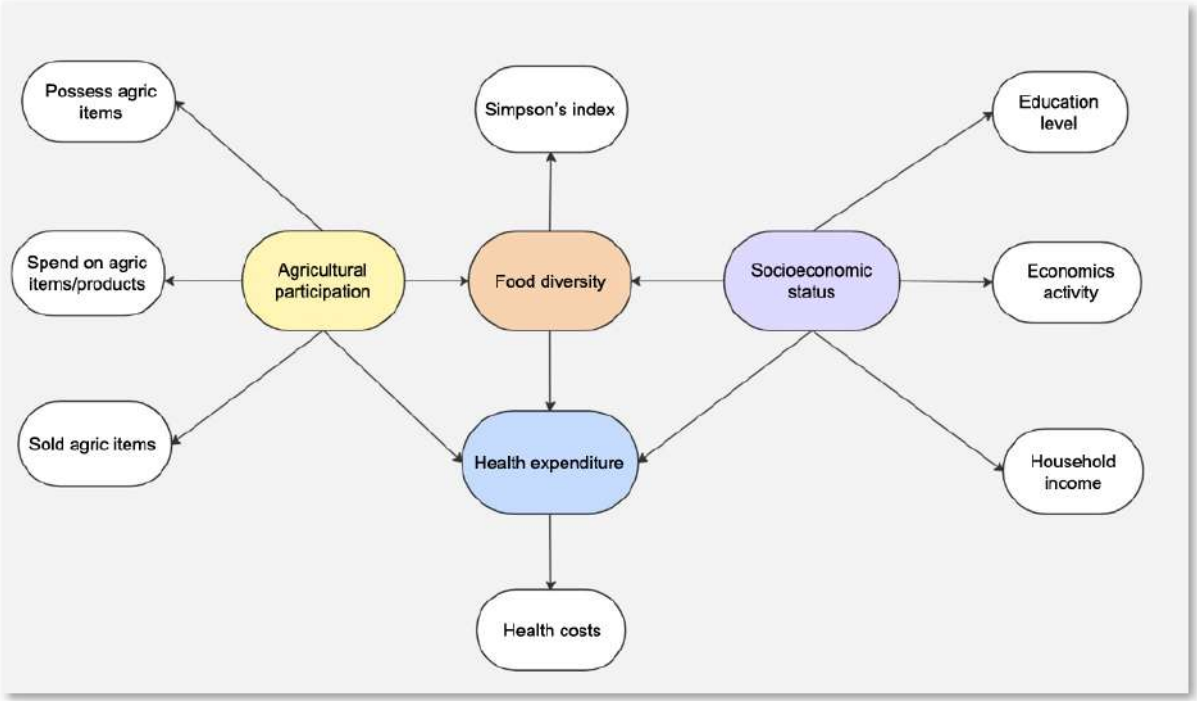

Figure 2. Postulated model connecting agricultural participation, socioeconomic status and health expenditure with food diversity.

7. RESULTS

The findings of this study are presented in this section. These findings stem from the data exploration conducted on consumption expenditure relative to the HBS food grouping, agricultural participation, demographic and sociodemographic characteristics, as well as health spending. The results reflect a combined outcome of descriptive statistics and PLS-SEM.

7.1. Descriptive Statistics

Table 2 shows the descriptive statistics for household consumption expenditure on food groups, including the expenditure on health over the three HBS cycles. Across the three measurements, the consumption expenditure was commonly high for a group of vegetables and the group of bread and cereals, while remaining low for a group of fruits and fish products, and modest for meats, milk, cheese, and eggs. The pattern could be indicative of a case where households prioritize their consumption expenditure on other food or non-food items deemed accessible or more essential to the household, such as vegetables, clothing, or health, relative to household purchasing power, as observed by Blisard, Stewart, and Jolliffe (2004). To provide context, during the HBS 2002/03, the household consumption expenditure on a group of vegetables in the month of assessment averaged ($\bar{x}$) = 3.4 of diverse vegetable products with a standard deviation, σ = 2.3, increasing to an average, $\bar{x}$ = 3.6 of diverse vegetables in 2017/18 with standard deviation, σ = 2.2. Inversely, the consumption expenditure on vegetables remained low in 2010/11, averaging, $\bar{x}$ = 1.2 of diverse products within the referenced HBS month, and this was the lowest across the three measurements.

Table 2. Descriptive statistics for household consumption expenditure on food groups and food diversity, participation in agriculture, socioeconomic variables and expenditure on health.

Food group	2002/03 Mean (SD)		2010/11 Mean (SD)		2017/18 Mean (SD)	
Bread and cereals	2.8	(1.5)	0.8	(1.1)	2.8	(1.6)
Meat	1.1	(1.1)	0.4	(0.9)	1.2	(1.2)
Fish	0.1	(0.4)	0.1	(0.3)	0.3	(0.5)
Milk, cheese and eggs	1.1	(1.1)	0.5	(0.8)	1.3	(1.2)
Fruit	0.8	(1.1)	0.1	(0.4)	0.7	(1.0)
Vegetables	3.4	(2.3)	1.2	(1.7)	3.6	(2.2)
Simpsons index	0.78	(0.12)	0.37	(0.41)	0.77	(0.14)
Agricultural participation						
Sold agric product (Yes in %)	13.4		6.7		3.7	
Spent on agric item (Yes in %)	8.2		3.3		17.3	
Possess agric item (Yes in %)	67.7		35.5		69.1	
Socioeconomic status						
Education level (Mode)	1		3		2	
Economic activity (Mode)	3		1		1	
Income (Mean, LSL)	1,273		681		16,355	
Health expenditure						
Spent (Yes in %)	28.9		7.8		24.3	

Source: LSL/M = Lesotho currency.

The registered decrease in consumption expenditure on vegetables in 2010/11 could have coincided with the after-effects of the 2007 to 2009 financial crisis, which could have potentially escalated inflationary pressures on the production and pricing of agricultural products, leaving many households with less money to spend on vegetables. In the same period, relatively low consumption expenditure on health is notable (i.e., 7.9% of households confirming that they spent on health-related costs) against 28.9% registered in 2002/03 and 24.3% registered in 2017/18. This could further reflect the financial difficulties experienced by households, with many left to make difficult choices on where to spend (i.e., the average income in 2010/11 was at M681, down from M1,273 in the past 7 years, HBS 2002/03). Nonetheless, the effect of government intervention in the form of health subsidies is a possible confounding variable and thus may not be downplayed in the differentials of household spending on health.

At the same time, the involvement of households in agricultural activities was variable across the survey years, with households participating by selling agricultural products having accounted for 13.4% in 2002/03, declining to 6.7% and 3.7% in 2010/11 and 2017/18, respectively. The decrease in households selling agricultural products could indicate various factors such as changes in market dynamics, shifts in consumer preferences, or challenges faced by agricultural producers, without ruling out the effects of climate change. Conversely, the data also suggest that households might have been involved in agricultural activities through other means, such as direct consumption or possession of agricultural items, with notable fluctuations in participation levels across the survey years. The lowest involvement in agricultural activities was recorded in 2010/11, showing a downward trend until a peak in participation was observed in 2017/18, emphasizing the changing dynamics of household involvement in agriculture.

7.1.1. Assessing The Composition of Different Food Groups Among Households — Consumption Expenditure

7.1.1.1. Bread and Cereals

The consumption expenditure on bread and cereals has remained consistently high across the three HBS rounds. This can be attributed to the global popularity of this food group, as it is considered a staple food for many, providing a significant source of dietary energy and nutrients in various human diets (Kushi, Meyer, & Jacobs Jr, 1999; McIntosh,

2001; McKevith, 2004). The consumption expenditure of this food group has also been connected to household sociodemographics that include the level of education and the occupation of the household head, as discussed by Abdollahi et al. (2014). This association is likely applicable in the context of Lesotho as well (see Figure 3). In line with the figure, the consumption expenditure on bread and cereals in 2002/03 was concentrated among households with primary education or lower, followed by a notable spread across households with secondary and vocational education. Interestingly, regardless of the education level of the household heads, a common trend was their involvement in various economic activities other than subsistence farming. This pattern suggests that the consumption of bread and cereals is widespread across different educational backgrounds, indicating its significance within the household food basket.

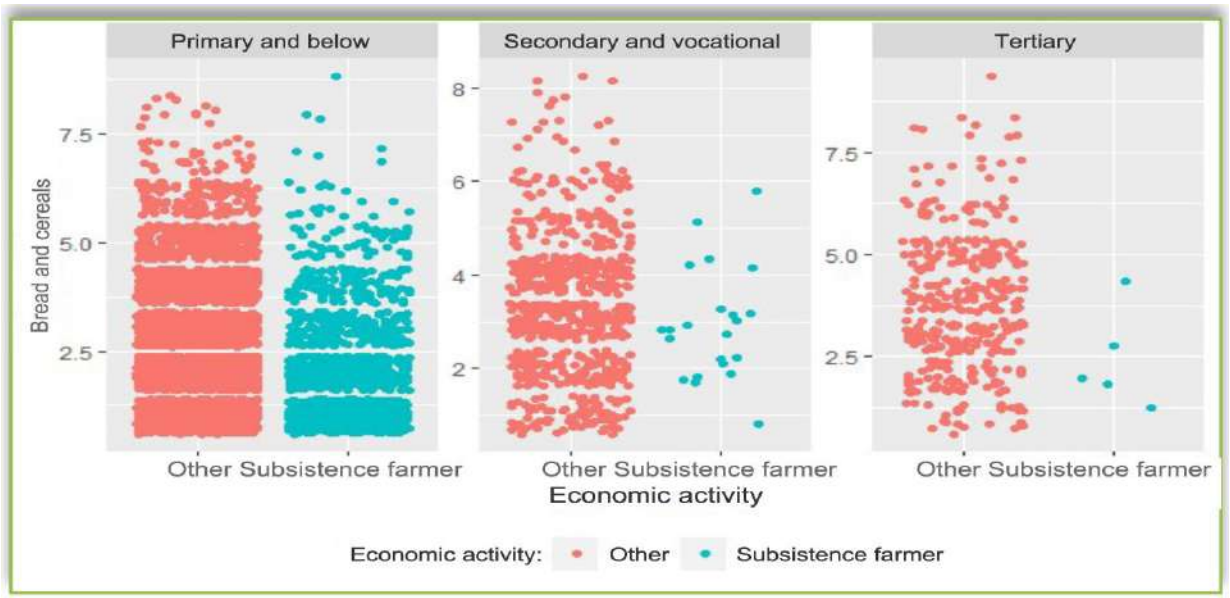

Figure 3. Consumption expenditure of bread and cereals by product count in a month for households, assessed on the education level and economic activity of the household heads, 2002/03.

In 2010/11, a similar trend is noted in the consumption expenditure on bread and cereals, although there is a distinct contrast with the patterns observed in 2002/03. During this period, the consumption expenditure on bread and cereals is largely concentrated below five product types within the group for all households, regardless of their education level, as depicted in Figure 4. This deviation from the earlier observations could suggest a shift in consumption behavior or market dynamics influencing the purchasing patterns of households in Lesotho. It is interesting to note that, in general, the variations in the distribution of consumption expenditure are minimal for subsistence farmers with higher levels of education, specifically tertiary education.

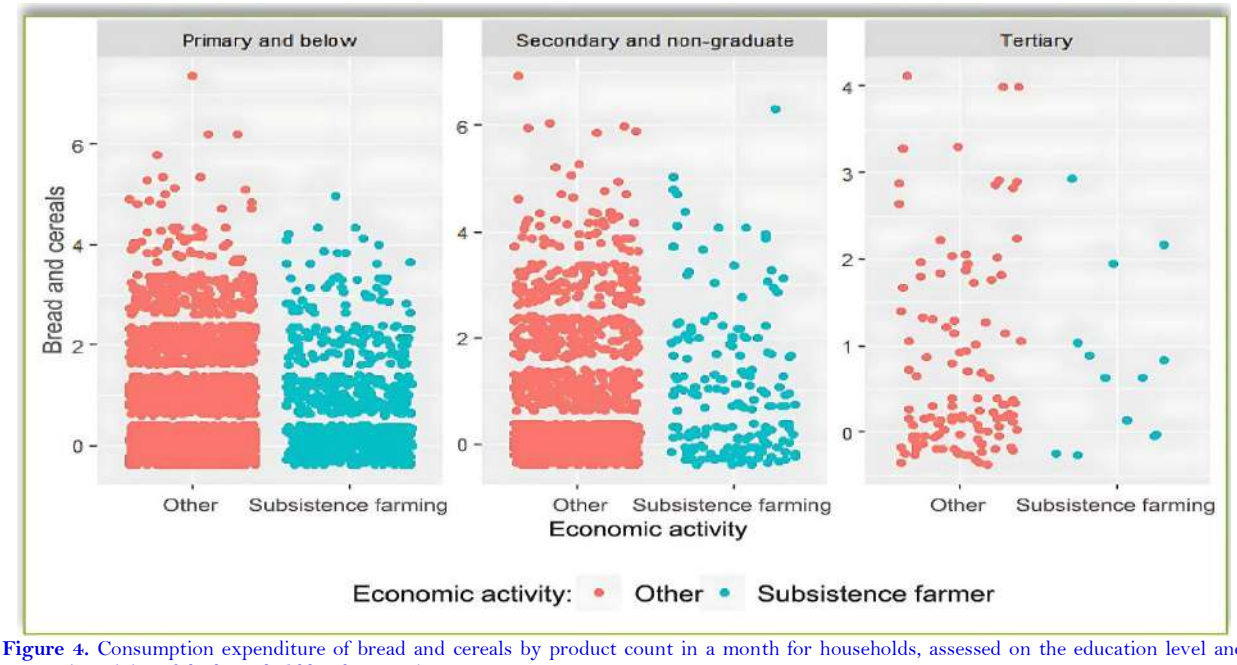

Figure 4. Consumption expenditure of bread and cereals by product count in a month for households, assessed on the education level and economic activity of the household heads, 2010/11.

In 2017/18, a slight deviation from previous trends is observed in the consumption expenditure on bread and cereals in Lesotho. During this period, a higher concentration of consumption expenditure on bread and cereal products is notable among households with secondary education and non-graduates, irrespective of their economic activity. This pattern extends further to include households with tertiary education levels, particularly those engaged in economic activities other than subsistence farming. Figure 5 illustrates this potential shift in consumption behavior, with a notable emphasis on households with secondary education and non-graduates as the primary consumers of bread and cereal products. This trend suggests that educational attainment continues to play a significant role in shaping consumption patterns, with households at different education levels exhibiting varying preferences and spending behavior on food items.

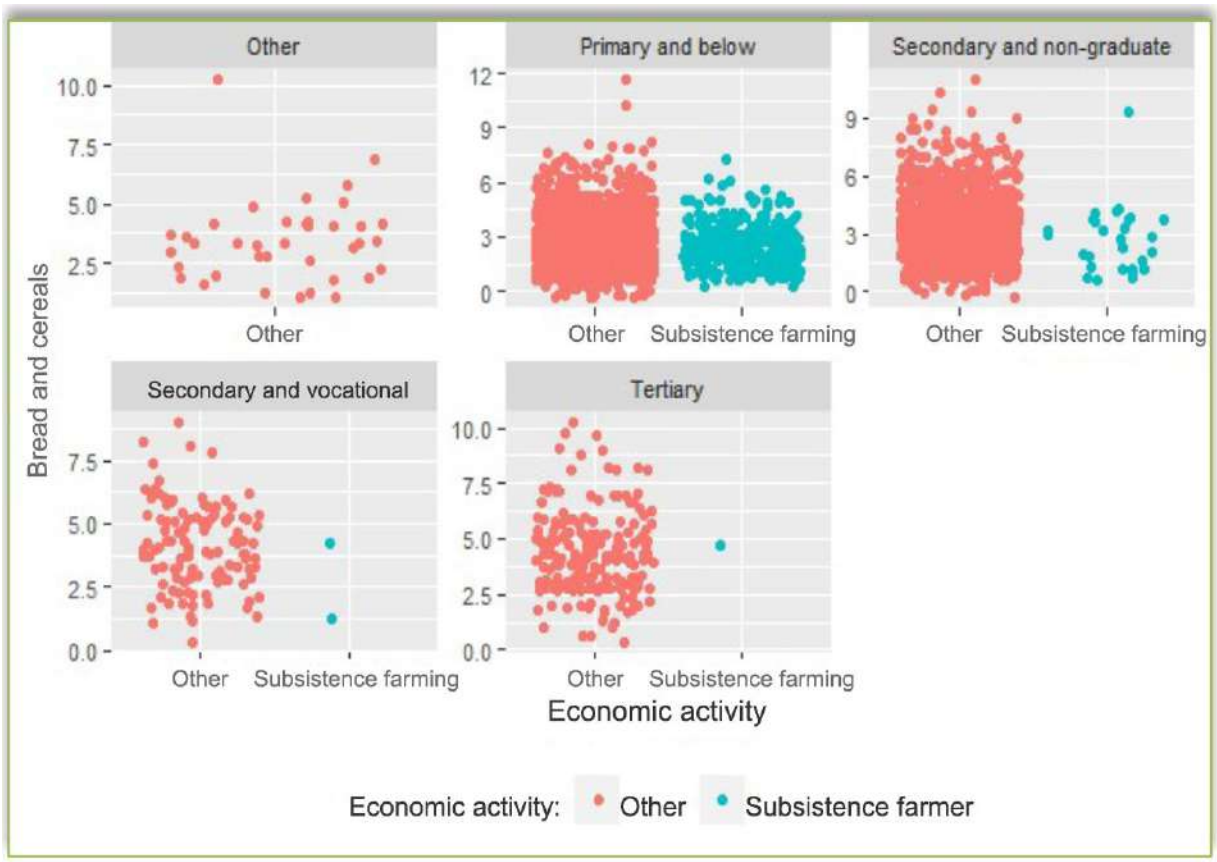

Figure 5. Consumption expenditure of bread and cereals by product count in a month for households, assessed on the education level and economic activity of the household heads, 2017/18.

7.1.1.2. Meat

Over time, the consumption expenditure on meat products in Lesotho remained relatively low, despite meat being among the top consumer foods. A different view and interpretation of this observation could mean that meat food groups were potentially compensated for by a higher intake of food products such as vegetables and other protein-rich foods while still maintaining a balanced overall diet. In contrast, factors such as affordability likely played a significant role in influencing these consumption patterns. As illustrated in Figure 6 for the year 2002/03, the consumption expenditure on meat products was generally low for household heads with primary education or lower, with the concentration of spending remaining below four product types per month. However, the spread of expenditure increased with higher levels of education among household heads. This pattern suggests that education may have an influence on the consumption of meat products, with individuals with higher education levels potentially allocating more of their food budget toward meat consumption. The skewed distribution of consumption expenditure on meat, as well as other food groups, is a common occurrence in many developing economies, as noted by Ndubueze-Ogaraku, Oyita, and Anyanwu (2016), and may be exacerbated by socioeconomic characteristics such as the economic activity of the household head. A comparison between households whose main economic activity is subsistence farming and those engaged in other activities can reveal the potential impact of income sources as determinants of meat consumption patterns.

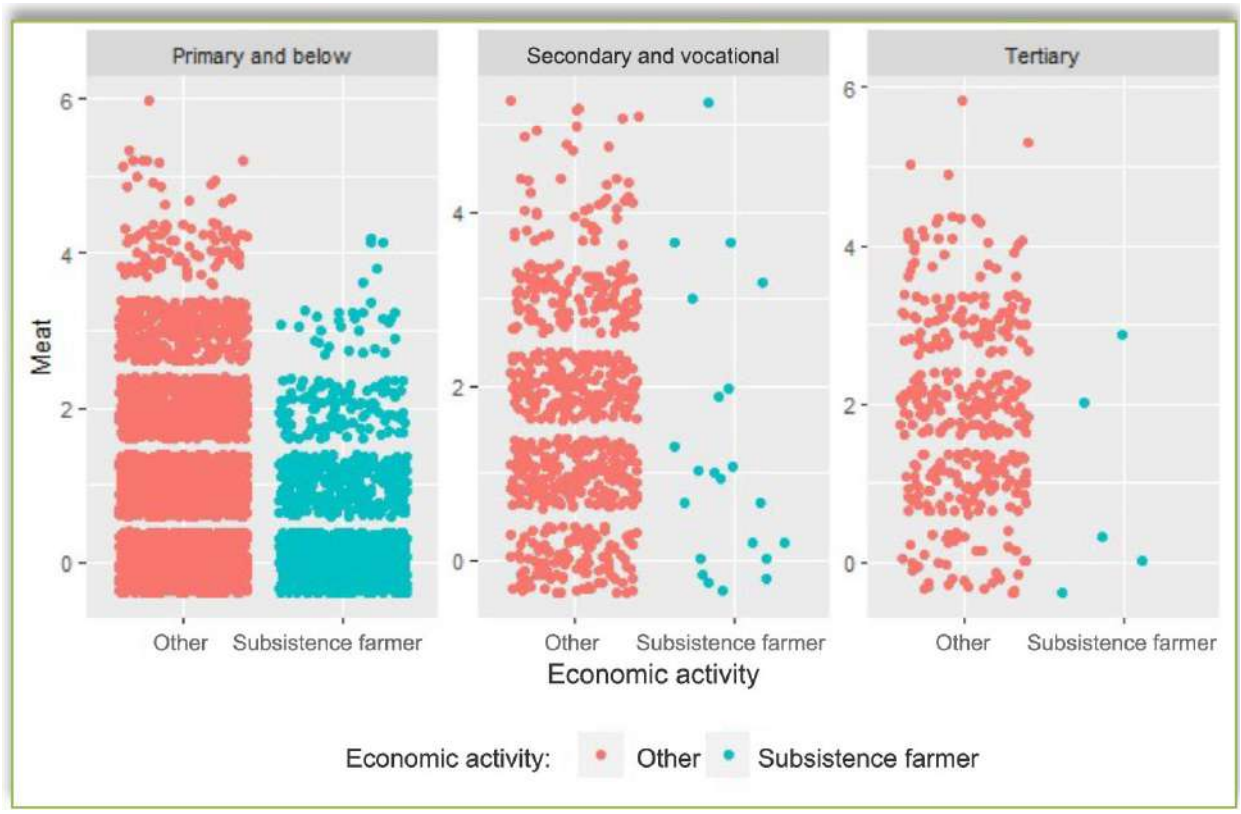

Figure 6. Consumption expenditure of meat by product count in a month for households, assessed on the education level and economic activity of the household heads, 2002/03.

Further decreases in the consumption expenditure of meat products are observed in 2010/11 and the concentration clusters below two product types a month, irrespective of the education level and economic activity of the household head see Figure 7. This trend suggests that households were faced with difficult choices during this period, likely prioritizing a macronutrient-balanced food basket within the constraints of their disposable income. This is in line with a further observation by Ndubueze-Ogaraku et al. (2016) that household income is among the major determinants of household expenditure patterns, and any changes due to time, economics, or market dynamics, among other factors will predict movements in household expenditure patterns among household groups or individual households.

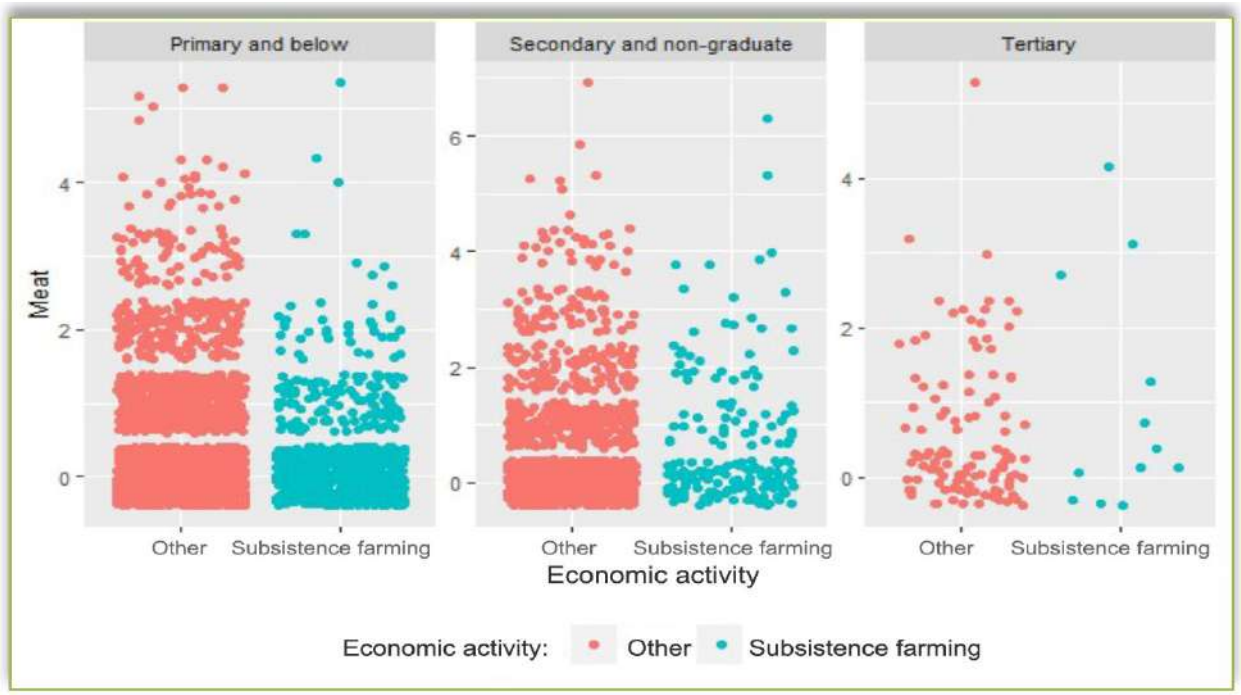

Figure 7. Consumption expenditure of meat by product count in a month for households, assessed on the education level and economic activity of the household heads, 2010/11.

In 2017/18, there was a rebound in household consumption expenditure on meat products in Lesotho, with the spread for the month increasing to levels reaching up to eight product types across all levels of education and economic activities of household heads other than subsistence farming, as shown in Figure 8. Despite this rebound, the largest concentration of spending remained below five product types per month for most households. This suggests that meat diversity could have been perceived more as a luxury rather than a staple, and in times of economic difficulties, households may have limited their meat consumption to a few selected products. The observed dynamics in meat consumption expenditure align with the findings of Bereżnicka and Pawlonka (2018), who studied the response of households in Poland (a developed economy) to changes in household economy or income levels. They noted that fluctuations in income levels were predictive of households either including or excluding certain meat products in their food basket. This highlights the sensitivity of meat consumption patterns to economic conditions and household incomes. The increase in meat consumption expenditure in 2017/18 could be attributed to improvements in the overall economic situation or changes in household incomes, prompting households to slightly increase their spending on meat products. However, the fact that the majority of households still kept their meat consumption within a limited range suggests that meat was not a fundamental component of their diet but rather a discretionary item that may be adjusted based on financial constraints. It is important to understand these dynamics in meat consumption expenditure to enable the promotion of dietary diversity, address food security issues, and improve overall nutrition outcomes towards developing targeted interventions for informed choices about food consumption.

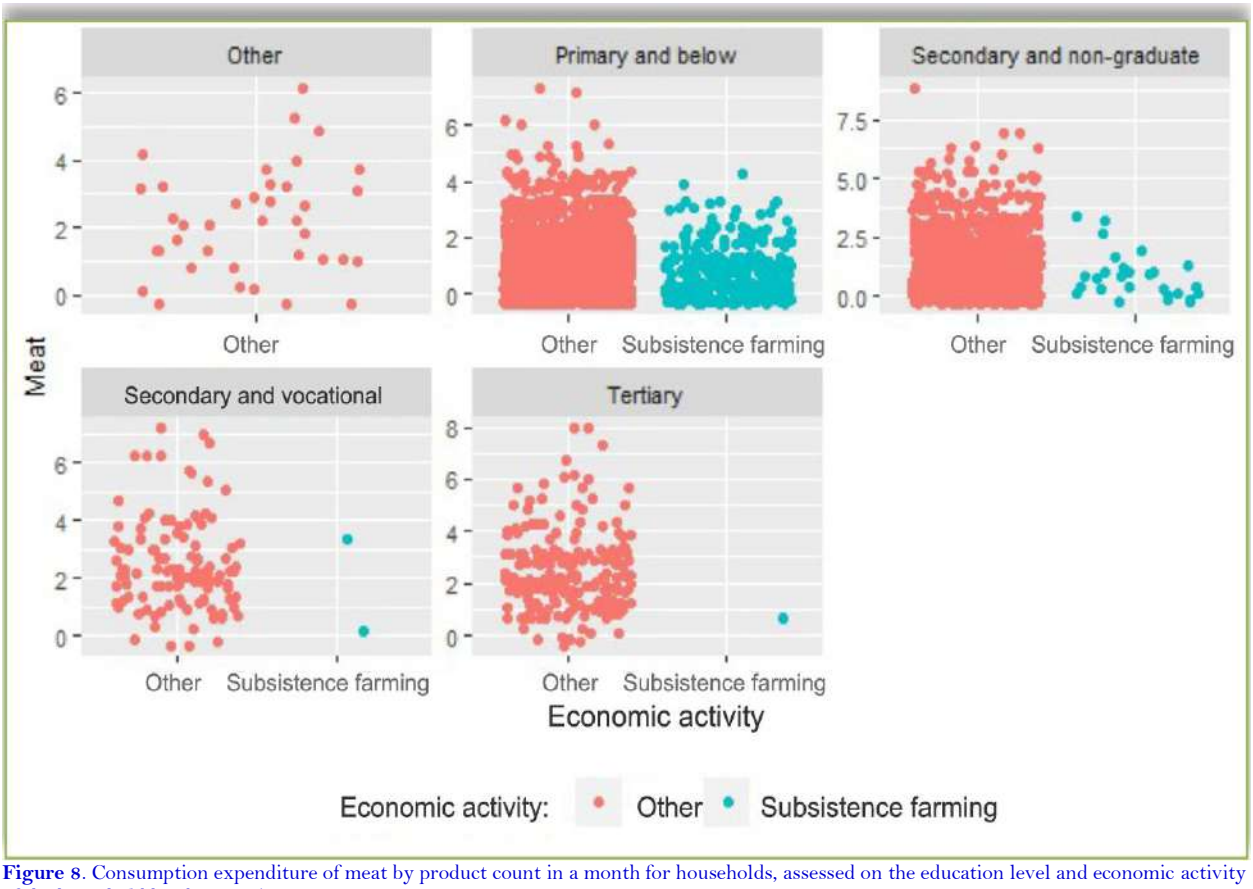

Figure 8. Consumption expenditure of meat by product count in a month for households, assessed on the education level and economic activity of the household heads, 2017/18.

7.1.1.3. Milk, Cheese and Eggs

The household consumption expenditure for a group of milk, cheese, and eggs generally compares with that of meat products, as observed in 2002/03. Despite variations in the education levels of the household heads, the expenditure on this particular food group generally stayed below four different types of products per month. This pattern remained consistent even among households with subsistence farmers, with little disparity in expenditure, even as education levels increased; see Figure 9, providing an illustrative representation of this trend. The similarity in the consumption expenditure on these protein-rich food products may be attributed to their shared importance in household diets and their status as viable alternatives to one another.

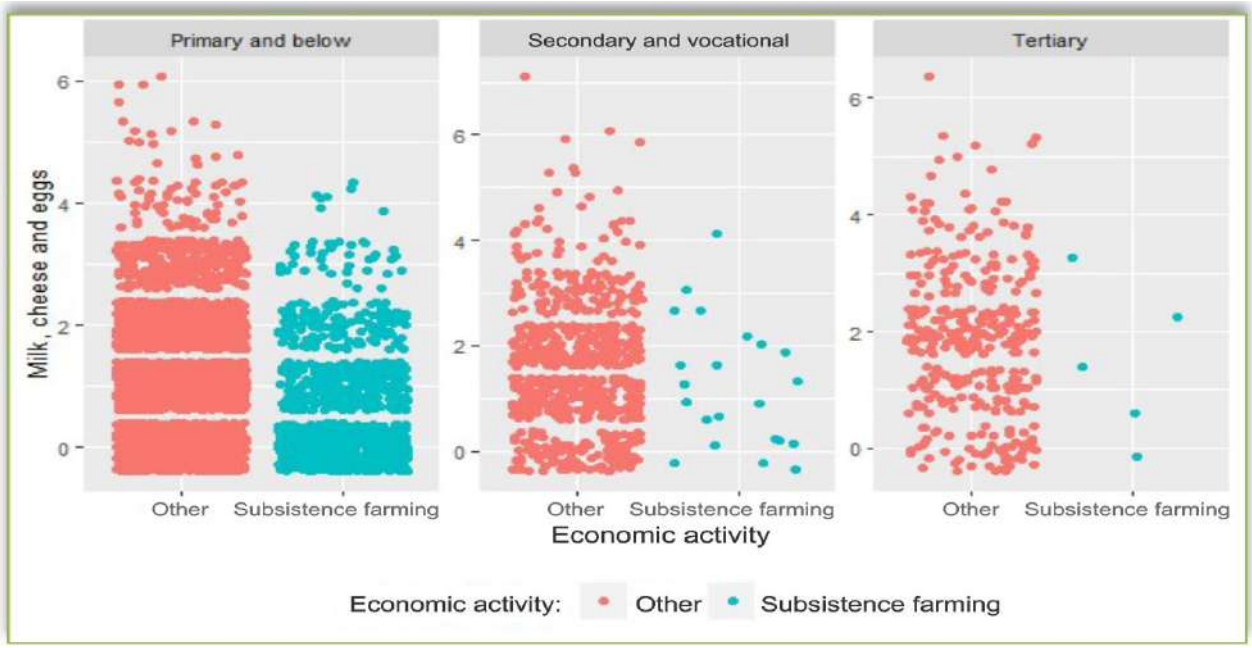

Figure 9. Consumption expenditure of milk, cheese and eggs by product count in a month for households, assessed on the education level and economic activity of the household heads, 2002/03.

Conversely, there was a marginal consumption expenditure on milk, cheese, and egg products in 2010/11, coinciding with a general decrease in household consumption expenditure on other food groups during the same period (i.e., modest consumption expenditure on bread, cereals, and meat). This trend could have been indicative of a shift in consumer preferences or economic circumstances within households. As illustrated in Figure 10, household consumption expenditure on milk, cheese, and egg products rarely exceeded four different product types in a given month of the HBS year. This pattern was consistent across households where the household heads had primary education or lower levels of schooling. However, there were slight increases to around eight product types for households where the heads had secondary or non-graduate education levels. Households with tertiary education, regardless of their economic activity, exhibited even more varied consumption patterns, with some consuming up to five different types of milk, cheese, and egg products in a single month. This diversity in consumption might indicate a higher level of disposable income or different dietary preferences among households with higher education levels.

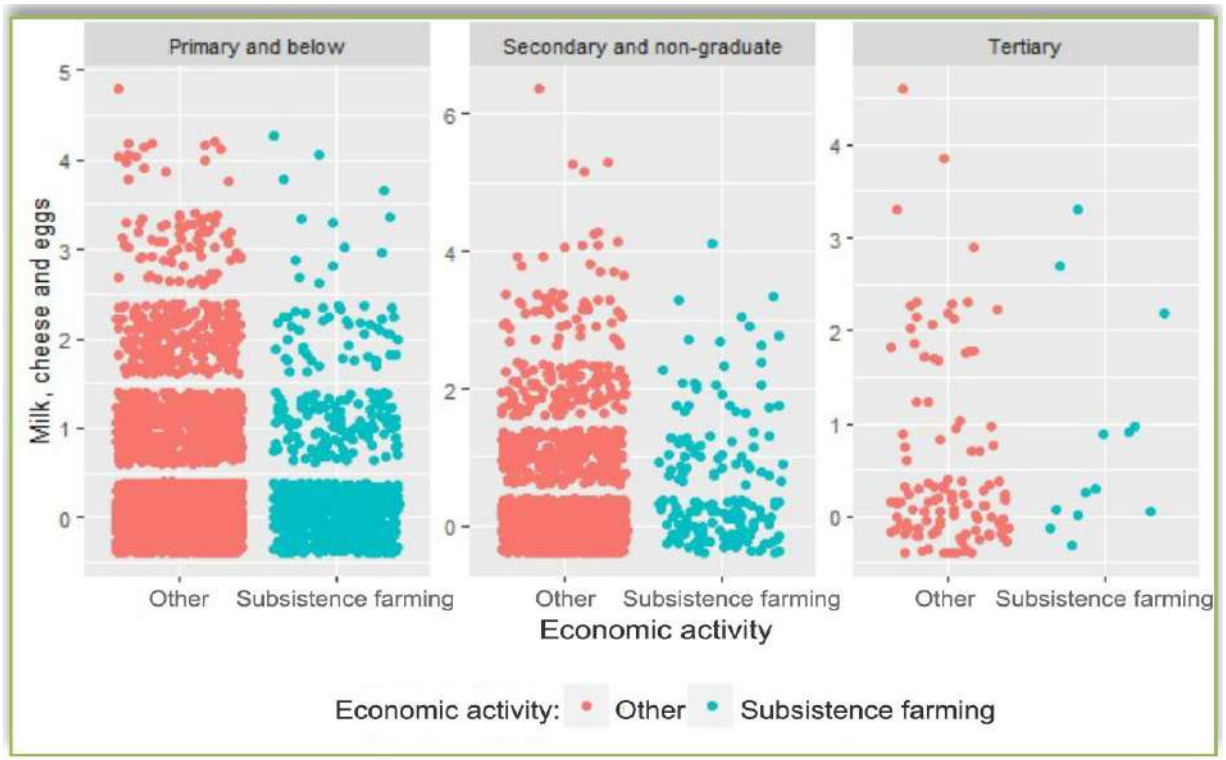

Figure 10. Consumption expenditure of milk, cheese and eggs by product count in a month for households, assessed on the education level and economic activity of the household heads, 2010/11.

In 2017/18, similar to other food groups, household consumption expenditure on milk, cheese, and egg products increased, surpassing four product types for most households regardless of their education level and economic activity (refer to Figure 11). This pattern appears to be in line with the general poverty dynamics or gap in Lesotho, where there was a modest reduction in the population below the national poverty line, decreasing to 49.7% in 2017/18 from 56.6% in 2002/03 and 57.1% in 2010/11, according to the Warren et al. (2015). Various factors may have influenced this upward trend in consumption. One plausible explanation could be a sense of consumer relief or optimism towards spending. This suggests that households may be feeling more financially secure, leading to an increase in discretionary spending on goods and services, potentially indicating an improvement in their overall purchasing power and economic well-being. Another possible factor contributing to this trend could be the rising education levels in Lesotho. As education levels increase, so does awareness of the importance of nutrition and the role that dairy and egg products play in a balanced diet. This increased awareness may have led to a higher demand for these products, driving up consumption expenditure, further coinciding with the launch of the Lesotho Food and Nutrition Policy, 2016-2025, which could have seen several programs in place aimed at increasing nutrition awareness in the country.

Figure 11. Consumption expenditure of milk, cheese and eggs by product count in a month for households, assessed on the education level and economic activity of the household heads, 2017/18.

7.1.1.4. Fish

Household consumption expenditure on fish remained relatively low across all the survey rounds. The observation is consistent with the generally low levels of food-fish consumption in Sub-Saharan Africa, with the food group observed to be more prominent in the diets of people near coastal areas and large inland water bodies (Delgado & McKenna, 1997). In the context of Lesotho, this is despite the fact that the country is surrounded by South Africa, which boasts seas that make it a hotspot for fishing activities. At the same time, Lesotho is producing fish (trout) from its freshwater ecosystems (dams, rivers, etc.). Nonetheless, an observation by Speedy (2003) is that the consumption of fish, similar to meat products, relies on other aspects: household wealth or the rapidly increasing per capita GDP[a] of a country are some of those key factors, which is likely inverse for many developing countries such as Lesotho, corroborating the fact that this food group is characteristic of luxury food. As illustrated in Figure 12, the household consumption expenditure on fish in Lesotho in 2002/03 was relatively low, with consumption levels averaging around two product types per month, regardless of the education level or economic activity of the household head. This suggests that fish consumption may not be a high priority in the household budget, possibly due to factors such as availability, cost, cultural preferences, and perceptions of fish as a luxury food item. Despite the fact that Lesotho is already producing fish, particularly trout from its freshwater ecosystems, it appears that fish consumption has not been widely adopted as a significant component of household diets in the country. This disconnect between fish production, fish importation, and consumption levels may indicate barriers such as logistical challenges in distribution, lack of awareness or promotion of locally sourced fish, and entrenched dietary habits that favor other protein sources.

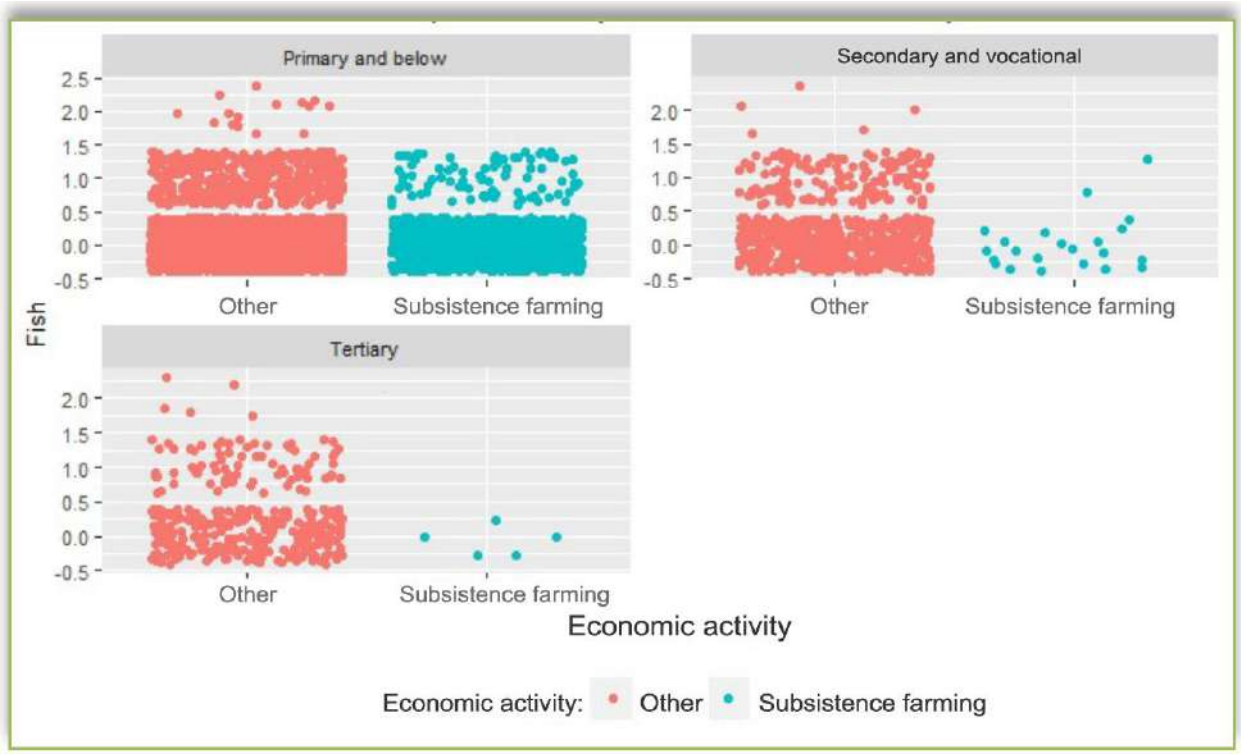

Figure 12. Consumption expenditure of fish by product count in a month for households, assessed on the education level and economic activity of the household heads, 2002/03.

Similar to the observation in 2002/03, household expenditure on fish remained low in 2010/11, with some households going a month without recording any consumption expenditure on this food group, as shown in Figure 13. This trend persisted even when taking into account the education level and economic activity of the household head.

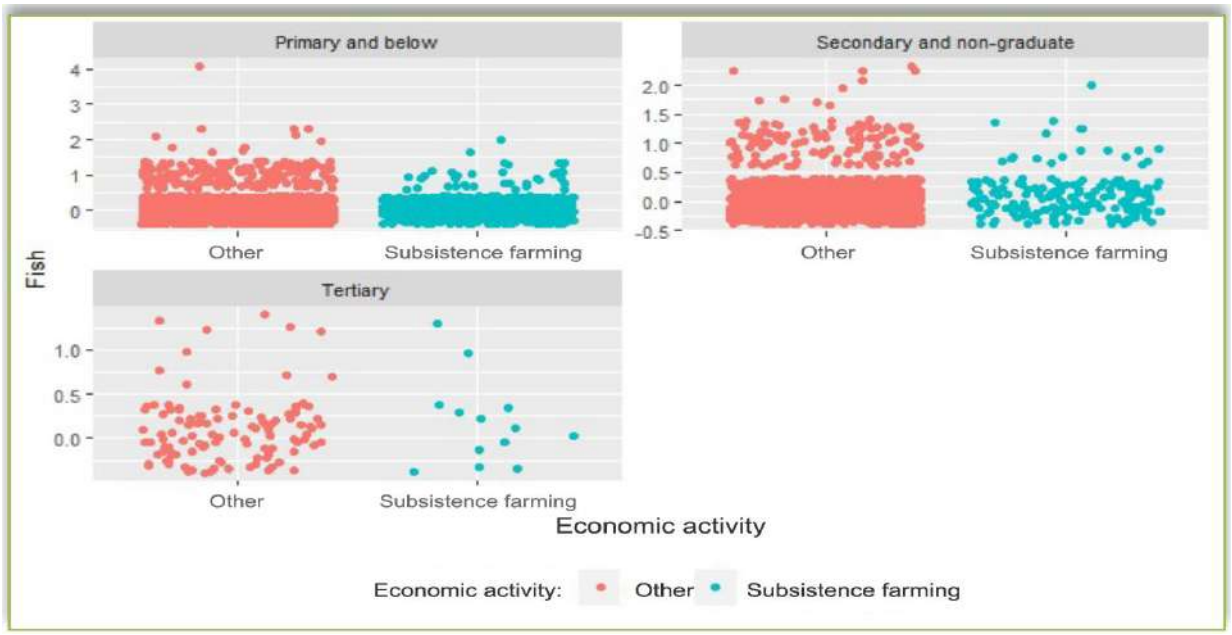

Figure 13. Consumption expenditure of fish by product count in a month for households, assessed on the education level and economic activity of the household heads, 2010/11.

Slight increases in the consumption expenditure on fish were observed in 2017/18, possibly correlating with the rising household income, which averaged M16,355 in 2017/18 compared to M1,273 in 2002/03. As illustrated in Figure 14, some households recorded consumption expenditure on up to six different types of fish products in a month (recall the fish composition in Table 1 on food groups). However, for the majority of households, the concentration of consumption expenditure remained below four product types per month. This trend persisted regardless of the education level and economic activity of the households.

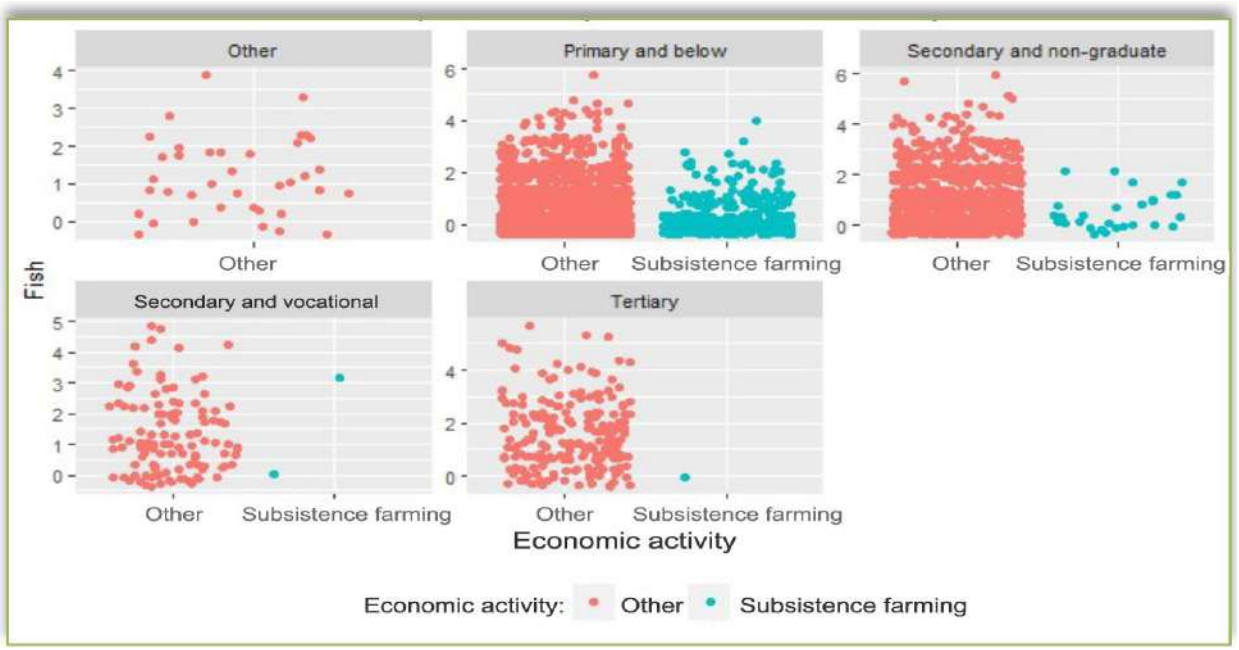

Figure 14. Consumption expenditure of fish by product count in a month for households, assessed on the education level and economic activity of the household heads, 2017/18.

7.1.1.5. Fruits

The household consumption expenditure on fruits remained fairly high across the three survey measurements. Fruits were categorized into various groups, including berries (i.e., blackberries and blueberries), core fruits (i.e., apples and pears), citrus fruits (i.e., oranges and lemons), pit fruits (i.e., pears and plums), and melons (i.e., watermelon). This wide grouping of types of fruits in the measurement increased the household's choice towards consuming fruits in a given time period. Some fruits could have been from their household produce, while others are easily accessible from the market. This accessibility and variety in fruit options may contribute to the sustained high consumption expenditure on fruits among households. For example, in 2002/03, household consumption expenditure on fruits approximated levels as high as 10 different types of fruits per month for households where the household heads had achieved primary education or lower. Increased levels of consumption were also observed for households with higher levels of education, with variations depending on the economic activities of the household heads, as shown in Figure 15. Further associations were noted for increased consumption expenditure on fruits among families with children. This could be due to fruits being part of the recommended diet for children and adolescents in some schools, leading to a higher incentive for families with children to include fruits in their diet. The consumption of fruits may also be recommended for pregnant mothers and lactating women for their nutritional benefits, as suggested by Shokrvash et al. (2013). This recommendation for a healthy diet for pregnant and lactating women may further contribute to the overall household consumption expenditure on fruits.

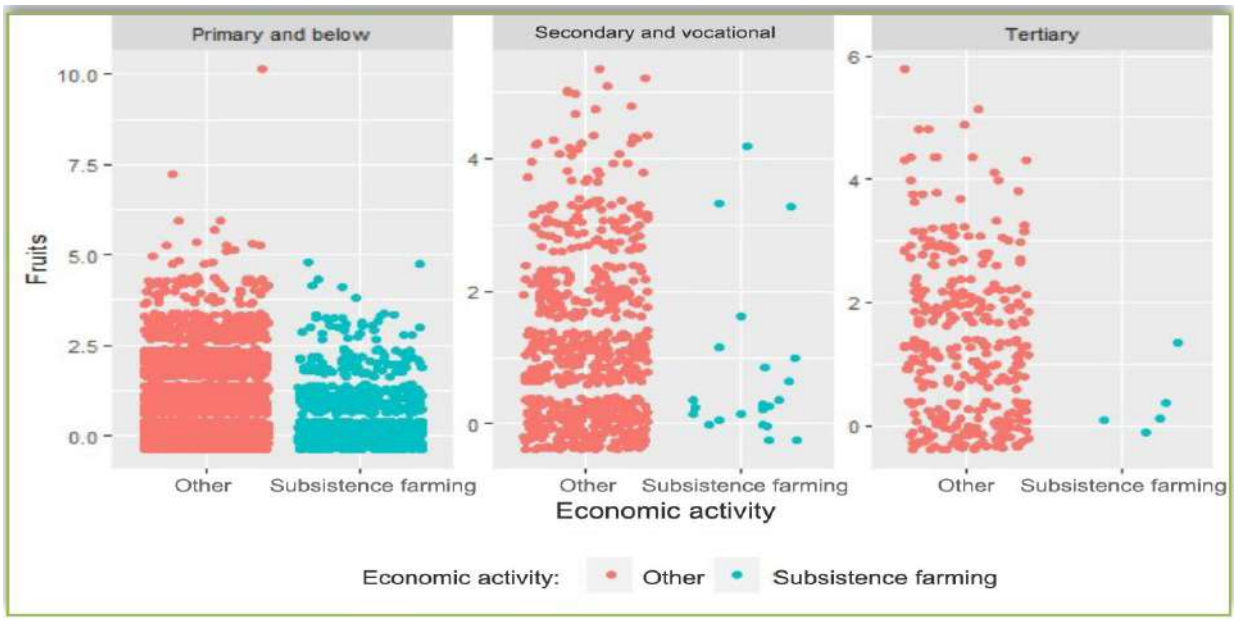

Figure 15. Consumption expenditure of fruits by product count in a month for households, assessed on the education level and economic activity of the household heads, 2002/03.

While household consumption expenditure on fruits was relatively high in 2002/03, a notable reduction was observed in 2010/11, with the concentration of consumption expenditure hovering below two types of fruits in the month under review. As illustrated in Figure 16, even after accounting for the education level and economic activity of the household heads, the pattern remains largely the same, with a few households registering consumption expenditure levels above four types of fruits per month.

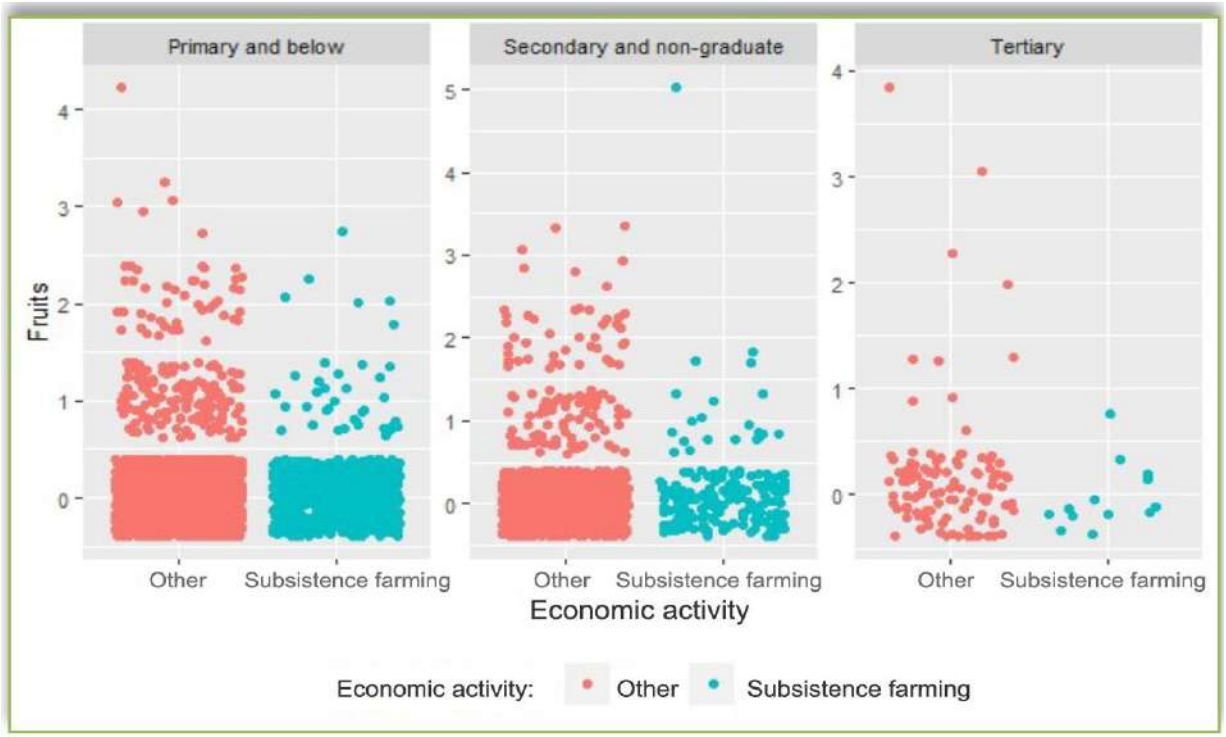

Figure 16. Consumption expenditure of fruits by product count in a month for households, assessed on the education level and economic activity of the household heads, 2010/11.

In 2017/18, there was a slight rebound in household consumption expenditure on fruits, as shown in Figure 17. The concentration of household consumption expenditure was evident among households where the household heads had attained primary education or lower, as well as among household heads with secondary education and no graduate education. This pattern held true for both demographic groups, regardless of their economic activities.

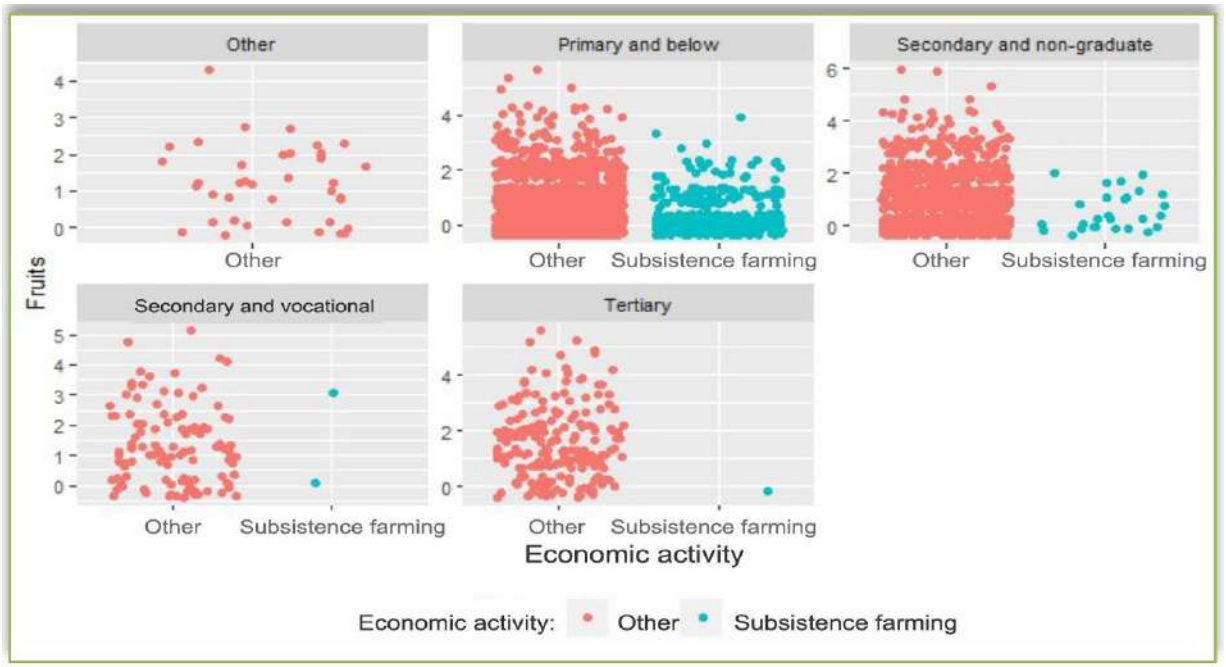

Figure 17. Consumption expenditure of fruits by product count in a month for households, assessed on the education level and economic activity of the household heads, 2017/18.

7.1.1.6. Vegetables

The consumption expenditure on vegetable products by households in Lesotho remained relatively high across the three HBS measurements (from 2002/03 to 2017/18, a 16-year gap), despite potential changes in economic growth, market integration, diversification, urbanization, changing lifestyles, and advancements in modern supply chains that are believed to impact transformations in food systems (Mergenthaler, Weinberger, & Qaim, 2009). Leafy vegetables, in particular, are known to significantly contribute to household food security and provide variety to cereal-based staple diets (Uusiku, Oelofse, Duodu, Bester, & Faber, 2010), hence their high consumption. In Lesotho, some of these vegetable products are indigenous and have been part of household diets for generations.

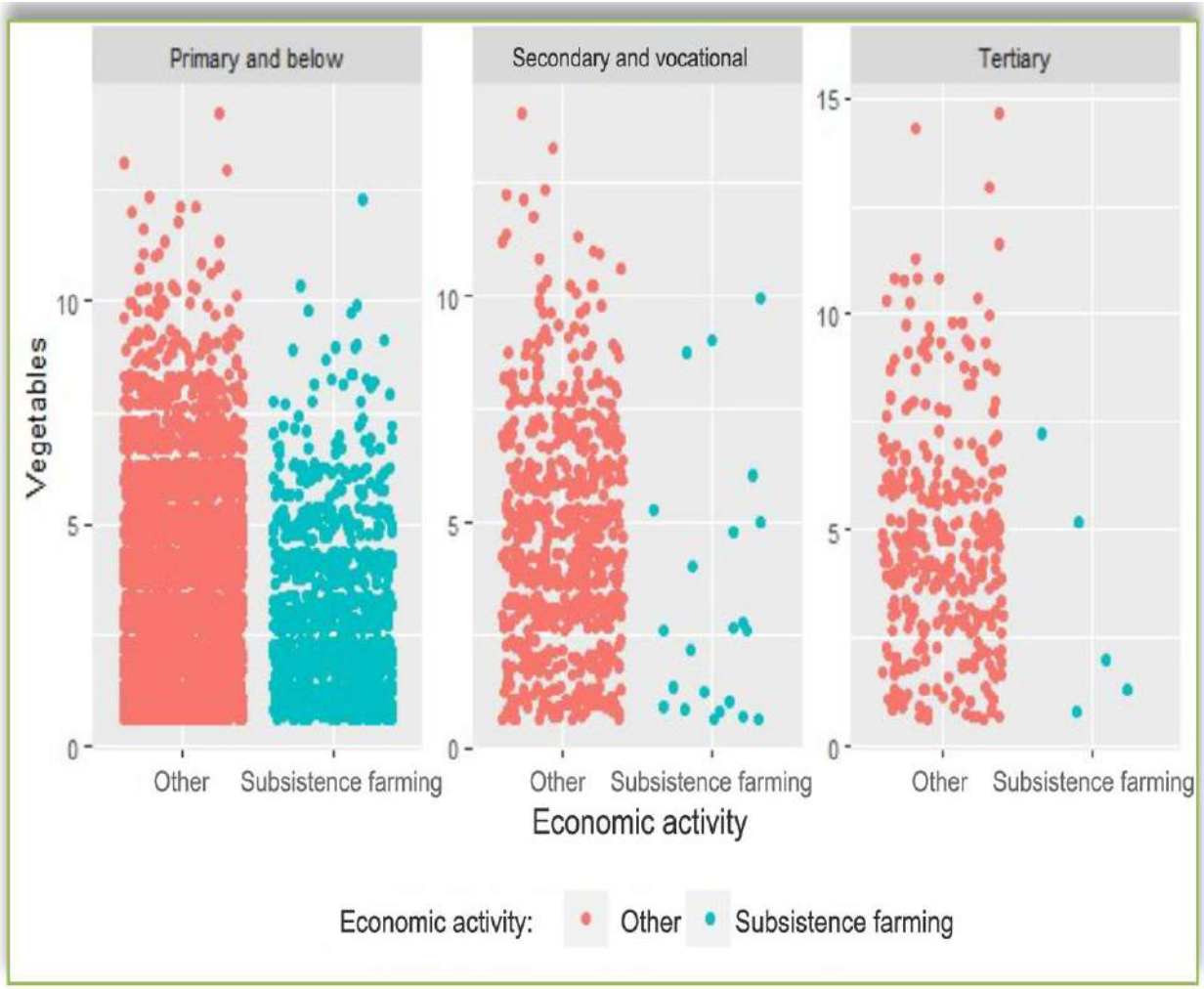

Figure 18. Consumption expenditure of vegetables by product count in a month for households, assessed on the education level and economic activity of the household heads, 2002/03.

For example, in 2002/03, household consumption expenditure on vegetable products could reach levels as high as 15 vegetable types per month for households regardless of their education level (see Figure 18). This notable consumption of diverse vegetable products was more prevalent in households engaged in activities other than subsistence farming.

Similar observations were made regarding other food groups, as household consumption expenditure on vegetables saw a slight decrease in 2010/11 compared to the diversity recorded in 2002/03. For instance, as illustrated in Figure 19, the concentration of consumption expenditure was found to be below 10 vegetable types per month in households where the household heads had primary education or lower, as well as in households with secondary education and non-graduates. The diversity of vegetables consumed notably decreased with higher levels of education, such as at the tertiary education level.

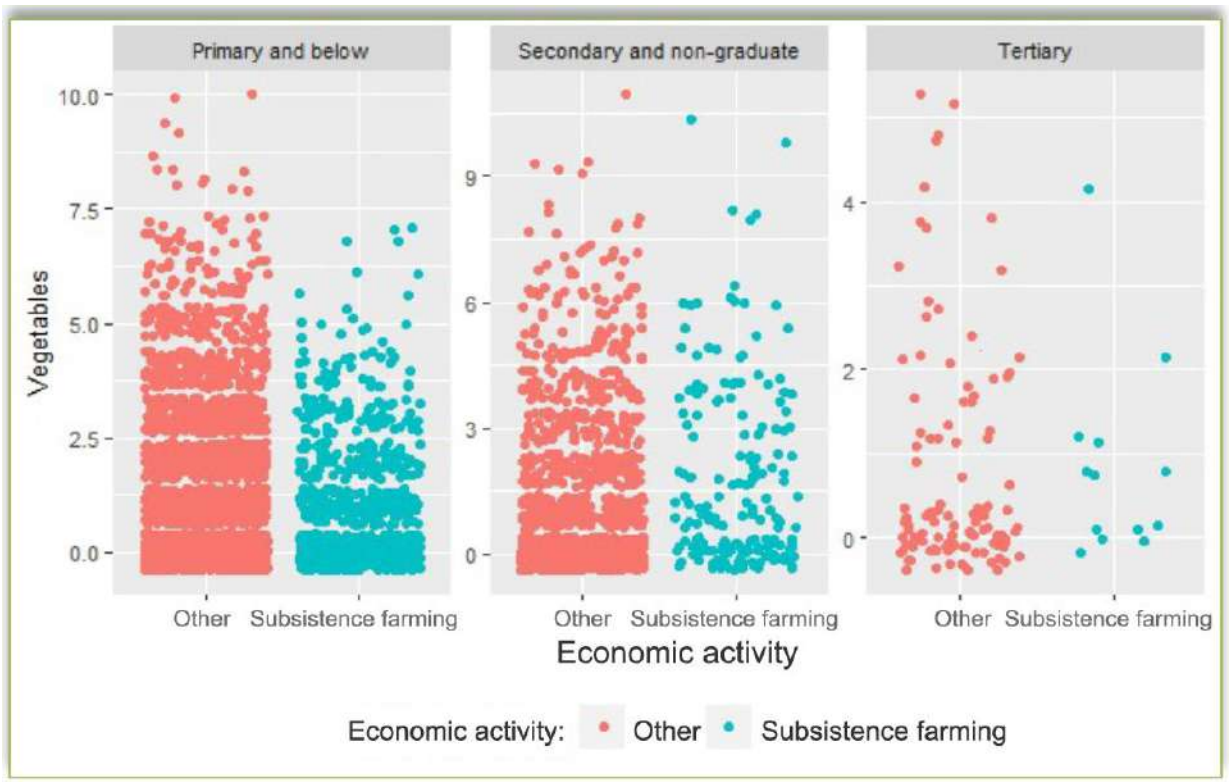

Figure 19. Consumption expenditure of vegetables by product count in a month for households, assessed on the education level and economic activity of the household heads, 2010/11.

In 2017/18, household expenditure on vegetable products remained steady at around 10 product types within the same food group as in 2010/11. However, there was a significant increase in consumption observed in households where the household head had a tertiary qualification and was also engaged in other economic activities besides subsistence farming, as shown in Figure 20.

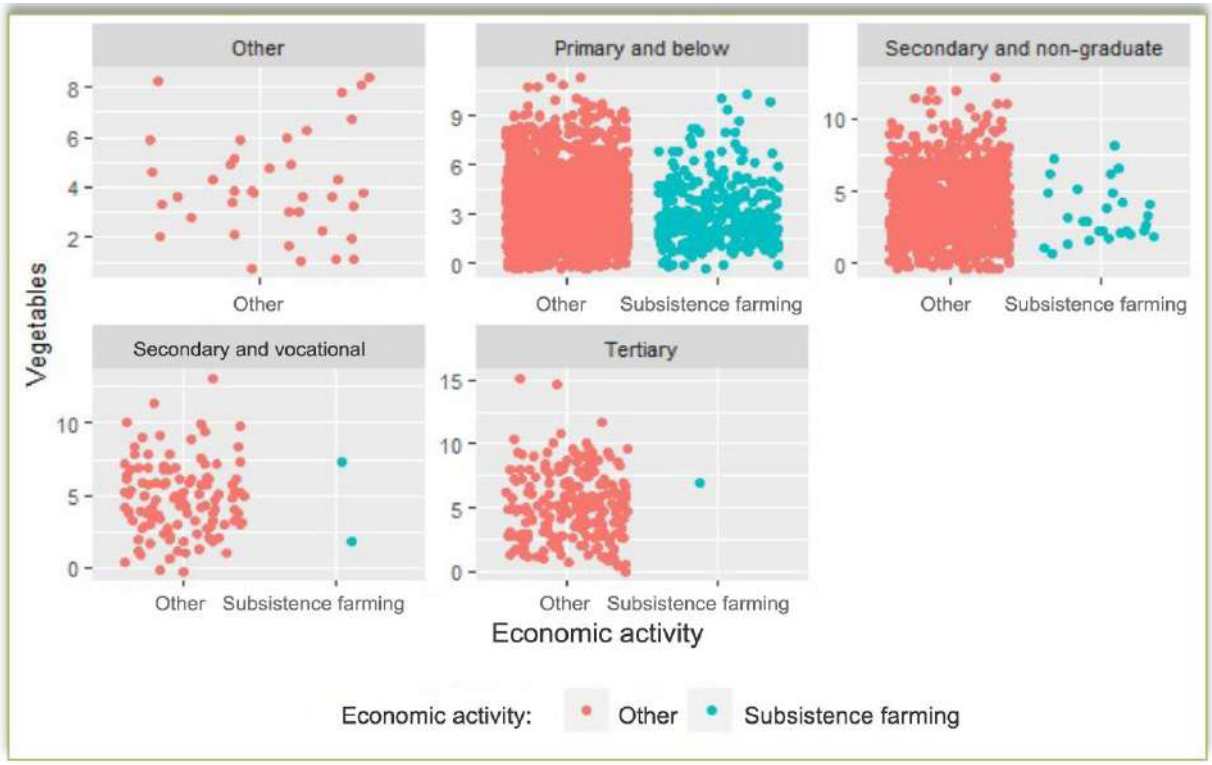

Figure 20. Consumption expenditure of vegetables by product count in a month for households, assessed on the education level and economic activity of the household heads, 2017/18.

7.1.2. Assessing Food Diversity Among Households by Their Socio-Demographic Characteristics

Several studies have posited differences in the consumption behavior of households regarding product types and household dynamics (i.e., socio-demographic characteristics of the household). The dynamism of this behavior has been argued to extend to other dimensions, such as the number of diverse products a household consumes in a specific time period. Factors such as the age structure of household members, the income of household members, and household size are among the predictors of changes in consumption patterns (Lee & Brown, 1989; Thiele & Weiss, 2003). Similarly, the determination of consumption expenditure on a variety of food products by Lesotho households reflects variations over time, influenced by the education level and economic activity of the household head. Simpson's Index or the related Berry Index (or Entropy Index, and/or Herfindahl Index) has been featured among a plethora of different approaches used to quantify the diversity of food products consumed or demanded by households or individuals in several of these studies; however, less attention has been devoted to connecting food diversity (with its argued nutritional benefits) to health costs, which is the aim of this study. Firstly, the study examines the relationship between household demographics and changes in aggregate diversity, measured using Simpson's Index. The next section of the study examines the connection between diversity and health expenditure in relation to household dynamics. As shown in Figure 21, an increase in household size generally results in higher household food diversity, consistent with existing literature. However, the study also notes that smaller households can achieve high food diversity, although they may consume less diverse products.

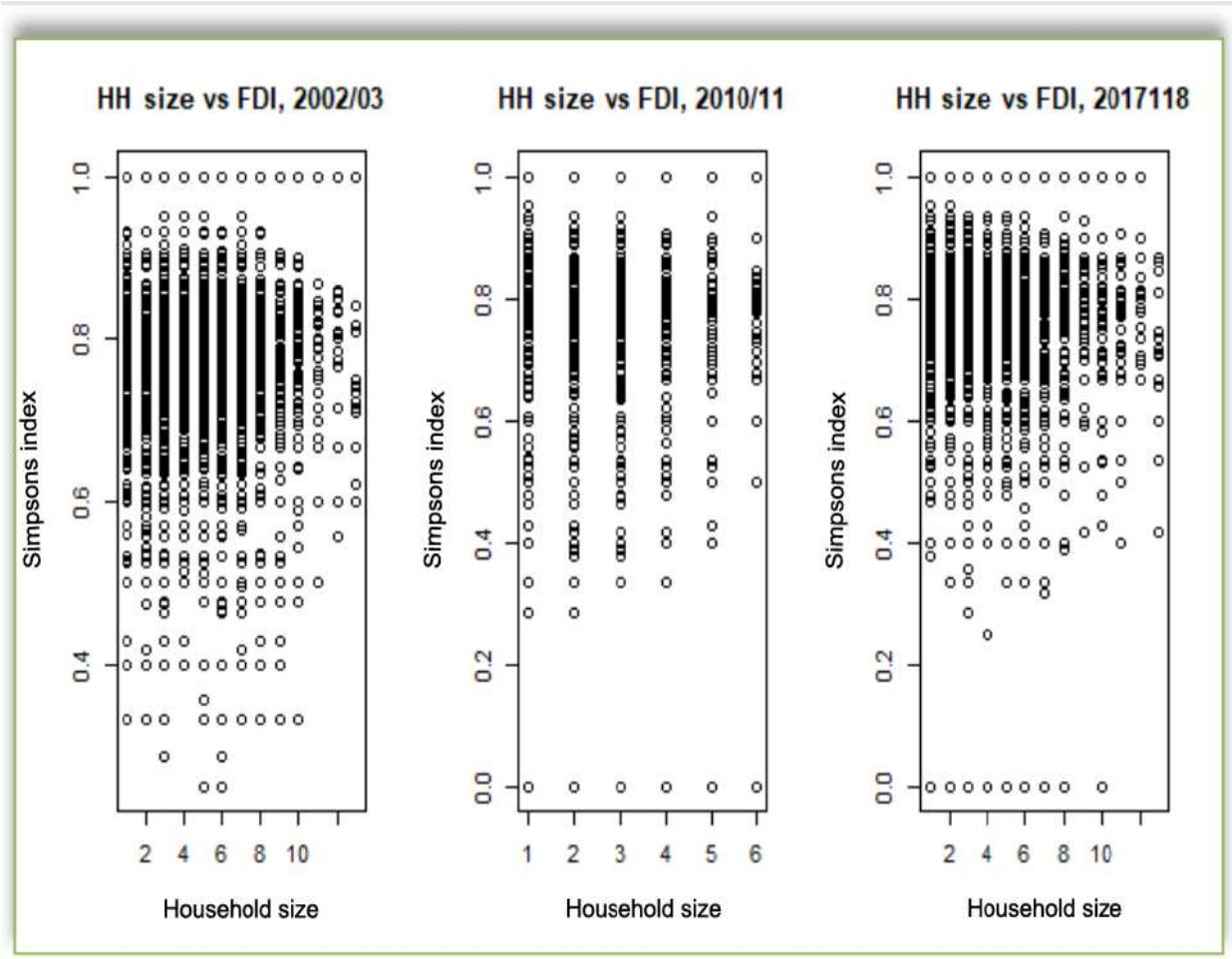

Figure 21. Assessing food diversity index by household size for three HBS cycles: 2002/03 to 2017/18.

When analysing the relationship between the educational background of the household head and household size, as well as household food diversity (refer to Figure 22), higher diversity scores were evident in 2002/03 with increases in the education level of the household head, regardless of household size. This contrasts slightly with households where the household heads have only obtained primary education or below (see clustering of diversity scores hovering below 0.6). This observation is consistent with existing research suggesting that advancements in education levels can lead to higher household income, thereby increasing purchasing power and awareness of the benefits of healthy eating (Singh, Jones, DeFries, & Jain, 2020).

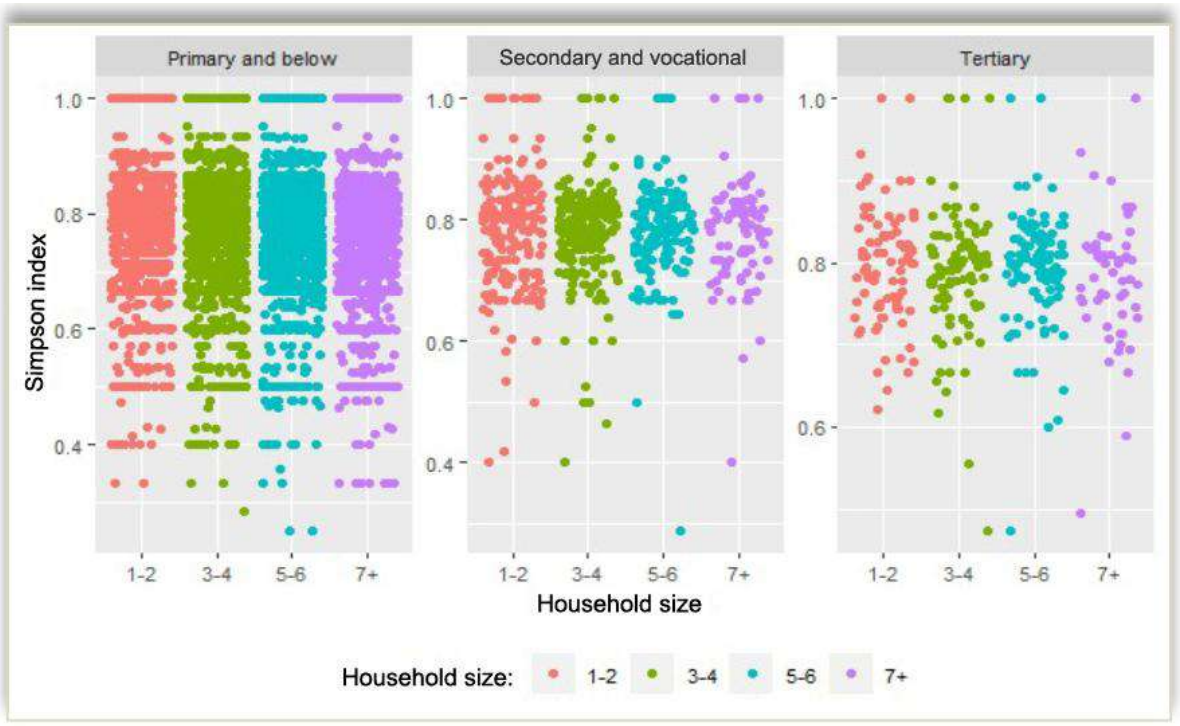

Figure 22. Assessing food diversity index by household size and education level of the household head, 2002/03.

The relationship between income and food diversity, and its potential impact on higher dietary diversity scores, is further highlighted in Figure 23. This pattern remains consistent across the three rounds of the HBS. As depicted in the figure, lower-income households may sometimes have limited options to enhance the diversity of their food choices (or food baskets), whereas higher-income households tend to cluster around higher diversity scores.

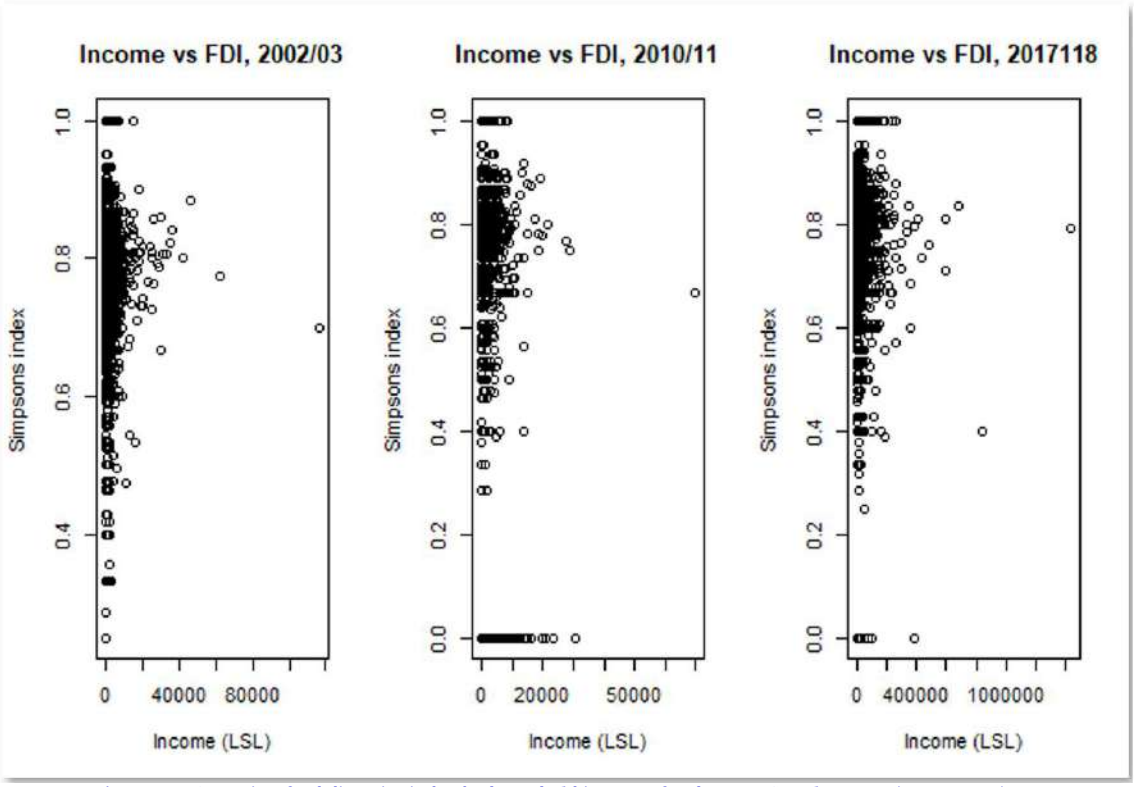

Figure 23. Assessing food diversity index by household incomes for three HBS cycles: 2002/03 to 2017/18.

A reflection of the same dynamics accounting for the education level of the household head corroborates findings from other literature where increases in education level become a factor in income increases and higher food diversity (see Figure 24).

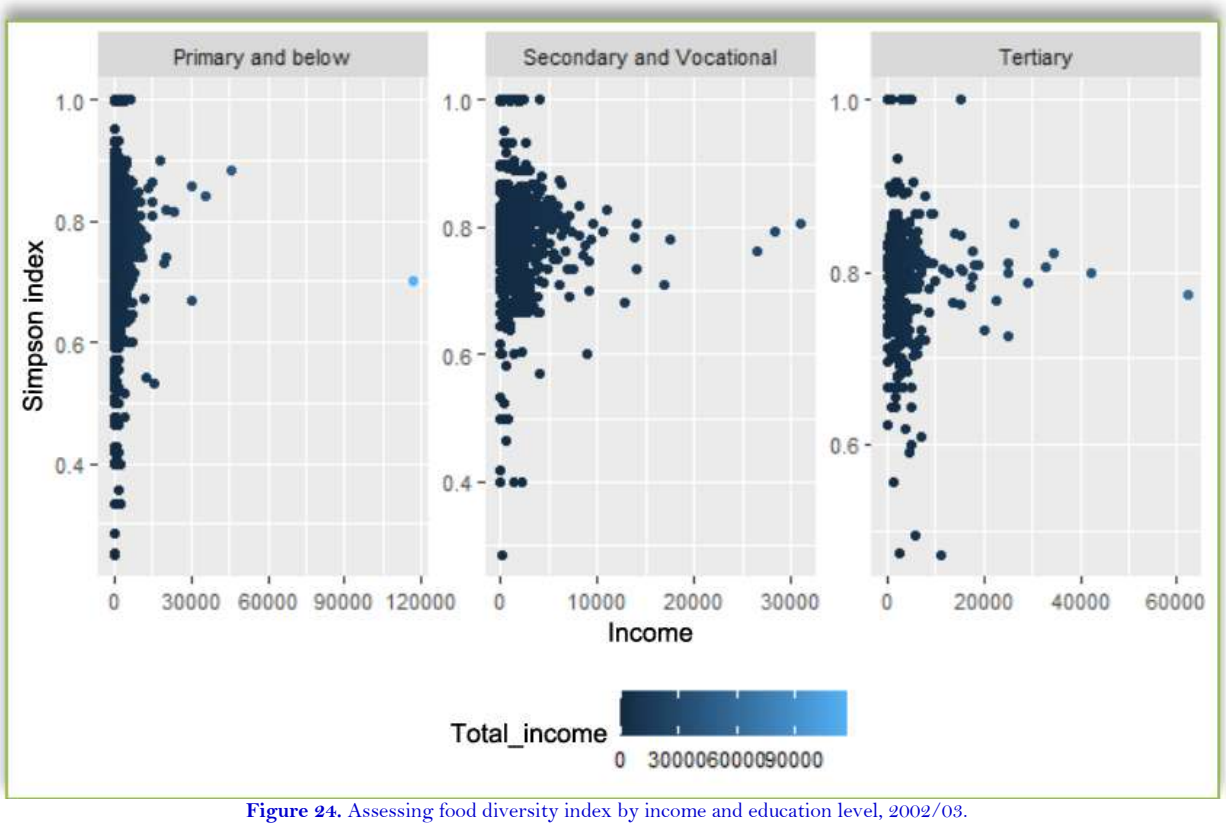

Figure 24. Assessing food diversity index by income and education level, 2002/03.

Regarding the geographic effect on household income and its influence on household food diversity, as illustrated in Figure 25, it is apparent that higher incomes were more prevalent among urban residents in 2002/03. The distribution of food diversity scores generally shows comparability between rural and urban regions; however, it is important to recognize that variables like market accessibility may impact food choices and composition. It is further noteworthy that rural areas may not exhibit the same correlation between income and food diversity as experienced in urban settings. This suggests that achieving food diversity in rural areas may rely more on factors such as agricultural output rather than income alone.

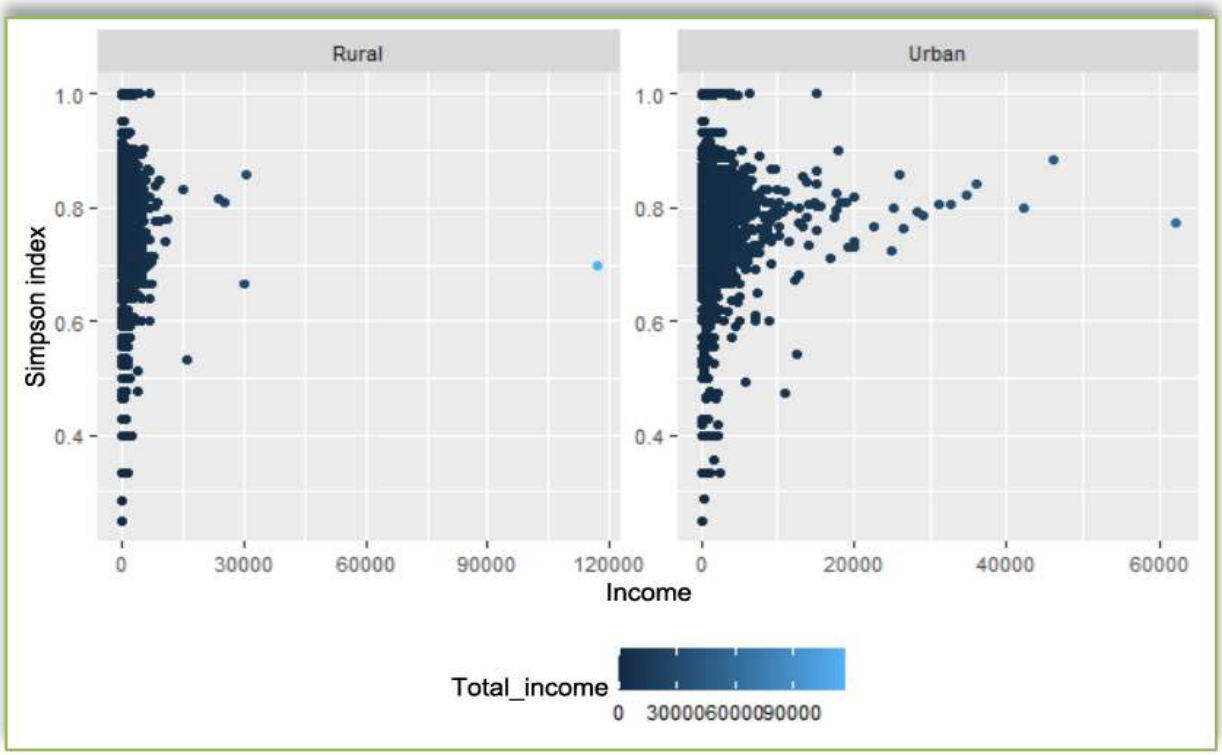

Figure 25. Assessing food diversity index by income and residence (Urban and rural), 2002/03.

Expanding the investigation into potential district disparities, insights from the HBS 2002/03 highlight variations in income distribution, indicating income inequality across households in Lesotho. Specifically, districts in the lowlands like Butha-Buthe, Leribe, and Maseru exhibit higher income scales. Despite this, all districts show similar distributions of food diversity scores, as depicted in Figure 26.

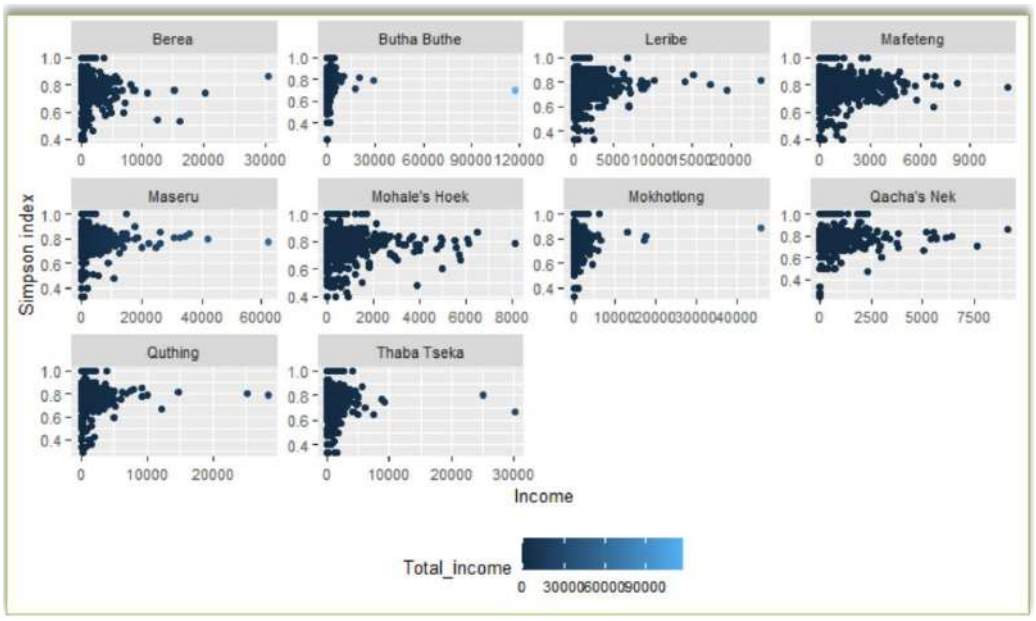

Figure 26. Assessing food diversity index by income and district of households, 2002/03.

7.1.3. Assessing Food Diversity and Expenditure on Health Among Households by Their Socio-Demographic Characteristics

The connection between varied foods (a potential proxy for diet quality) draws support from previous studies, from which a recommendation to consume a wider variety of foods and food groups has been a key highlight for informing dietary guidance in some countries. As observed by Vadiveloo et al. (2014), the connection between greater consumption of a variety of foods was historically associated with a reduction in mortality and the risk of chronic disease. However, in recent years, concerns have arisen about the potential association between dietary variety and health issues (i.e., obesity due to a possible high intake of some food groups that may contribute to excess energy). While the concern registers as a potential drawback, if, on the one hand, a dietary pattern comprises a variety of healthy foods, this may contribute to the well-being of individuals and lower illnesses and mortality.

Figure 27. Assessing food diversity index and expenditure on health by households across districts in Lesotho, 2002/03.

Building upon this, the study investigated the potential distribution between food diversity, health expenditure, and the possible impact of household location. Figure 27 posits that in 2002/03, the distribution of household expenditure on health-related costs was consistent across districts, regardless of the dynamics describing food diversity. This suggests that the distribution of food diversity scores is similar for all districts in Lesotho, regardless of whether health expenditure is registered or not. In other words, despite differences in food diversity, households in

different districts tend to spend similar amounts on health-related expenses, indicating that the location of the household may not have a significant impact on the relationship between food diversity and health expenditure. The study also found that the distribution between food diversity, health expenditure, and household location remained consistent across different time periods. Specifically, the analysis of data from 2010/11 revealed that the relationship between these three variables was similar to that observed in 2002/03, as illustrated in Figure 28. This suggests that the dynamics between food diversity, health expenditure, and household location did not change significantly over the nine-year period, indicating a stable and persistent relationship between these variables.

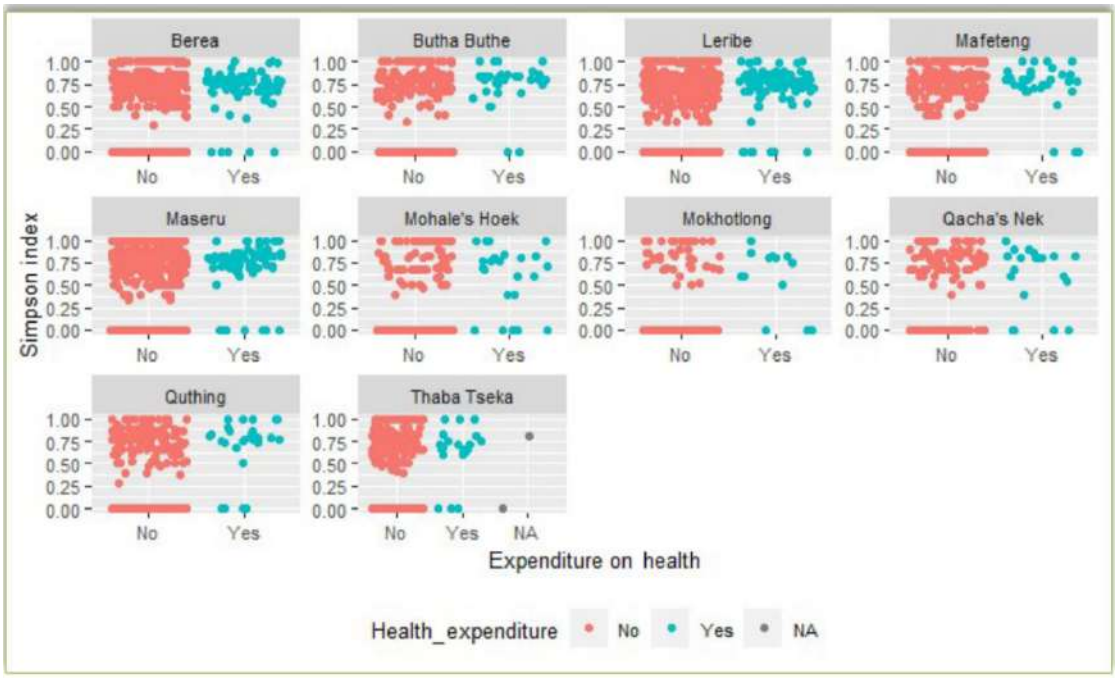

Figure 28. Assessing food diversity index and expenditure on health by households across districts in Lesotho, 2010/11.

Reflecting on the recent measurement made in 2017/18, the potential connection between food diversity, expenditure on health, and location appears to be similar to the previous HBS rounds (Figure 29). A notable observation is the consistency in the distribution of food scores over the past 16 years between measurements, which could imply that the household food composition has remained relatively static or has undergone slow changes in consumption dynamics, despite current consumer behavior and available alternatives. The interpretation may also be reflective of the constant demand for health services over the survey rounds, which is likely given that there were no major health disasters or public health emergencies during the period. In contrast, the COVID-19 pandemic occurred in late 2019, which is not a factor in this analysis.

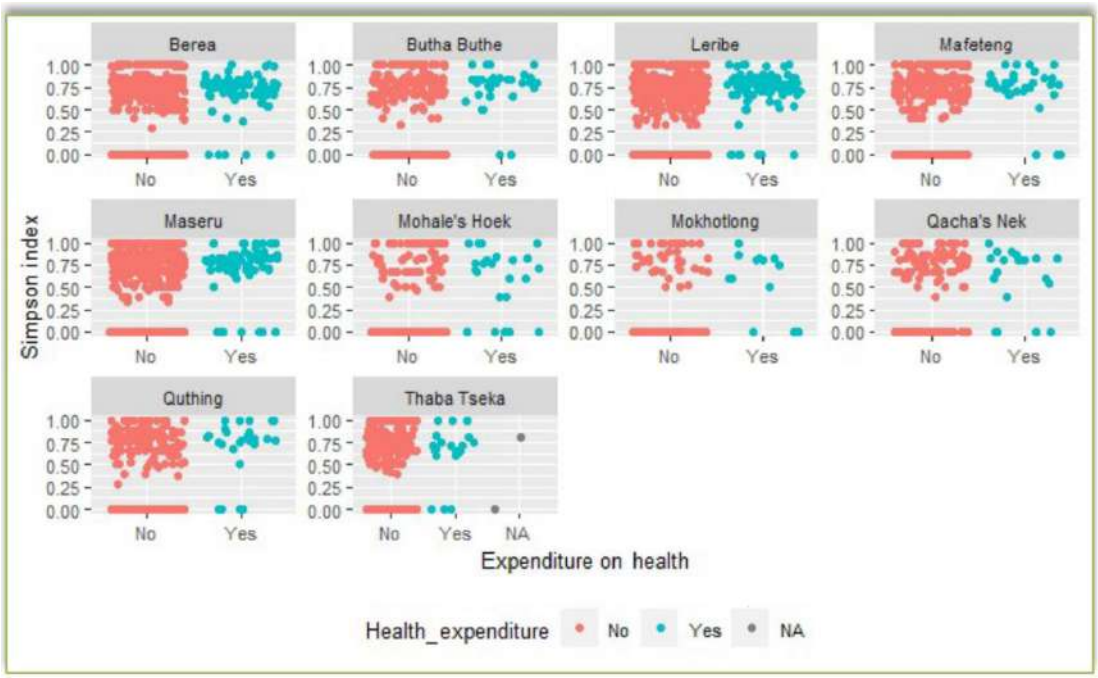

Figure 29. Assessing food diversity index and expenditure on health by households across districts in Lesotho, 2017/18.

In terms of the urban-rural strata, the distribution of food diversity scores and health expenditure also compares similarly to that observed at the district level. However, notable clustering is observed for rural households that have spent on health and are characterized by low food diversity scores. Figure 30 is an illustrative chart of the association between the three variables in 2002/03.

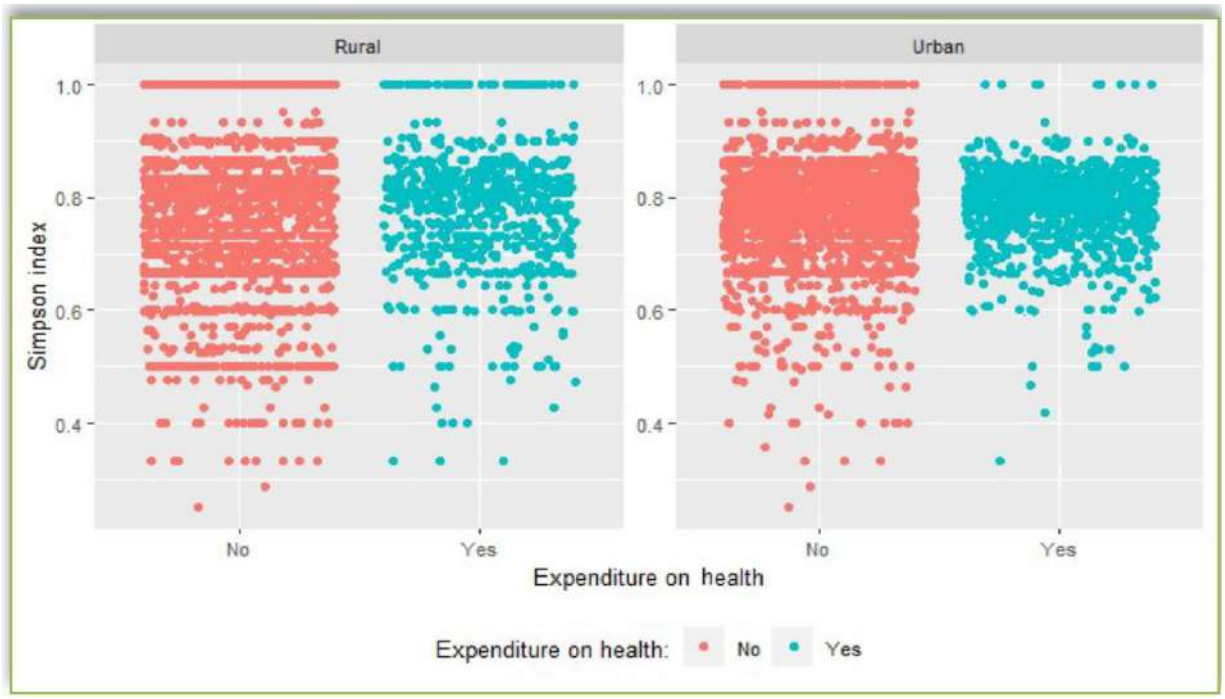

Figure 30. Assessing food diversity index and expenditure on health by households categorised by urban-rural setting, 2002/03.

In 2010/11, the distribution of food diversity scores and health expenditure was consistent with the observations made in 2002/03, but with marginal clustering of households with low food diversity scores spending on health costs (Figure 31).

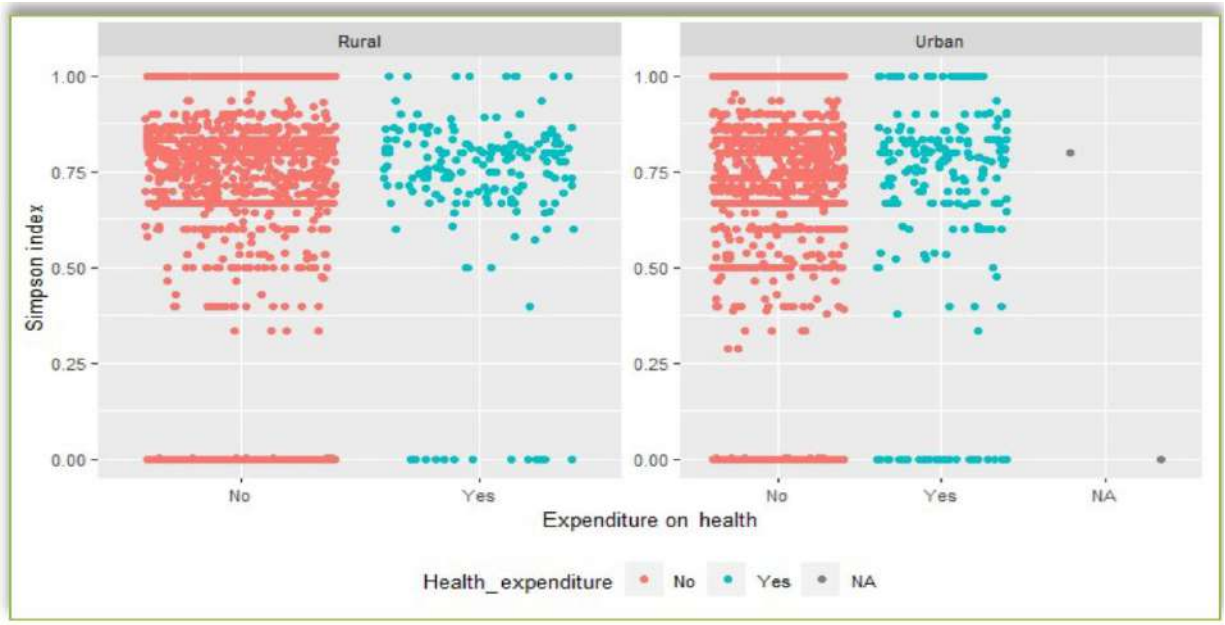

Figure 31. Assessing food diversity and expenditure on health by households categorised by urban-rural setting, 2010/11.

The persistence of consistent patterns in food diversity scores and health expenditure across the 2017/18 data is a notable finding. Consistent with previous years, the overall distribution of these variables remained stable, mirroring the patterns seen in both the 2002/03 and 2010/11 HBS rounds. This consistency suggests that the homogeneity of households in Lesotho, in terms of their food diversity and health expenditure patterns, has persisted over time. As illustrated in Figure 32, this consistency is evident in the visual representation of the data.

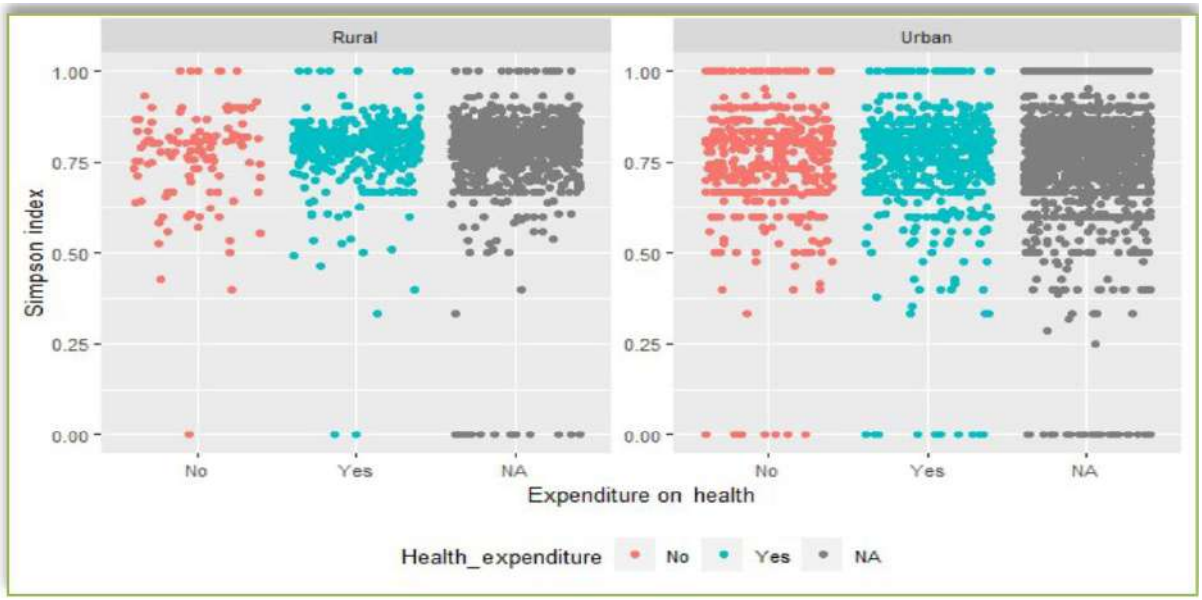

Figure 32. Assessing food diversity and expenditure on health by households categorised by urban-rural setting, 2017/18.

7.2. Results from PLS-SEM

Literature emphasises the effectiveness of PLS-SEM in analysing structural relationships between variables, particularly when dealing with small sample sizes or non-normal distributions (Hair et al., 2019). In this paper, we leveraged the capabilities of PLS-SEM to examine the relationships between our variables, which included a mix of categorical and continuous variables. This mixture of variable types was well-suited for PLS-SEM, as it is designed to accommodate such complexities. The approach combines principal components analysis with ordinary least squares regression to estimate partial model structures, allowing us to capture the intricate relationships between our variables (Mateos-Aparicio, 2011; Sarstedt et al., 2020). In evaluating the performance of our model, we examined the R^2 and the adjusted R^2, which indicates the proportion of variance explained by the model. The R^2 ranges from 0 to 1, with higher values indicating greater explanatory power. Furthermore, we conducted tests for convergent and discriminant validity to ensure that our measurement models were reliable and accurately captured the constructs of interest. We then evaluated the average variance extracted (AVE) and composite reliability (CR) to assess the overall quality of our measurement models.

As shown in Table 3, for the 2002/03 period, food diversity exhibits a very low R^2 value (0.000), indicating that the model predictors do not explain a significant portion of the variance in food diversity. Health expenditure, on the other hand, shows a relatively low but non-negligible R^2 value (0.012), suggesting that the independent variables explain a small portion of the variance in health expenditure. The adjusted R^2 values for both food diversity and health expenditure are consistent with the regular R^2 values, indicating that the performance of the model is similar to the intercept-only model. Relatedly, the path coefficients reveal a range of relationships between variables. For example, the path coefficient between agricultural participation and food diversity is -0.008, indicating a weak and negative relationship between agricultural participation and food diversity. In contrast, the path coefficient between agricultural participation and health expenditure is 0.057, indicating a moderate and positive relationship between agricultural participation and health expenditure. Similarly, the path coefficient between socioeconomic status and food diversity is 0.004, indicating a weak and positive relationship between socioeconomic status and food diversity, while the path coefficient between socioeconomic status and health expenditure is 0.057, indicating a moderate and positive relationship between socioeconomic status and health expenditure. The relationship between food diversity and health expenditure is weak and negative (-0.010). In general, the model explains little to no variance in food diversity, but a small portion of the variance in health expenditure. The analysis further revealed a weak and negative relationship between agricultural participation and food diversity, while the relationship between agricultural participation and health expenditure is moderate and positive. The relationship between socioeconomic status and food diversity is weak and positive, while that between socioeconomic status and health expenditure is moderate and positive, further noting a weak and negative relationship between food diversity and health expenditure. At the same time, in 2010/11, the R^2 values indicate a moderate level of explanatory power for food diversity (0.100) and health expenditure (0.061). The adjusted R^2 values are identical to the R^2 values, suggesting that the performance of the model is not significantly affected by the number of predictors. The path coefficients reveal strong relationships between variables. For example, the coefficient between agricultural participation and food diversity is 0.297, indicating a strong and positive relationship between agricultural participation and food diversity. Similarly, the coefficient between agricultural participation and health expenditure is 0.094, indicating a moderate and positive relationship between the two variables. Socioeconomic status also exhibits moderate and positive relationships with food diversity (0.141) and health expenditure (0.016). Notably, the relationship between food diversity and health expenditure is strong and positive (0.202), indicating that an increase in food diversity is associated with an increase in health expenditure. Overall, the results suggest that agricultural participation is a significant driver of food diversity, which in turn has a significant

impact on health expenditure. Socioeconomic status also plays a role in shaping food diversity, but its impact on health expenditure is limited.

Table 3. Inspection of the model's path coefficients and the (adjusted) R^2.

Statistic/Construct	Food diversity	Health expenditure
HBS 2002/03		
R^2	0.000	0.012
Adjusted R^2	-0.000	0.012
Agricultural participation	-0.008	0.057
Socioeconomic status	0.004	0.093
Food diversity	-	-0.010
HBS 2010/11		
R^2	0.100	0.061
Adjusted R^2	0.100	0.061
Agricultural participation	0.297	0.094
Socioeconomic status	0.141	0.016
Food diversity	-	0.202
HBS 2017/18		
R^2	0.005	0.014
Adjusted R^2	0.005	0.014
Agricultural participation	-0.036	0.095
Socioeconomic status	0.060	0.087
Food diversity	-	0.001

In 2017/18, the performance of the model is similar to that observed in 2002/03, with limited explanatory power for both food diversity and health expenditure. Notably, the relationships between agricultural participation and food diversity are weak and negative, indicating that agricultural participation may not be a strong driver of food diversity. In contrast, the relationship between agricultural participation and health expenditure is moderate and positive, suggesting that agricultural participation has a positive impact on health expenditure. Furthermore, the relationship between socioeconomic status and food diversity is weak and positive, indicating that socioeconomic status has a limited influence on food diversity.

The relationship between socioeconomic status and health expenditure is moderate and positive, suggesting that socioeconomic status has a moderate impact on health expenditure. The extremely weak relationship between food diversity and health expenditure suggests that other factors may be driving this relationship, and further investigation is needed to fully understand the underlying mechanisms. Continuing the analysis, we evaluated the reliability of the model (see Table 4 showing the results), focusing on the average variance extracted (AVE) as a measure of indicator reliability. The AVE values for agricultural participation and socioeconomic status in 2002/03 reveal varying levels of construct reliability. Agricultural participation exhibited a low AVE of 0.356, indicating that only 35.6% of the variance in its indicators is explained by the latent variable, suggesting limited reliability. In contrast, socioeconomic status demonstrated a relatively high AVE of 0.487, indicating that approximately 50% of the variance in its indicators is explained by the latent variable, suggesting a moderately defined and reliable construct. In 2010/11, the AVE for agricultural participation improved to 0.408, indicating a moderate level of reliability, which may be affected by some measurement error or noise. At the same time, socioeconomic status also showed a moderate level of reliability, with an AVE of 0.363. Food diversity and health expenditure maintained their high levels of reliability, with AVE values of 1.000 in both years. In 2017/18, agricultural participation had an AVE of 0.424, suggesting a moderate level of reliability, while socioeconomic status had an AVE of 0.294, indicating that the indicators may not provide a complete representation of the underlying construct.

Table 4. Reliability metrics across the HBS datasets: 2002/03, 2010/11 and 2017/18.

Construct	Alpha	rhoC	AVE	rhoA
HBS 2002/03				
Agricultural participation	0.275	0.515	0.356	0.318
Socioeconomic status	-0.176	0.346	0.487	0.507
Food diversity	1.000	1.000	1.000	1.000
Health spending	1.000	1.000	1.000	1.000
HBS 2010/11				
Agricultural participation	0.315	0.647	0.408	0.476
Socioeconomic status	0.175	0.576	0.363	0.186
Food diversity	1.000	1.000	1.000	1.000
Health spending	1.000	1.000	1.000	1.000
HBS 2017/18				
Agricultural participation	0.267	0.659	0.424	0.378
Socioeconomic status	-0.291	0.282	0.294	-0.664
Food diversity	1.000	1.000	1.000	1.000
Health spending	1.000	1.000	1.000	1.000

The analysis proceeds by performing bootstrapping to estimate standard errors and compute confidence intervals. As illustrated in Table 5, the path between agricultural participation and food diversity reveals a complex relationship. The original estimate is -0.008, indicating that an increase in agricultural participation is associated with a decrease in food diversity. However, the bootstrap mean and standard deviation (SD) are relatively large, indicating that there is some uncertainty in this estimate. The t-statistic is -0.473, which is not significant at the 5% level. In contrast, the relationship between agricultural participation and health spending is significant. The original estimate is 0.057, indicating that an increase in agricultural participation is associated with an increase in health spending. This estimate is relatively consistent across bootstraps, with a bootstrap mean and SD close to 0. The t-statistic is 3.086, indicating a significant relationship at the 5% level. The analysis also reveals significant relationships between socioeconomic status and both food diversity and health spending. The original estimate for the path between socioeconomic status and food diversity is 0.004, indicating that an increase in socioeconomic status is associated with a small increase in food diversity. However, the bootstrap SD is relatively large, indicating that there may be some uncertainty in this estimate. The t-statistic is 0.382, which is not significant at the 5% level. The relationship between socioeconomic status and health spending is more robust, with an original estimate of 0.093, indicating that an increase in socioeconomic status is associated with an increase in health spending. This estimate is relatively consistent across bootstraps, with a bootstrap mean and SD close to 0. The t-statistic is 6.464, indicating a highly significant relationship at the 5% level. The path between food diversity and health spending has an original estimate of -0.010, indicating that an increase in food diversity is associated with a decrease in health spending. However, the bootstrap SD is relatively large, indicating that there may be some uncertainty in this estimate. The t-statistic is -0.879, which is not significant at the 5% level. Overall, these results suggest that agricultural participation has a significant positive effect on health spending, while socioeconomic status has a significant positive effect on health spending. There may be some uncertainty in the relationships between agricultural participation and food diversity, as well as between socioeconomic status and food diversity. Additionally, there may be no significant.

In 2010/11, the estimated path coefficient between agricultural participation and food diversity is 0.297, indicating that a one-unit increase in agricultural participation is associated with a 0.297-unit increase in food diversity. The bootstrap mean also matches the original estimate, and the T-statistic is 23.418, indicating that this relationship is highly statistically significant. In contrast, the estimated path coefficient between agricultural participation and health spending is 0.094, but the bootstrap standard error is relatively large, suggesting that this estimate may not be as reliable as others. The analysis also reveals positive relationships between socioeconomic status and both food diversity and health spending. The estimated path coefficient between socioeconomic status and food diversity is 0.141, which is consistent with the bootstrap mean, and the T-statistic is 10.776, indicating that this relationship is statistically significant. Similarly, the estimated path coefficient between socioeconomic status and health spending is 0.016, which is relatively small but still significant. However, the bootstrap standard error is also relatively large, suggesting that this estimate may not be as reliable as others. The analysis also reveals a positive relationship between food diversity and health spending. The estimated path coefficient is 0.202, which matches the bootstrap mean, and the T-statistic is 16.131, indicating that this relationship is statistically significant. These results suggest that agricultural participation and socioeconomic status are positively related to food diversity and health spending, while on the other hand, there appears to be a positive relationship between food diversity and health spending. In 2017/18, the results indicate that the relationship between agricultural participation and food diversity is uncertain, with an original estimate of -0.036 and a relatively large bootstrap SD. The T-statistic is -2.122, indicating that the relationship is not significant at a 5% level. In contrast, the relationship between agricultural participation and health spending is significant, with an original estimate of 0.095 and a consistent bootstrap mean and SD. The T-statistic is 5.729, indicating a highly significant relationship at a 5% level. Socioeconomic status has a positive effect on health spending, with an original estimate of 0.093 and a consistent bootstrap mean and SD. However, the relationship between socioeconomic status and food diversity is uncertain, with an original estimate of 0.060 and a relatively large bootstrap SD. The T-statistic is 1.546, indicating that the relationship is not significant at a 5% level.

Table 5. Estimated standard errors and confidence intervals following bootstrapping the model across the HBS datasets.

Construct	Original est.	Bootstrap mean	Bootstrap SD	T-stat.	5% CI	95% CI
HBS 2002/03						
Agricultural participation -> Food diversity	-0.008	-0.011	0.018	-0.473	-0.042	0.019
Agricultural participation -> Health spending	0.057	0.057	0.018	3.086	0.032	0.081
Socioeconomic status -> Food diversity	0.004	0.004	0.01	0.382	-0.012	0.02
Socioeconomic status -> Health spending	0.093	0.096	0.014	6.464	0.072	0.121
Food diversity -> Health spending	-0.01	-0.01	0.011	-0.879	-0.028	0.008
HBS 2010/11						

Construct	Original est.	Bootstrap mean	Bootstrap SD	T-stat.	5% CI	95% CI
Agricultural participation -> Food diversity	0.297	0.297	0.013	23.418	0.276	0.317
Agricultural participation -> Health spending	0.094	0.096	0.018	5.187	0.064	0.127
Socioeconomic status -> Food diversity	0.141	0.143	0.013	10.776	0.121	0.164
Socioeconomic status -> Health spending	0.016	0.017	0.013	1.19	-0.005	0.038
Food diversity -> Health spending	0.202	0.201	0.013	16.131	0.181	0.222
HBS 2017/18						
Agricultural participation -> Food diversity	-0.036	-0.038	0.017	-2.122	-0.067	-0.012
Agricultural participation -> Health spending	0.095	0.094	0.017	5.729	0.066	0.12
Socioeconomic status -> Food diversity	0.06	0.05	0.039	1.546	-0.052	0.087
Socioeconomic status -> Health spending	0.087	0.083	0.031	2.836	0.024	0.121
Food diversity -> Health spending	0.001	0.002	0.015	0.088	-0.022	0.026

Our approach to assessing the convergent validity of our constructs involved applying the Fornell-Larcker criterion to calculate the square root of the average variance extracted (AVE) for each construct. The results, as presented in Table 6, reveal a non-linear picture of the internal consistency and reliability of our constructs. Specifically, the square root of AVE values for agricultural participation indicates a moderate level of internal consistency across the three years, ranging from 0.597 to 0.651. Although the construct has shown some improvement over time, its internal consistency remains relatively moderate. In contrast, socioeconomic status exhibits a decline in internal consistency over the three years, with values decreasing from 0.698 in 2002/03 to 0.542 in 2017/18. This decline may be indicative of a less well-defined construct or measurement tools that have become less reliable. On the other hand, food diversity and health expenditure demonstrate high levels of internal consistency, with square root of AVE values of 1.00 for all three years, suggesting effective measurement and reliability.

Table 6. Discriminant validity assessment, across the three HBS datasets.

Construct	Agricultural participation	Socioeconomic status	Food diversity	Health expenditure
HBS 2002/03				
Agricultural participation	0.597	.	.	.
Socioeconomic status	0.038	0.698	.	.
Food diversity	-0.008	0.003	1.000	.
Health spending	0.060	0.096	-0.010	1.000
HBS 2010/11				
Agricultural participation	0.639	.	.	.
Socioeconomic status	-0.100	0.602	.	.
Food diversity	0.283	0.112	1.000	.
Health spending	0.150	0.029	0.231	1.000
HBS 2017/18				
Agricultural participation	0.651	.	.	.
Socioeconomic status	-0.135	0.542	.	.
Food diversity	-0.044	0.065	1.000	.
Health spending	0.083	0.075	0.003	1.000

Next and towards assessing discriminant validity, the paper used the heterotrait-monotrait ratio (HTMT), and in line with the literature, values of HTMT must be below 0.90 to prove data validity (Sohail & Chen, 2022). As illustrated in Table 7, and while context could matter regarding the thresholds, the HTMT ratios indicate that agricultural participation has moderate relationships with socioeconomic status (HTMT = 0.426) and health spending (HTMT = 0.077), suggesting that they may be related or confounded with each other. In contrast, agricultural participation and

food diversity are not strongly related (HTMT = 0.044), indicating that they are distinct and not confounded with each other. Socioeconomic status and food diversity are weakly related (HTMT = 0.019), indicating that they are distinct and not confounded with each other. The pattern does not vary much for 2010/11 and 2017/18.

Table 7. Results from bootstrap confidence intervals to test if the heterotrait-monotrait ratio (HTMT) is significantly different from 1.00, across the HBS datasets.

Construct pair	Original est.	Bootstrap mean	Bootstrap SD	T-stat.	5% CI	95% CI
HBS 2002/03						
Agricultural participation -> Socioeconomic status	0.426	0.425	0.038	11.310	0.367	0.488
Agricultural participation -> Food diversity	0.044	0.052	0.019	2.309	0.022	0.084
Agricultural participation -> Health spending	0.077	0.087	0.020	3.885	0.056	0.120
Socioeconomic status -> Food diversity	0.019	0.024	0.008	2.221	0.011	0.039
Socioeconomic status -> Health spending	0.134	0.134	0.019	7.192	0.103	0.164
Food diversity -> Health spending	0.010	0.012	0.009	1.136	0.001	0.028
HBS 2010/11						
Agricultural participation -> Socioeconomic status	0.366	0.389	0.051	7.149	0.307	0.482
Agricultural participation -> Food diversity	0.424	0.424	0.028	15.422	0.380	0.472
Agricultural participation -> Health spending	0.253	0.255	0.033	7.743	0.203	0.309
Socioeconomic status -> Food diversity	0.231	0.233	0.031	7.522	0.186	0.284
Socioeconomic status -> Health spending	0.090	0.091	0.027	3.283	0.046	0.136
Food diversity -> Health spending	0.231	0.230	0.011	20.810	0.213	0.248
HBS 2017/18						
Agricultural participation -> Socioeconomic status	0.742	0.749	0.056	13.144	0.657	0.843
Agricultural participation -> Food diversity	0.087	0.091	0.025	3.471	0.053	0.135
Agricultural participation -> Health spending	0.153	0.153	0.030	5.013	0.105	0.203
Socioeconomic status -> Food diversity	0.131	0.132	0.026	5.040	0.092	0.176
Socioeconomic status -> Health spending	0.132	0.145	0.025	5.310	0.104	0.187
Food diversity -> Health spending	0.003	0.012	0.009	0.317	0.001	0.028

8. CONCLUSIONS

The study examined the relationship between food diversity and healthcare expenditure in Lesotho, highlighting the importance of agricultural participation and household socioeconomic factors. From a hypothesis-based perspective, the study associated households with higher levels of food diversity with lower healthcare expenditures, suggesting that promoting diverse diets could be a cost-effective strategy for reducing healthcare costs. This relationship is supported by previous research, which highlighted the importance of product variety on nutritional intake and overall health outcomes. Specifically in Lesotho, this area has not been extensively explored. The analysis revealed that household socioeconomic factors, such as income and education, play a crucial role in shaping dietary patterns and health expenditure decisions. Households with economically active heads and higher education levels tend to have greater access to a variety of nutritious foods, which can improve health outcomes. This is particularly important in Lesotho, where limited access to healthy food options is a significant challenge for many households. The PLS-SEM framework provided a comprehensive understanding of the interplay between these variables, revealing that food diversity is influenced by demographic and socioeconomic factors, and further suggesting the influence of agricultural participation on food diversity, which in turn affects health outcomes. The PLS-SEM analysis provides a nuanced understanding of this relationship, revealing that agricultural participation can have a direct impact on food diversity and health outcomes. In general, these findings could have important implications for policymakers seeking to develop targeted interventions to improve health outcomes in Lesotho. An intense promotion of agricultural participation could lead to increases in accessing diverse food options, potentially reducing healthcare costs and improving overall health outcomes.

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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