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Does production diversity support dietary diversity? Evidence from pastoral and agro-pastoral households in West Pokot County, Kenya

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Consumption of part of own-produced food is regarded as a sustainable approach to attaining dietary diversity and a pathway to improved food and nutrition security. However, empirical evidence on the relationship between production diversity and dietary diversity is inconclusive, with some studies demonstrating a positive relationship while others reveal conflicting results. Furthermore, this relationship has not been examined in pastoral contexts. We used data from 502 pastoral and agro-pastoral households in West Pokot County, Kenya, to assess the relationship between production indicators and household dietary diversity. Our results show that households with more diverse production had more diverse diets. Additionally, we find that nutritional awareness, engagement in off-farm enterprises, income, market participation, and location based on agro-ecological characteristics influence dietary diversity. Our findings suggest that more diverse crop-livestock systems appropriate to the agro-ecological conditions of West Pokot may be a strategy toward addressing the nutritional inadequacies experienced in the region. Further investigation of the wider implications of such a transition is suggested.

KEYWORDS

dietary diversity, pastoral and agro-pastoral households, production diversity, Poisson regression, West Pokot, Kenya

1 Introduction

Food systems continue to face significant challenges in providing adequate nutrition to a growing human population (Trinh et al., 2021; FAO, IFAD, UNICEF, WFP, and WHO, 2023). Furthermore, Lähde et al. (2023) emphasize that the existing globalized agri-food system model is increasingly seen as unsustainable, undermining health, social equity and food security, as well as local food cultures and economies. The FAO acknowledges that smallholder farmers in low-income countries, who rely on agriculture for a living, are the most vulnerable to these challenges (FAO, IFAD, UNICEF, WFP, and WHO, 2023) According to the FAO's *State of Food Security and Nutrition in the World (SOFI) reports* for 2022 and 2023, global food insecurity is deteriorating due to factors such as conflict, climate extremes, economic shocks and rising inequality (FAO, IFAD, UNICEF, WFP, and WHO, 2023; FAO, IFAD, UNICEF, WFP, and WHO, 2022).

Given the rapid transformations of food systems, Goh et al. (2024) argue that unhealthy food environments may lead to malnutrition and nutrition insecurity through limited access, availability, and affordability of nutritious food coupled with strong competition from nutrient-poor, energy-dense ultra-processed food. Nevertheless, the link between agriculture and nutrition has long been acknowledged (Meeker and Haddad, 2013; Ogutu et al., 2020; Nzuma et al., 2024) indicating that agricultural production enhances food and nutrition security by increasing availability and accessibility. According to Schönfeldt et al. (2024), in many African countries, a considerable proportion of the population relies on agriculture not just for food but also for their livelihoods. Transforming the agricultural and food systems is thus an essential way of addressing the burden of malnutrition.

The shifts in food systems have substantial implications for the populations in Sub-Saharan Africa (SSA), particularly pastoral and agro-pastoral groups, who are vulnerable to changing food patterns, climate change and land-related dynamics (Uddin and Kebreab, 2020). Pastoralism is a livelihood strategy that enables those who practice it to meet their basic needs through raising livestock (WISP, 2010). According to the FAO (2024), pastoralism is a livelihood system based on extensive livestock production and plays an important role in the world's drylands. It is characterized primarily by animal mobility and common use of natural resources, both important strategies for managing environmental uncertainty and shocks. Furthermore, the FAO (2018) notes that pastoral communities rely on large livestock production, particularly cattle, camels, sheep, and goats, as their primary source of livelihood, food security, nutrition, income, and well-being.

Pastoralism is recognized as an adaptation mechanism for dealing with difficult ecological systems that limit rain-fed agricultural production (Barrow et al., 2007). Agro-pastoralism, which combines crop cultivation, livestock production, and transhumance has also expanded to arid and semi-arid lands (ASALs; Scoones, 2021). The majority of people in East Africa's ASALs are pastoralists and agro-pastoralists, who mostly raise livestock with crop cultivation being less popular (FAO, 2013). Climate change contributes to a decline in food availability, higher food prices and reduced access to nutrient-dense foods (Willett et al., 2019). Stavi et al. (2022) argue that changes in land use and ownership have influenced livestock mobility, rangeland conditions, livestock productivity and herd size in pastoral and agro-pastoral communities. These changes have had a considerable impact on food production, food security and pastoralists' well-being. In response to these changes, ASAL households have turned to livelihood diversification (Achiba, 2018). On-farm production diversification is one method for spreading risks across different crop and animal species (Below et al., 2012; Antwi-Agyei et al., 2014).

Jones et al. (2014) state that agricultural biodiversity is an underutilized strategy for improving nutrition, particularly among rural smallholder farming households. According to DeClerck et al. (2011), smallholder farming households compensate for their limited purchasing power by relying on their farms to produce a variety of foods. In contrast, resource-endowed farmers may have less on-farm diversity but better health due to their ability to afford nutritionally balanced diets. Diversifying smallholder production is considered an effective way to promote dietary and nutritional diversity (Pellegrini and Tasciotti, 2014; Jones et al., 2014; Powell et al., 2015). Muthini et al. (2020) argue that diversifying farm production can boost nutritional diversity among farming households, as long as farmers consume what they produce. This diversification could help to reduce the risk of increased market prices for food, establish markets for food, reduce dependency on commodity prices, and boost biodiversity and resilience (The UNEP, 2019).

A number of studies in sub-Saharan Africa (SSA) like Jones et al. (2014) in Malawi; Sibhatu et al. (2015) in Malawi, Ethiopia and Kenya; Bellon et al. (2016) in Benin; Koppmair et al. (2017) in Malawi; Chegere and Stage (2020) in Tanzania, Sekabira and Nalunga (2020) in Uganda and Sambo et al. (2022) in South Africa have explored the relationship between on-farm production diversity and dietary diversity. Several studies in Kenya have also examined this relationship. For example, Ng'endo et al., 2016 found that socio-economic variables had a substantial impact on dietary habits. Muthini et al. (2020) investigated how agricultural production diversity influenced the dietary diversity of households, women, and children in Kenya's Nyamira and Kisii counties. The study found a significant positive relationship between farm production diversity and dietary diversity in women and their households, but not in children. Nzuma et al. (2024) observed in their study in South Eastern Kenya that farm production diversity had a positive and significant effect on dietary diversity.

However, there are gaps in documenting this relationship, especially among pastoral and agro-pastoral contexts. Furthermore, past research has produced inconsistent results, influenced by contextual factors such as changing gender roles, level of agricultural diversification, household wealth and market orientation. It is crucial not to assume that there is a consistent positive relationship, particularly in pastoral and agro-pastoral settings. In order to contribute to the agriculture-nutrition debate, we investigated the relationship between agricultural production diversity and dietary diversity. Our research focuses on pastoral and agro-pastoral contexts, assessing the potential for agricultural production diversification as a dietary improvement strategy in these areas.

We use the case of West Pokot County, Kenya, which is a livestock-dependent ASAL region to highlight the farm diversity-dietary diversity relationship. According to the 2022 *Kenya Demographic and Health Survey (DHS)* Report by Kenya National Bureau of Statistics (KNBS), undernutrition is a significant concern in West Pokot, with the county having the second highest prevalence of stunted growth among children under the age of five, at 34%. In addition, the county has a high rate of malnutrition (KNBS and ICF, 2022). Our research was motivated by the following research questions: (1) How diverse are production and dietary patterns in pastoral and agro-pastoral households in West Pokot County? (2) What effect does production diversity have on dietary diversity in pastoral and agro-pastoral households? (3) How do socioeconomic, market, and agro-ecological factors influence the relationship between production diversity and dietary diversity?

Our research provides evidence to support the link between production diversity and diet diversity and thus may offer a pathway toward improving diet quality in West Pokot County. The findings are especially relevant for the County Government of West Pokot in fulfilling its objective of achieving food and nutrition security, as stated in the County Integrated Development Plan (CIDP) for 2022 to 2027 (Republic of Kenya, 2023). The findings suggest that local policy design and food security initiatives could benefit from incorporating a nutritional perspective.

2 Materials and methods

2.1 Conceptual framework

Households have two basic options to obtain food that they consume (Ogutu et al., 2020). The first is farming (subsistence pathway), which involves consuming the animal and crop items produced by household. The second channel is via markets (market pathway), in which households buy a range of food items to consume at home. Farm households may also sell some of their produce to markets, so as to purchase other food commodities that they do not produce. In addition to farm production and market purchase, other alternative food pathways in pastoral contexts may include wild gathering, exchanges, gifting or bartering. While these strategies may not be widely utilized in the context discussed, it is crucial to acknowledge their existence. However, it should be highlighted that the primary means of obtaining food in this setting are self-production and market-based purchases. These pathways shape diets, and food and nutrition security.

Figure 1 shows the conceptualized potential pathways and links between two types of diversity from the context of pastoral and agro-pastoral households: production diversity and diversity of products bought as well as sold at market, their relationship to dietary diversity, and as their effect on household welfare in terms of dietary patterns. The interactions between the different elements of diversity are complex and can change depending on several factors. Studies like Bellon et al. (2016) define diversity as (a) the multiplicity of plants produced, (b) the variety of foods consumed, and (c) the combination of foods and products sold and purchased in markets. The current study builds on the conceptualization of farm diversity, by including a wide variety of crop and livestock products produced by pastoral and agro-pastoral households.

Pastoral and agro-pastoral households generate significant welfare outcomes such as income, diet quality and food security. Influencing factors, such as household size, market participation, climatic variability, land size, gender relationships, influence each of these types of diversity within specific contexts. Some of these factors may have an impact on all two types of diversity, while others may be limited to one. In addition, household factors, nutritional education, infrastructure, market structure and seasonality all contribute to shaping these linkages. The assumption in this

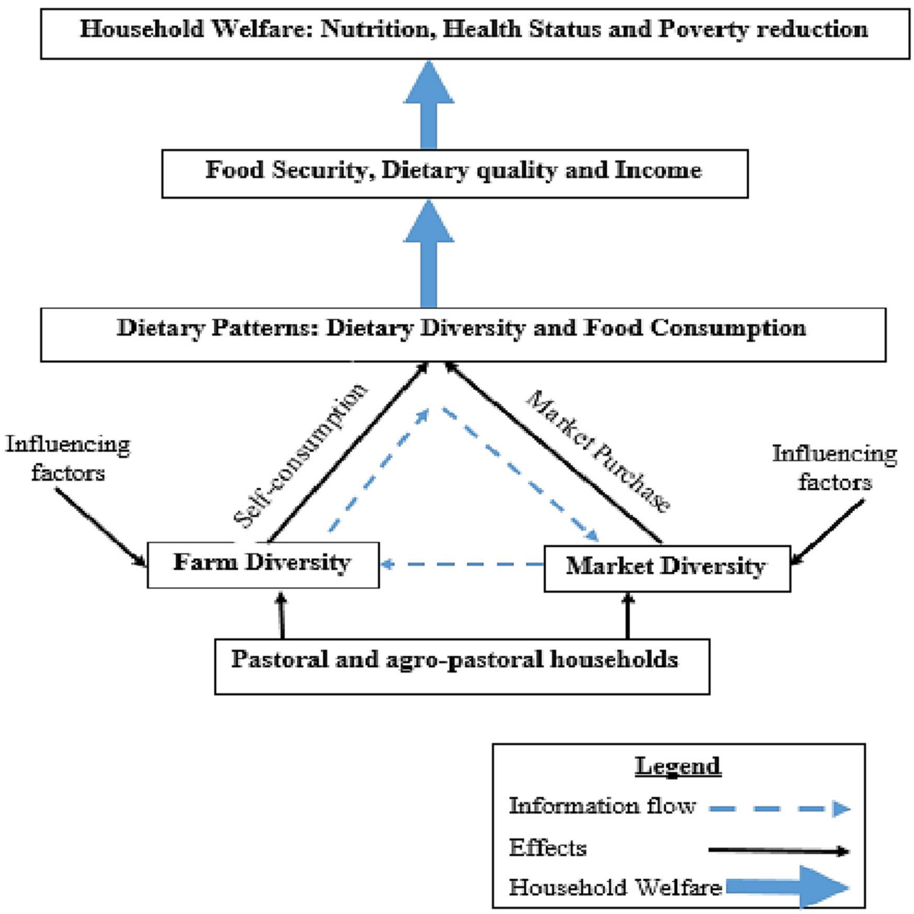

FIGURE 1
Conceptualization of relationships between diversities and welfare outcomes.

conceptual framework is that farm production diversity can be expected to influence consumption patterns through dietary diversity.

The framework deductively postulates that increasing either production diversity, or market diversity (or both together) will lead to an improved dietary diversity, though mediating pathways and decisions may complicate this relationship (for example when farmers raise crops or livestock only for market but not for consumptions). In this study, we explore the relationship between production diversity and dietary diversity. Enhancing household dietary diversity, particularly through the farm-production diversity pathway is expected to contribute to positive welfare and nutritional outcomes at the household level, such as improved access to food, improved nutrition and better health status, helping to achieve the UN's Sustainable Goals (SDGs) 1, 2, and 3 on reduced poverty, zero hunger, and good health and well-being, respectively (UN, 2015).

2.2 Description of the study area

The study was conducted in West Pokot County, an ASAL region in Kenya, where livestock production is the primary source of food and income. The county is ranked 37th out of 47 Kenyan counties in terms of contribution to the national gross domestic product (GDP), and 32nd in its contribution to the agricultural GDP (KNBS, 2023a). The county is divided into six sub-counties that include: Kipkomo, North Pokot, Pokot Central, South Pokot, Kacheliba and West Pokot. As highlighted in Figure 2, the county is further classified into three livelihood zones: pastoral (33% of the land area) in the very dry parts, agro-pastoral (37% of the land area) in the semi-arid areas and mixed farming (30% of the land area) in the relatively wetter areas (Republic of Kenya, 2023).

In terms of food security, at least 60% of West Pokot residents are unable to meet their annual food needs, necessitating interventions to reverse the trend (Republic of Kenya, 2023). In West Pokot, smallholder farmers are predominantly pastoralists or agro-pastoralists, with livestock production playing a central role (Virgin and Kugbega, 2023). Over the past few years, this region has been grappling with persistent droughts, resulting in agricultural losses that have had severe repercussions on the income and food security situation in the area. However, efforts to address these challenges have generally focused on short-term aid rather than long-term sustainable and holistic approaches that utilize indigenous knowledge, practices, and resources to build capacity for healthy and resilient livelihoods (Muricho et al., 2018).

The county's development indices are lower than the national average and recommended levels, indicating that the West Pokot population is underdeveloped (KNBS, 2023b; KNBS, 2023c). At least 60% of West Pokot residents are unable to meet their annual food needs, necessitating intervention to halt and reverse the trend (Republic of Kenya, 2023). According to the *West Pokot County*

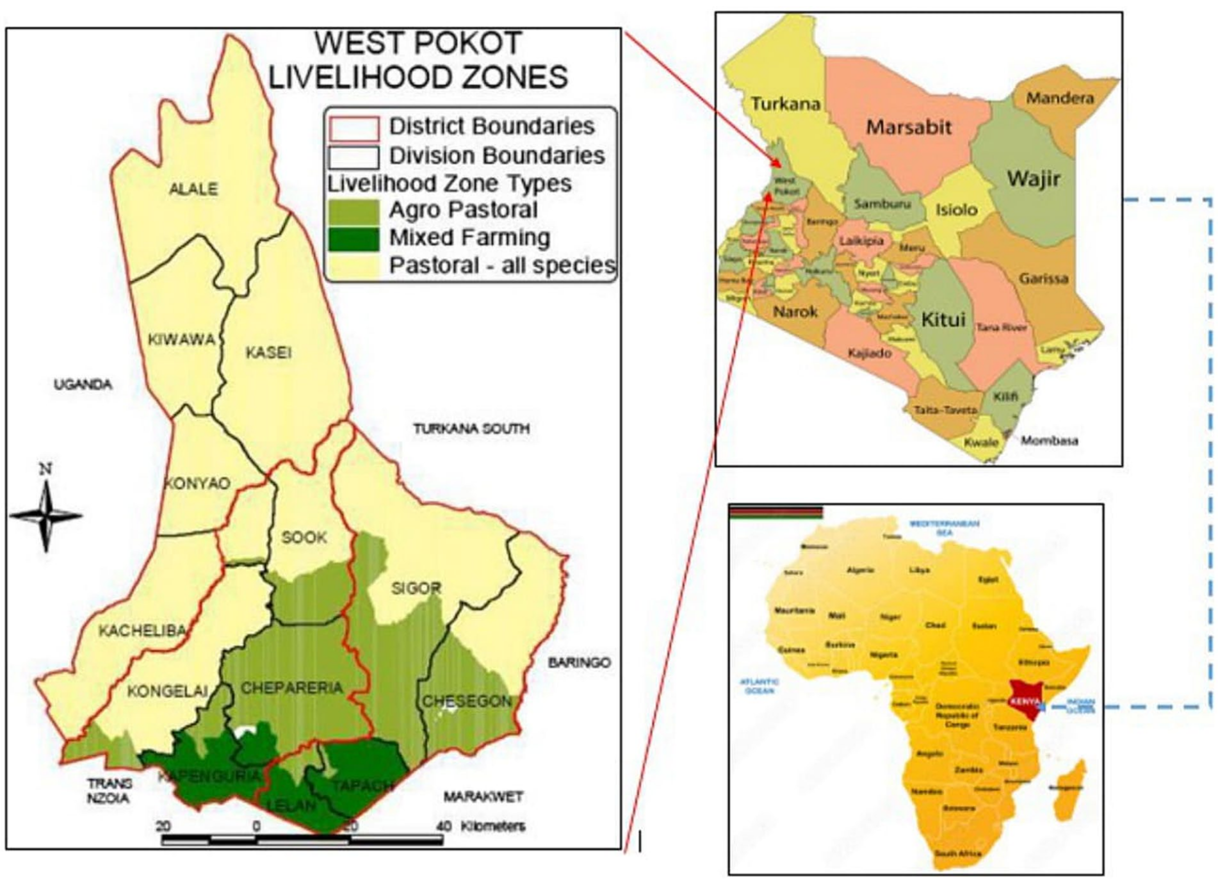

FIGURE 2
Map of West Pokot County, Kenya.

Integrated Standardized Monitoring and Assessment of Relief and Transitions (SMART) Survey of 2022, there was a 14.5% increase in acute malnutrition compared to 11.9% in 2021, due to increased household food insecurity (NDMA, 2023).

2.3 Sampling and data collection

This study used a four-stage sampling approach to collect data from 502 households in West Pokot County, Kenya between August and September, 2023. In the first stage, five sub-counties were purposively selected based on agro-ecological, livelihood and urbanization characteristics. West Pokot sub-county, which also serves as the county headquarters, represented the urban and peri-urban regions. South Pokot sub-county represented the wet and highland zones with a focus on mixed farming, while North Pokot and Kacheliba represented the arid regions where pastoralism is the main livelihood source. Kipkomo represented semi-arid regions where agro-pastoralism is the primary source of livelihood.

We then used the criteria outlined by Himelein et al. (2013) to identify sampling clusters within sub-counties, by systematically selecting proportional clusters based on livelihood patterns, population distribution, and agricultural activities. In this stage, household head attributes such as gender were not used as the technique focused on grouping households based on location rather than individual characteristics. Furthermore, due to mobility and dispersed populations in pastoral settings, it is sometimes difficult to determine household characteristics such as gender during sampling. However, gender dynamics were later examined during data analysis. This stage of the research was critical to ensuring that the sampling technique reflected the diversity of the sub-counties. To do this, we engaged with local officials who provided on-the-ground insights and key informants such as community leaders and agricultural experts to ensure that the clusters were balanced, representative, and effectively captured variations across households.

Next, villages were selected from each sub-county, taking into account travel distances to primary market centers, to represent variations in market participation options, resulting in the selection of 24 villages. A systematic approach was then used to select 22 households in each of the selected villages for survey, with every five households skipped, resulting to an initial sample size of 528. During data entry and cleaning, incomplete questionnaires were excluded resulting to a valid sample size of 502 that was used in analysis.

Structured questionnaires were administered in Kiswahili language using face-to-face interviews, with occasional translations into the local Pokot language. Respondents were either the key decision-makers in the households or members above the age of 18 years, with extensive knowledge of farm production, food consumption and nutrition matters in the household. Prior to household surveys, a stakeholders' workshop was held in Makutano Town, West Pokot, to gather historical perspectives on agricultural production, marketing, and the county's food and nutrition trends. Participants included representatives from the County Ministries of Agriculture and Health, women's, youth, and senior citizen groups, as well as household and trade representatives. Key informant interviews (KIIs) were also done with senior agriculture and nutrition officials from West Pokot County. The KIIs and stakeholder workshop results were used to improve and validate the survey questionnaire, and to explain the context of the quantitative data results.

2.4 Empirical data analysis

2.4.1 Regression analysis

We explored the effects of production diversity (PD) on the dietary diversity of pastoral and agro-pastoral households in West Pokot using a count data model. The dependent variable for the study is the household dietary diversity (HDDS), which is a count variable. Following Greene (2003, 2007), the Poisson Regression Model (PRM) was used to estimate the association between FPD and HDDS. The dependent variable, HDDS, was calculated as a count of the food groups consumed by a household in a 7-day period preceding the survey. When the dependent variable is a non-negative integer, 0, 1, 2, *n*, which is a count data type, the PRM is appropriate data analysis (Cameron and Trivedi, 2005; Greene, 2007).

The PRM was estimated in two ways. The first form examined the effect of PD on the HDDS, as shown in Equation 1.

$$HDDS_i = \alpha_o + \alpha_i PD_i + \ell_{ij}. \tag{1}$$

where the HDDS i is a function of PD of the farm by household i. The terms α and ℓ denote the coefficients to be estimated and the random error term, respectively. The various measures of PD (Simpson's Index, count of animal species, count of crop species, and production diversity score) were then estimated against HDDS as the dependent variable in each model.

Following studies such as Muthini et al. (2020) and Nzuma et al. (2024), because HDDS is influenced not only by the consumption of own produce through production diversity, but also by the household's ability to obtain them from other sources and other factors, the PRM was re-estimated with the market participation variable and socioeconomic, wealth, production, and agro-ecological location factors taken into account. Equation 2 specifies the adjusted models.

The model also included one key independent variable of interest to track food purchases (FP). This is a dummy variable indicating whether or not the household's primary source of food is purchase. According to Mulenga et al. (2021), markets can provide access to additional food categories that are outside own production, potentially improving dietary diversity. However, the variable does not account for the quantity purchased, the variety within a food category, or the processing level of foods purchased.

$$\begin{aligned} HDDS_i &= \alpha_o + \alpha_i PD_i + \alpha_i SE_i + \alpha_i FP_i + \alpha_i MP_i \\ &+ \alpha_i W_i + \alpha_i AEZ_i + \ell_{ij} \end{aligned} \tag{2}$$

The $HDDS_i$ is therefore a function of production diversity (PD), attributes of the head of the household (SE), food purchase (FP) variables, nutrition awareness and market participation factors (MP), household wealth (W) and agro-ecological location (AEZ).

2.4.2 Measurement of key variables

2.4.2.1 Farm production diversity

In this study, production diversity is defined as the number of crop varieties grown and animal species kept on the farm in the preceding year. Three unweighted and one weighted measures were used to evaluate farm production diversity. The unweighted measures are the animal species count, crop varieties count and food production diversity score, whereas the weighted measure is the Simpson index.

The use of multiple measurements enabled comparison of results as well as testing for the consistency and strength of the relationship between farm production diversity and dietary diversity.

The Simpson's index is a weighted index which accounts for both the number of species (richness) and their relative abundance (evenness; Simpson, 1949; Jones et al., 2014). The index was calculated as shown in Equation 3.

$$\text{Simpson diversity index} = 1 - \sum \left[\frac{n_i (n_{i-1})}{N(N-1)} \right] \quad (3)$$

The crop and livestock counts are unweighted totals of all the crops and animals, in the farm, respectively. In contrast, the food production diversity score takes a dietary approach, mapping crop varieties and animal species produced on the farm to the number of food groups used to calculate dietary diversity (Koppmair et al., 2017: Sibhatu and Qaim, 2017).

Household dietary diversity score.

Data on household food consumption was collected over a 7-day recall period and used to generate the HDDS, which is a tally of the number of food groups consumed by a household/person over a given time period (Kennedy et al., 2010). The study collected data using 16 food categories, but adjusted the final tally to a score derived from 12 main different food categories (see Table 1). A higher HDDS score indicates greater dietary diversity.

The HDDS was calculated as shown in Equation 4 below. A higher HDDS score indicates greater dietary diversity (Kennedy et al., 2010).

$$HDDS = Sum(1+2+3+4+5+6+7+8+9+10+11+12) \quad (4)$$

2.4.2.2 Food consumption score

The household food consumption score (FCS) is a score based on how frequently a household consumed different food groups (Table 1) in the 7 days preceding the data collection. The data collection period (August and September), corresponds to the "short dry season," which is characterized by periods of reduced rainfall. The season is typically a harvesting period, especially for crops such as maize, beans, and sorghum. The household FCS was calculated for each household using the World Food Program (WFP) FCS technical guidance sheet by multiplying the frequency of each food group by its weight to produce a single composite score at the household level (see Appendix 1).

Table 2 describes the factors expected to influence dietary diversity alongside farm production diversity measures, which were grouped into attributes of the household head, household wealth characteristics, production factors (such as land area and livestock units), household food security and nutrition indicators, market-related variables, and agro-ecological characteristics.

The study used market participation as a proxy for market access, with a dummy variable indicating whether the household sold agricultural produce to the market. Households that participate in markets, particularly through commercialization are likely to have more diversified diets (Sibhatu et al., 2015; Bellon et al., 2016). According to Koppmair et al. (2017), farming households sell agricultural products in the market and make use of the revenues to buy food that they do not or cannot produce themselves. In the context of pastoral and agro-pastoral communities, market engagement can occur at times as a result of distress sales, in which some households sell limited output to meet an immediate need for cash for non-food items. For example, Gebresenbet (2020) and Catley (2021) highlight market engagement in the form of distressed sales in pastoral communities, which is connected to deteriorating food security. The variable on market participation was thus crucial in this study to explain whether market participation enhances or reduces dietary diversity in such contexts.

We additionally calculated a proxy for household wealth using the domestic asset weight index, which is based on the International Livestock Research Institute's (ILRI) gender, livestock, and livelihood indicators (Njuki et al., 2011). The farmers' wealth was estimated using the value of their household assets, transportation

TABLE 1 Food groups classification for household dietary diversity score.

	Food categories	Examples
1	Cereal/food from cereal crops	Millet, sorghum, maize, rice, and wheat products like bread
2	Tubers and roots	Irish/ ordinary potatoes (*waru*), yams, and white sweet potato, cassava, cooking banana or foods made from these
3	Vegetables	Orange vegetables like pumpkins and carrots, spinach, kales (*sukuma wiki*), black nightshade (*sucha/ managu*), amaranth (*terere*), cowpea (*kunde*), spider plant (*saga*), *sokoria,* pumpkin leaves (*seveve*), tomato, onion, eggplant, cabbage, capsicum, mushroom
4	Fruits	Orange, mango, pawpaw, watermelon, apple, ripened banana, pineapple, avocado, oranges, tree tomato, *tingas/ tingoswo*
5	Livestock and poultry meat	Liver, kidney, heart, other organ meat, beef, pork, lamb, goat, rabbit, wild game, chicken, other poultry
6	Fish	Fish, fish products, silver cyprinid (*omena*)
7	Eggs	Eggs
8	Legumes, nuts and seeds	Beans, peas, pigeon pea, green grams, chickpeas, lentils, nuts
9	Milk and dairy products	Milk, cheese, yoghurt, other dairy products
10	Oils and fats	Any oil, any butter
11	Sugar	Sugar and sugar products, honey
12	Spices, condiments, beverages	Spices, tea, coffee, salt, and small amounts of milk for tea

Source: Inddex Project (2018).

TABLE 2 Farm diversity and socio-economic factors that influence dietary diversity.

Variable	Description and measurement of variable	Expected effect
Dependent variable		
HDDS	Household dietary diversity scores (Count)	
Measures of farm producation diversty		
Crop diversity	Number of crop species grown by the household (count)	+
Livestock diversity	Number of livestock species reared by the household (count)	+
Simpson index	Number of crops relative to area allocated to a crop (Index 0–1)	
Food production diversity	Count of crop/ animal species mapped from the food groups used to compute dietary diversity (Score 0–12)	+
Characteristics of the household head		
Gender of head	Household head is male (Dummy: 1 = Yes, 0 = Otherwise)	+/−
Education of head	Education level of the head (Dummy: 1 = Above Primary, 0 = Otherwise)	+
Off-farm	Household head participates in off-farm activity (Dummy: 1 = Yes, 0 = Otherwise)	+
Nutrition and market related variables		
Nutrition awareness	Household head is aware of nutrition value of foods (Dummy: 1 = Yes, 0 = Otherwise)	+
Market participation	Household sells commodities to the market (Dummy: 1 = Yes, 0 = Otherwise)	+
Food purchase	Household main food source is through purchase (Dummy: 1 = Yes, 0 = Otherwise)	+
Household wealth variables		
Household income	Average monthly income of households in Kenya shillings (Kshs)	+
Household wealth	Total household wealth index (Continuous)	+
Production variables		
Land size	Total size of land operated by household in acres (Continuous)	+
TLU	Tropical livestock units (TLUs; Continuous)	+
Agro-ecological and livelihood zone location		
Location	Agro-ecological location of the household	
Arid zone	Household is located in the arid zone	−/+
Semi-arid zone	Household is located in the semi-arid zone	−/+
Wet zone	Household is located in the wet zone	−/+

assets and farm assets. Farmers were first asked to provide the quantity of assets they owned, and each asset was allocated a weight. The household domestic asset weight was then calculated by summing the asset weights.

2.4.3 Model diagnostic tests

For the econometric analyses, the variables included in the models were tested for multicollinearity, a problem which occurs when there exists a near-perfect linear relationship between the explanatory variables, using the variance inflation factor (VIF). The VIF values that exceed 10 are generally viewed as evidence of the existence of multicollinearity (Gujarati and Porter, 2009). In our case, there was no evidence of multicollinearity as the VIF values were below 10 (see Appendix 2), and the variables were found to be suitable for inclusion in the model. Heteroscedasticity was examined in the error term but was not found, as evidenced by the statistically non-significant Breusch-Pagan test results. Furthermore, Pearson goodness of fit tests were insignificant in the regressions. The overdispersion hypothesis was hence rejected, supporting the PRM's appropriateness for this study. Despite low Pseudo-R^2 values, Wald Chi-square statistics were significant at the 1% level, indicating a high predictive capacity of the PRM results.

3 Results

3.1 Descriptive characteristics

Table 3 presents the descriptive results for the sampled households. In terms of production diversity, households produced at least two crops or livestock species on their farms. These findings highlight households' efforts to spread production risk across multiple crop and livestock species. Additionally, households had a food group production diversity score of 4.7. This shows that, households that produce a diverse selection of commodities across various food categories are more likely to consume a diverse diet.

Men headed the majority of households in West Pokot County (71.5%). This emphasizes the traditional patriarchal household structure in pastoral and agro-pastoral areas like West Pokot, while women headed approximately 30% of households, which is a

TABLE 3 Descriptive statistics of pastoral and agro-pastoral households.

Variable	Statistics (n = 502)
Farm production diversity measures	
Crop diversity (count)	2.9 (1.4)
Livestock diversity (count)	2.6 (1.1)
Simpson index (score 0–1)	0.53 (0.26)
Food production diversity (number 0–12)	4.7 (1.5)
Characteristics of the household head	
Gender of household head (% male)	71.5 (45.2)
Education of household head (% above primary level)	43.0 (49.6)
Off-farm activity (% yes)	45.8 (49.9)
Nutrition and market related variables	
Nutrition awareness (% yes)	82.1 (38.4)
Market participation (% yes)	81.5 (38.4)
Food purchase (% yes)	44.8 (49.8)
Household wealth variables	
Mean household income (Kenya shillings)	34,546.2 (56,408.8)
Mean domestic asset weight	49.9 (77.0)
Production variables	
Mean land size (acres)	2.4 (4.3)
Mean TLU (number)	5.3 (8.0)
Agro-ecological and livelihood zone location	
Location	
Arid zone (%)	26.7 (44.3)
Semi-arid zone (%)	26.1 (44.0)
Wet zone (%)	47.2 (50.0)

Standard deviations are presented in parentheses. *Kshs 135 were equivalent to 1USD at the time of survey. TLU equivalents for various livestock were considered as: cattle = 1, camels = 1, donkeys = 0.8, goats and sheep = 0.2 and poultry = 0.04.

significant proportion. This number shows a demographic trend of women-headed households that could have far-reaching consequences for household dynamics, economic decision-making, and social structures, particularly in West Pokot's traditionally patriarchal communities. Insights from the stakeholder workshops, KIIS, and surveys show that women heads in pastoral and agro-pastoral contexts are frequently single parents or widows. Our finding here corroborates that of Oyieng et al. (2021) that male-headed households dominate Kenyan pastoral communities.

Approximately two-fifths of household heads had attained above primary level of education. This is consistent with the most recent Kenyan census data (KNBS, 2019). Approximately 45% of household heads engaged in off-farm activities to supplement their income. This reflects an ongoing trend of shifting livelihood strategies where households are diversifying their income streams through non-farm activities (Republic of Kenya, 2018; Kirui et al., 2022). Household wealth was relatively modest, with an average monthly income of Kenya shillings (Kshs) 34,546.2, which is lower than the average per capita income reported in the most recent economic survey statistics in Kenya (KNBS, 2024), Furthermore, West Pokot is Kenya's eighth poorest county, with a poverty rate of 61.4% and more than half of its population living in extreme poverty (KNBS, 2023b). This demonstrates that, despite having livestock, West Pokot households are poorer than the average Kenyan household.

Our findings revealed that households had an average domestic asset weight index of 49.9, indicating relatively low asset ownership, with livestock being the most common asset, and less of farming tools and equipment, transportation, and household items. The study also sought to understand livestock ownership using tropical livestock units (TLU), which is an index generated by assigning different weights to different livestock species owned by the household (Njuki et al., 2011). The average TLU for households was found to be five, which is lower than the TLU values of more than 10 that were frequent among pastoralists decades ago. Traditionally, households in West Pokot raised indigenous cattle breeds like Zebu, sheep, goats, and camels. However, as noted in the KIIs and stakeholders' workshop, changes in livestock diversity have occurred over time due to changes in species composition, the introduction of improved breeds, and the introduction of mixed livestock production. Muricho et al. (2019) observed that arid areas had an average of more than 15 TLUs, whereas semi-arid areas had an average of eight TLUs in West Pokot, Kenya. The low TLUs found in our study could be attributed to West Pokot households shifting their production away from exclusively livestock production to crop farming and agro-pastoralism.

Households operated an average of 2.4 acres of land. This rather small portion of land point to a trend of greater land subdivision resulting in smaller land sizes, which could be attributed to factors such as changing land tenure regulations. Land in pastoral and agro-pastoral communities, as well as range lands, has traditionally been communally owned (Githu et al., 2022), but in recent years, there has been a shift toward sedentarization and range fragmentation as a result of changing land tenure (Kimiti et al., 2018). This might explain the reported land sizes in this study. According to Reid et al. (2014) and Coppock et al. (2017), land privatization, pastoralist sedentarization, cropland development, farmer-herder conflicts, and large-scale land grabbing and acquisition all lead to rangeland fragmentation.

In terms of agro-ecological zone location, the majority of households (52.8%) in our survey live in the dry part of the county which includes the arid and semi-arid regions. These areas, which include Kasei, Konyao, Kacheliba, Kongelai, Lomut, Sook, Chepararia, Chesogon, and Sigor, are distinguished by a large proportion of households practicing pastoralism and agro-pastoralism as principal livelihood activities (see Figure 2).

3.2 Food and nutrition security status analysis

Table 4 illustrates the household food consumption characteristics and dietary patterns in West Pokot, which includes results for the pooled sample and gender-based disaggregation into male-headed households (MHHs) and female-headed households (FHHs) to evaluate gender differences. The pooled sample results show that the HDDS was about 5, implying that households consumed about 5 of the 12 food groups evaluated in this study. There was no statistical

TABLE 4 7-day dietary diversity characteristics in West Pokot County.

Dietary diversity scores	MHHs (*n* = 359)	FHHs (*n* = 143)	Pooled (*n* = 502)
Mean HDDS	4.9 (1.24)	4.8 (1.3)	4.8 (1.3)
Lowest HDDS	2	2	2
Highest HDDS	9	9	9
HDDS Categories	% of HHs (SD)		
Low HDDS [≤3 food groups] (%)	14.5 (35.2)	14.0 (35.2)	14.3 (35.1)
Moderate HDDS [4–6 food groups] (%)	78.6 (41.1)	77.6 (41.8)	78.3 (41.3)
High HDDS [> 6 food groups] (%)	6.9 (25.5)	8.4 (27.8)	7.4 (26.2)

Standard deviations are presented in parentheses. MHHs and FHHs denote male-headed and female-headed households, respectively.

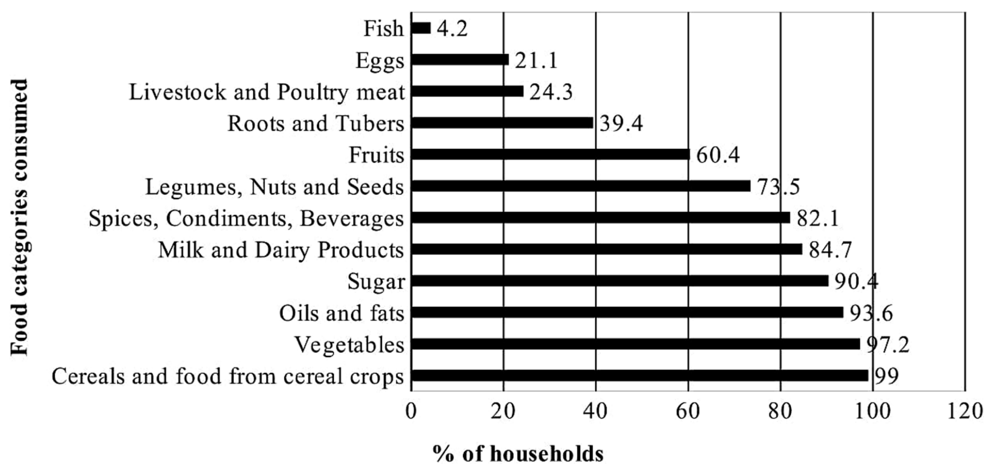

FIGURE 3
Food groups consumed by households in West Pokot.

difference in HDDS between MHHs and FHHs. Further unpacking of the HDDS revealed that the majority of households had low to moderate HDDS. About 78% of the household had moderate HDDS, while 14% suffered from low HDDS. However, only 7.4% of households had a high HDDS. When the data was further disaggregated, no significant differences were observed in dietary diversity categories between MHHs and FHHs.

We did a further investigation of the HDDS to identify the most common categories of food consumed by households, and the findings are shown in Figure 3. As previously stated, this data was gathered between August and September 2023, during the "short dry season," which is distinguished by periods of reduced rainfall and is often a harvesting period. As a result, the study did not account for seasonal fluctuations, which frequently affect food supply in these areas. Cereal-based foods, notably *Ugali* (a carbohydrate source derived from maize and millet flour), was the most common food group, consumed by almost every household (99%). Vegetables like kales, cabbage, common nightshade (locally named *sucha* or *managu*), and pumpkin leaves (locally named *seveve*) were the second most consumed category, accounting for 97%. This was followed by oil and fats (93.6%), as well as sugar (90.4%).

Given the importance of livestock as a store of wealth and cultural asset in pastoral and agro-pastoral communities, it is not surprising that only 24% of households had consumed meat or poultry or other animal-source foods during the preceding week, with the exception of milk and milk products which were more commonly consumed. Insights from stakeholders' workshops, KIIs, and household surveys revealed that livestock is primarily perceived as an economic and cultural asset in the study area. Households therefore prioritize livestock as a source of immediate income, a symbol of cultural prestige, and a store of value, rather than for their own dietary consumption. Thus, meat and eggs are consumed sparingly and only on special occasions or when purchased from a market for home usage.

On the contrary, milk and milk products, such as fresh milk and fermented milk (locally named *lolon*), are more commonly used in traditional diets. Hetherington et al. (2017) and Kebede et al. (2023) observed that milk intake increased with animal ownership. On the other hand, Acharya et al. (2021) and Kebede et al. (2023) noted that owning cattle was negatively connected to meat consumption in pastoral contexts, implying that livestock are kept for prestige and cash through the sale of milk and calves rather than for meat.

As shown in Table 5, the average household food consumption score (FCS) was 27.5 out of 112. When the FCS was further disaggregated by the gender of the household head, no significant difference was seen between MHHs and FHHs. To further understand food consumption trends, each household's score was classified into three categories: poor, borderline, and acceptable, according to the WFP's suggested cut-offs (WFP, V. A. M, 2008). A majority (48%) of

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TABLE 5 Food security status of households in West Pokot County.

Food consumption and nutrition	MHHs (*n* = 359)	FHHs (*n* = 143)	Pooled (*n* = 502)
Food consumption scores (mean)	28.3 (17.0)	27.6 (16.2)	27.5 (16.6)
Food consumption category	% of HHs (SD)		
Poor [FCS Score 0–21] (%)	49.3 (50.1)	44.8 (49.9)	48.0 (50.0)
Borderline [FCS Score 21.5–35] (%)	16.4 (37.1)	16.8 (37.5)	16.5 (37.2)
Acceptable [FCS Score > 35] (%)	34.3 (47.5)	38.5 (48.8)	35.5 (47.9)
Nutrition awareness (% yes)	84.1 (36.6)*	76.9 (42.3)	82.1 (38.4)
Education level (% above primary school)	44.9 (49.8)	38.5 (48.8)	43.0 (49.6)

Standard deviations are presented in parentheses. MHHs and FHHs denote male-headed and female-headed households, respectively. ** denote statistically significant differences between MHHs and FHHs at 10%.

surveyed households had poor FCS, with a further 16% showing borderline status (Table 5), emphasizing the prevalence of insufficient diversity of food consumption. Disaggregation of the FCS categories by household head's gender indicated no significant differences between MHHs and FHHs. According to the *2022 Integrated Food Security Phase Classification* (IPC) study, West Pokot's acute food insecurity and lower food consumption patterns are expected to reach crisis status, with serious malnutrition levels (IPC, 2022). For this study, the poor FCS trends could be attributed to the region's high food costs and unfavorable trade terms during the period that the survey was undertaken.

We examined two variables related to food and nutrition security that can also be assessed through the gender lens. These variables include nutritional awareness and education of the household head. The results in Table 5 reveal that the sampled households had a high level of nutrition awareness. On the contrary, we find a statistical difference regarding nutrition awareness, with MHHs being more nutritionally aware than FHHs. The high level of nutrition awareness among MHHs shows that there may be a gender gap in access to information, implying the necessity for focused interventions for FHHs to close the gap. In terms of education, slightly more than two-fifths of household heads in the pooled sample had attained above primary school level of education. But, there were no significant differences in educational attainment between MHHs and FHHs. The lack of significant variations between MHHs and FHHs may suggest that structural and systemic barriers may be the key constraints to education rather than gender-specific disparities.

3.3 Association between production diversity and dietary diversity

In order to understand the link between production diversity and dietary diversity, we computed four measures of production diversity (crop diversity, livestock diversity, Simpson index, and food production diversity) and assessed how they affected the HDDS. The results are presented in Table 6. All the four indicators were positively associated with HDD. The Simpson index had the largest magnitude/change on HDDS. A 1% increase in the Simpson Index (a measure of diversity widely used for assessing biodiversity) corresponds to a 7.7% increase in dietary diversity. We view the Simpson index as a measure of biodiversity or variety within a dataset, therefore a slight rise in the Simpson index corresponds to a bigger improvement in dietary diversity. In terms of crop diversity, having an additional crop species increases HDDS by 0.021, and keeping an additional livestock species increases HDDS by 0.022.

TABLE 6 Household dietary diversity scores and farm production diversity.

Measures of farm production diversity	HDDS (*n* = 502)
Crop diversity (count)	0.021 (0.012)*
Livestock diversity (count)	0.022 (0.012)**
Simpson index (score 0–1)	0.077 (0.045)*
Food production diversity (number)	0.020 (0.012)*
Pseudo likelihood	−936.137
Prob > chi2	0.000
Pseudo R^2	0.069
Goodness of fit	1.0000

** denote statistical significance at 10 and 5% levels, respectively. Values in parentheses are standard errors.

The intensities of the association therefore vary, with food production diversity having the smallest effect and the Simpson index having the most influence. Our results show that regardless of the measure, households with higher levels of production diversity exhibit higher dietary diversity. This correlation highlights the potential relevance of agricultural diversification as a strategy for improving nutritional outcomes in pastoral and agro-pastoral settings. Secondly, because numerous studies have shown that HDDS is influenced by factors other than farm production diversity, the regression models controlled for factors such as household head characteristics, farm production variables, nutrition awareness and market participation, household wealth, and household agro-ecological location, as well as each of the four measures of production diversity.

Table 7 shows the results, with the regression for each production diversity measure indicated in the columns. The overall significance of the results is consistent across all the regressions, independent of the production diversity measure. We find that consistency in the factors influencing HDDS across all four regressions. Furthermore, we observed consistency in the factors influencing HDDS across all four regression models. We found that taking part in off-farm activity was positively and significantly associated with HDDS in all regressions. This demonstrates that households in which the decision maker participates in off-farm activities consume greater diversity of foods. The results also demonstrate that the household head's nutrition

TABLE 7 Dietary diversity scores and farm production diversity, adjusted for food purchase and socioeconomic factors.

Variable	Household dietary diversity score (HDDS)			
	(1) Crop diversity	(2) Livestock diversity	(3) Simpson index	(4) Food Production diversity
Crop diversity (count)	0.021 (0.008)***			
Livestock diversity (count)		0.022 (0.010)**		
Simpson index (score 0–1)			0.098 (0.037)***	
Food group production diversity (number)				0.019 (0.008)**
Gender of head (1 = male)	−0.016 (0.026)	−0.016 (0.025)	−0.018 (0.025)	−0.018 (0.025)
Education of head (1 = above primary)	0.030 (0.023)	0.031 (0.023)	0.033 (0.023)	0.029 (0.023)
Off-farm activity (1 = yes)	0.076 (0.024)***	0.073 (0.024)***	0.073 (0.023)***	0.078 (0.024)***
Nutrition awareness (1 = yes)	0.117 (0.037)***	0.127 (0.037)***	0.124 (0.037)***	0.118 (0.038)***
Market participation (1 = yes)	0.089 (0.031)***	0.091 (0.032)***	0.098 (0.031)***	0.087 (0.032)***
Food purchase (1 = yes)	−0.023 0(0.023)	−0.029 (0.023)	−0.030 (0.023)	−0.023 (0.023)
Household income (Kshs)	3.99e-07 (1.98e-07)**	3.85e-07 (2.04e-07)*	4.12e-07 (2.01e-07)**	4.05e-07 (2.01e-07)**
Domestic asset weight (continuous)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
TLU (number)	0.001 (0.001)	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)
Land size (acres)	−0.002 (0.001)	−0.002 (0.002)	−0.001 (0.002)	−0.002 (0.001)
Location (base category = arid zone)				
Semi-arid zone (2)	0.079 (0.0304)***	0.091 (0.030)***	0.086 (0.030)***	0.079 (0.031)***
Wet zone (3)	0.084 (0.029)***	0.101 (0.029)***	0.095 (0.029)***	0.079 (0.030)***
Sample size (*n*)	502	502	502	502
Pseudo likelihood	−927.207	−927.430	−927.288	−927.422
Prob > chi^2	0.000	0.000	0.000	0.000
Pseudo R^2	0.0163	0.0161	0.162	0.0161
Goodness of fit	1.0000	1.0000	1.000	1.000

***, ** and * denote statistical significance at 1, 5, and 10% levels, respectively. Coefficients are presented, with standard errors reported in parentheses. Source: Survey Data (2022).

awareness had a significant and positive influence on HDDS across all four regression models. Nutritional awareness can help people understand the importance of key nutrients for a balanced diet, encouraging them to eat a wider range of foods. This may influence dietary diversity for households.

Our findings show a positive relationship between household participation in output markets and HDDS of pastoral and agro-pastoral families in West Pokot across all four regression models. This shows that households that participate in markets by selling crops and/or livestock have higher HDDS. Household income was found to have a significant and positive effect on HDDS in all four regression models. This indicates that higher-income households reported a greater HDDS. One possible explanation is that higher-income households can afford to access diverse foods because they have the economic ability to do so. Households in the semi-arid and wet parts of the county also had higher HDDS compared to those in the arid regions of West Pokot. This explains the relationship between agro-ecological characteristics and dietary diversity in pastoral and agro-pastoral locations.

4 Discussion of results

The study assesses the link between production diversity and dietary diversity among pastoral and agro-pastoral households. A PRM estimation was performed with the HDDS as the dependent variable and the three production diversity indicators as independent variables. In addition, the PRM estimates for the relationship between production diversity and dietary diversity were adjusted to account for market participation, nutrition awareness, food purchase, wealth, agro-ecological location, and socioeconomic factors The overall model results reveal that agricultural diversity has an independent relationship with HDDS. The magnitude does not significantly differ from the findings, and the results are similar across all models. These influences align with our conceptual framework in Figure 1, which indicates that diversifying farm production is an effective pathway for improving diet. The results are also consistent with previous studies by Kissoly et al. (2018), Muthini et al. (2020), Gaillard et al. (2022), and Nzuma et al. (2024).

We observed that all four measures of production diversity were positively associated with HDDS. Crop diversification exhibited the strongest correlation with HDDS. Crop diversity is the number of crops grown by a household. The data show that households producing multiple crop species were likelier to consume a diverse diet. The strength of the link varies, with food category production diversity having the least effect and crop diversity having the most influence. Previous investigations by Bellon et al. (2016), Koppmair et al. (2017), Sibhatu and Qaim (2017), Muthini et al. (2020), and Nzuma et al. (2024) have found correlations ranging from 0.05 to 0.20. The results show that production diversity relates positively with dietary diversity. This is similar with the findings of Jones et al. (2014), Sibhatu et al. (2015), Bellon et al. (2016), Koppmair et al. (2017), Kissoly et al. (2018), Muthini et al. (2020), and Nzuma et al. (2024). Overall, our findings show that when households diversify their production, they achieve higher dietary diversity.

Second, the regression model controlled for additional factors such as household head characteristics, farm production variables, nutrition understanding and market participation, household wealth, household agro-ecological location, and the four measures of production diversity. The magnitude of the results is consistent across all models, irrespective of the production diversity measure. Furthermore, we found consistency in the parameters influencing HDDS across all four regressions. Our findings indicate that off-farm activity was positively and significantly associated to HDDS in all regressions. This demonstrates that households in which the decision maker engages in off-farm activities consume diverse diets. Participation in off-farm activities increases household income, allowing households to access a wider range of food commodities, particularly from the market. The finding aligns with studies like Muthini et al. (2020) in Kenya and Mulenga et al. (2021) in Zambia.

We also observed that the household head's nutrition awareness had a significant positive influence on HDDS across all four regression models. Insights from the stakeholder workshop and KIIs revealed that indigenous knowledge and practices around food nutrition among communities in West Pokot were passed down through generations, raising awareness in some households. Ogutu et al. (2020) emphasize that diets are influenced by nutrition knowledge, which improves with higher education levels. Nutritional awareness therefore informs individuals on the importance of key nutrients for a balanced diet and promotes consumption of diverse foods categories to meet the nutritional needs. According to Sekabira and Nalunga (2020), education, which signifies improved nutrition knowledge, guides households to the appropriate quantities and quality of foods, leading to access to diverse foods.

Our findings show a favorable relationship between household participation in output markets and HDDS of pastoral and agro-pastoral households in West Pokot across all four regression models. This shows that households that participate in markets by selling crops and/or livestock tend to exhibit higher HDDS. Sibhatu et al. (2015) demonstrated that smallholder farmers' participation in output markets results in greater dietary diversification than diversifying their produce. According to studies by Bellon et al. (2016), Koppmair et al. (2017), and Mulenga et al. (2021), market participation is frequently acknowledged as one of the most effective techniques to increase rural household incomes and improving access to commercially available diversified foods. Our results are consistent with previous studies in the SSA region, including Sibhatu et al. (2015), Bellon et al. (2016), Rajendran et al. (2017), Ntakyo and van den Berg (2019), and Kihiu and Amuakwa-Mensah, 2021 from Kenya.

Household income was found to have a significant and positive effect on HDDS in all four regression models. This indicates that higher-income households reported a greater HDDS. A probable explanation is that higher-income households can afford to buy a wide variety of foods because they have the economic ability to obtain a variety of food, most probably through market purchase. According to Nzuma et al. (2024), wealth can supplement domestic food production since wealthier households can afford purchased food. Silvestri et al. (2015) found a correlation between food security and per capita income in East African households. Income is thus likely to boost households' purchasing power, allowing them to purchase a wider range of foods. Gebremichael and Asfaw (2019) also reported comparable results, finding that financial status was an important factor on dietary choices among pastoral and agro-pastoral groups in Ethiopia.

Households in the semi-arid and wet parts of the county exhibited higher HDDS than those in the arid regions of West Pokot. According to Di Falco et al. (2010), given the current agro-ecological characteristics of West Pokot, the availability of rainfall enhances smallholder farm diversity, particularly crop species. Mutea et al. (2019) observed that the kind of agro-ecological zone significantly influences household food security in Kenya. In West Pokot's arid regions, a lack of rainfall encourages livestock reliance, limiting food options and dietary diversity. Semi-arid and wet conditions, on the other hand, encourage crops and livestock farming, which increases household food choices and dietary diversity.

5 Conclusion and policy implications

This study investigated the association between production diversity and household dietary diversity in pastoral and agro-pastoral contexts, using different measures of production diversity for comparison. Our findings are consistent with prior studies, but they provide novel perspectives and contextual differences. The findings demonstrate a strong connection between production diversity and HDDS, underscoring the link between productivity and food and nutrition security. Furthermore, after controlling for socio-demographic factors, wealth, market participation, location based on agro-ecological zones, and food purchasing behaviors, we show that the dietary diversity of households is also influenced by factors such as nutritional awareness, household engagement in off-farm activities, household income, market participation, and the household's agro-ecological location.

These findings demonstrate that, while pastoral and agro-pastoral households traditionally rely heavily on livestock, notably cattle and goats, diversifying their production to include drought-tolerant fruits and vegetables can improve their diets. In order to accomplish this, efforts targeted at developing capacity and increasing understanding among these households regarding "nutrition-sensitive" farming methods could be beneficial to boost the production of different nutrient-rich foods. Encouraging crop-livestock integration systems that suit West Pokot's specific agro-ecological settings, could help overcome the region's regular nutritional deficiencies.

This study supports the value of nutrition-related policy measures for households, as well as the need for increased nutrition awareness efforts. As such, the county government and development partners who operate in the region could prioritize training households on how to incorporate nutritional considerations in their production systems and their food choices. Additionally, more diverse production systems could boost farmers' and pastoralists' resilience and adaptive capacity in the face of changing climatic conditions, and ensure a steady supply of a wide range of food products from within the region. This will contribute to the realization of the first goal in the agriculture, rural, and urban development sector of West Pokot County, as stated in its county integrated development plan for the period 2023–2027, which seeks to achieve food and nutrition security while increasing farm productivity within the county (Republic of Kenya, 2023).

While this study provides important insights on the relationship between agricultural production and the diets of pastoral and agro-pastoral households, it had limitations in terms of sample size and observation durations. For example, our dietary diversity observation period was limited to seven consecutive days. Future studies could provide more robust findings from larger sample sizes and longer data periods for example over 1 month of food diaries and/or panel data, spanning different seasons. Furthermore, because our study did not account for seasonal variations and fluctuations in food availability and affordability, we recommend that future research should focus on seasonal variations in food supply and the unique strategies used by pastoral and agro-pastoral groups in coping with these fluctuations. Assessments of individual dietary diversity scores, women's dietary diversity scores, and child dietary diversity scores, would also give intra-household food consumption data; for example, some members in the same home eat different food groups compared to others.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study used a survey to collect cross-sectional data on farmers' socio-economic variables, avoiding key ethical issues that arise in randomized controlled trials. Before beginning the study, the research team briefed West Pokot County officials and distributed the study questionnaire, after which they received official authorization to conduct the research. Enumerators adhered to ethical standards by informing respondents about the academic nature of the data collection, emphasizing non-commercial use, and maintaining anonymity during data processing. Every household in the sample agreed to participate in the interviews. Ethical concerns were carefully explored throughout the study to ensure compliance and transparency.

Author contributions

BI: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. DO: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing. WO-K: Funding acquisition, Project administration, Resources, Supervision, Validation, Writing – review & editing. AA: Methodology, Supervision, Validation, Visualization, Writing – review & editing. MJ: Funding acquisition, Resources, Supervision, Validation, Visualization, Writing – review & editing. HM: Funding acquisition, Resources, Supervision, Validation, Visualization, Writing – review & editing. FF: Funding acquisition, Resources, Supervision, Validation, Visualization, Writing – review & editing. ER: Funding acquisition, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendices

Appendix 1 Food items, food groups and weights used to calculate food consumption scores.

	Food items (examples)	Food groups (Definitive)	Weight (Definitive)
1	Maize, maize porridge, rice, sorghum, millet, bread, and other cereals. Cassava, potatoes, sweet potatoes, other tubers, plantains.	Main staples	2
2	Beans. Peas, groundnuts, green grams	Pulses	3
3	Vegetables, leaves	Vegetables	1
4	Fruits	Fruits	1
5	Beef, goat, mutton, poultry meat and offal, pork, eggs, and fish	Meat and fish	4
6	Milk, yogurt and other dairy product	Milk	4
7	Sugar and sugar products, honey	Sugar	0.5
8	Oils, fats, and butter	Oil	0.5
9	Spices, tea, coffee, salt, fish power, and small amounts of milk for tea.	Condiments	0

Source: WFP-VAM (2008).

Appendix 2 VIF of variables included in the PRM regression.

Variable	VIF	1/VIF
Crop diversity	2.56	0.391
Livestock diversity	1.41	0.711
Simpson index	1.12	0.892
Food group production diversity	3.01	0.333
Gender of head	1.06	0.947
Education of head	1.14	0.881
Off-farm activity	1.17	0.852
Nutrition awareness	1.22	0.822
Market participation	1.17	0.853
Food purchase	1.19	0.838
Household income	1.29	0.777
Domestic asset weight	1.13	0.888
TLU	1.20	0.833
Land size	1.14	0.875
Location		
Semi-arid zone (2)	1.63	0.615
Wet zone (3)	1.73	0.577
Mean VIF	1.45	

Source: Survey Data (2022).