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Impact of agricultural land use changes on food access in Mwatate Sub-County, Taita Taveta County, Kenya

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Introduction: Whereas Sustainable Development Goal 2 seeks to achieve zero hunger by 2030, food security remains a global challenge. Therefore, SDG 2 aims to achieve sufficient food access through sustainable agriculture. This is in line with the tenets of SDG1 that endeavor to end poverty in its diverse forms and, among other targets, secure land tenure rights. However, disparities in land tenure security still exist, especially in developing societies, and the prevalence of food insecurity is rising. Consequently, this study sought to establish the influence of land use patterns on food security.

Methods: A sample of 301 households was selected using proportionate sampling techniques. Accordingly, we used a cross-sectional research design, whereas data was collected using semi-structured interview guides. The Malthusian theory was used as an interpretive theoretical framework for this study.

Results and discussion: Furthermore, using the Household Food Insecurity Access Scale (HFIAS), it was established that the study site was food insecure, whereby only 22.6% of the households were food secure. Moreover, 39.5% of households experienced severe food insecurity, 16.3% had moderate food access, and 21.3% had mild food security. Results further revealed that agriculture characterized by subsistence farming was the primary land use pattern. Additionally, findings revealed agricultural expansion and increased demand for settlement spaces, resulting in deforestation, clearing of bushes, and general land degradation. Consequently, soil erosion and loss of soil fertility necessitating the use of pesticides and fertilizers were reported. Using a 5% significance level, a chi-square analysis revealed that these land use changes significantly influenced food security. Based on these findings, we recommend adopting sustainable agriculture to boost land productivity and diversify livelihood sources to reduce overreliance on mono-crop subsistence farming. Moreover, we draw the need to increase awareness of environmental conservation through agriculture extension services.

KEYWORDS

land use changes, food security, land degradation, sustainable agriculture, food access

1 Introduction

Food security is a global phenomenon that has attracted much attention (Maggio et al., 2015). We face a double threat of food insecurity in feeding undernourished and hungry populations, especially in developing countries (Gupta, 2019). Food security is the ability for people to be guaranteed constant physical, social, and economic access to safe, adequate, and suitable food (Le Mouël et al., 2018). It is premised on food access, stability, nutrition, and affordability (Bozsik et al., 2022). Historically, population growth, climate change, food price inflation, poor socioeconomic status, and, recently, the COVID-19 pandemic has aggravated food insecurity (Yusof et al., 2023). Moreover, Nchanji et al. (2023) link food insecurity in Sub-Saharan Africa to the underdevelopment of the agricultural sector. Based on the preceding, SDG 2 was instituted to end global hunger by 2030.

As a result, many countries still fall short of the targets of SDG 2 (Maggio et al., 2015; Pérez-Escamilla, 2017). Moreover, the global population is expected to rise to approximately 9 billion by 2050, translating to a more than 50% increase in food demand (Mulusew and Mingyong, 2023).

Statistically, by 2017, 800 million people worldwide faced acute food scarcity (Pérez-Escamilla, 2017). The number of people facing food insecurity has risen to over 2 billion (Delgado et al., 2023). While other parts of the world have made significant progress in SDG 2, Africa still lagged in reducing hunger (FAO et al., 2023). The food insecurity situation in Kenya is also rising (IBRD, 2022). For example, approximately 2.1 million Kenyans faced acute food insecurity in 2021 (Republic of Kenya and FAO, 2021). In 2022, Kenya was ranked in food crisis IPC stage 3, with 3.5 million Kenyans affected (Food Security Information Network (FSIN) and Global Network Against Food Crises, 2022). This population grew to 4.4 million in 2023 (Food Security Information Network (FSIN) and Global Network Against Food Crises, 2023).

Food security is directly related to agricultural systems (Schanbacher, 2010). There is a consensus that the way out of this quagmire is through agricultural expansion and intensification (Mockshell and Villarino, 2019). This is because while expansion and intensification of agriculture are necessary to combat food insecurity, they contribute to land use changes (Maggio et al., 2015). It further contributes to poor soil quality, increasing food insecurity (United Nations, 2022a), and emission of Green House Gases (Okeleye et al., 2023). Additionally, FAO (2017) posits that even though technology has positively impacted agriculture and food production, attainment of optimal food security remains significantly low due to land degradation. Consequently, land use changes increase soil erosion and poor soil quality, reducing agricultural food production (Ogechi and Hunja, 2012). Eventually, this land degradation accelerates food insecurity (Okeleye et al., 2023). The panacea to this challenge lies in proper land use and management of the available agricultural land (Nchanji et al., 2023).

Africa accounts for approximately 60% of the world's arable land (Republic of Kenya and FAO, 2021). This partly explains why farming is Africa's primary livelihood source (IFAD, 2013).

However, access to land for most households in Africa remains a significant challenge (Mulusew and Mingyong, 2023). Moreover, land dedicated to farming (crops and livestock) has significantly reduced due to population increase, urbanization, and food demand (Mockshell and Villarino, 2019). The continent's increasing population has decreased household farm sizes remarkably (Mulusew and Mingyong, 2023). This means increased land use intensity due to population growth has negatively impacted food production. The centrality of land in attaining food security calls for attention to understanding the influence of land tenure on food security (Kamau et al., 2022). This calls for an urgent need to seal the disconnect between land and food to increase food production to feed this population (Mulusew and Mingyong, 2023). However, it is notable that land use should be done without causing environmental calamities or exacerbating food insecurity (McConnell and Viña, 2018). This study, therefore, takes an interest in how agricultural land use changes contribute to reduced food production and ultimately result in food insecurity.

The need for sustainable agriculture is inherently embedded in SDG 2 to achieve food security (Mockshell and Villarino, 2019). Food systems account for about 40% of Earth's surface and directly contribute to 80% of global deforestation (Meza, 2023). Comprehensive research on the influence of agricultural systems on food access is still needed, given that food access is the most significant component of household food security (Nicholson et al., 2021). Sufficient focus has not been laid on the effect of agricultural land use changes due to agricultural expansion and intensification on food security (Mockshell and Villarino, 2019).

1.1 Research gap

Food security and land use are inextricable because unsustainable use of agricultural land negatively affects food security. Increased agrarian activity fuels changes in land use, disrupts biodiversity, and degrades land, resulting in low food productivity (Zabala, 2018). Land use change is a global concern that compromises livelihood security (Parven et al., 2022) and contributes to land degradation, resulting in food insecurity (Republic of Kenya and FAO, 2021). Therefore, food insecurity leads to hunger and malnutrition, tremendously affecting human health against the tenets of SDG2 because access to healthy diets is critical for positive health outcomes (Yusof et al., 2023).

Taita Taveta County has undergone tremendous land degradation due to agricultural and other anthropogenic activities. Moreover, the County is categorized as food stressed in IPC stage 2 of food insecurity. While existing studies draw a nexus between food security and land use, the focus has not been directed to the influence of land use in Taita Taveta. Therefore, this study aimed to establish the impact of land use changes on the prevalence of food insecurity in the study site.

1.2 Theoretical model

The global population will rise to over 9 billion by 2050 (United Nations, 2022b). the effect of this rise is expected to manifest through an increased vulnerability to food insecurity, raising the risk of hunger and malnutrition (FAO, WBG and WTO, 2023). Over the last decade, Africa has experienced rapid population growth (OECD, 2017). On the one hand, the global human population is increasing, and food insecurity is also increasing on the other hand (Food Security Information Network (FSIN) and Global Network Against Food Crises, 2023; Lanz et al., 2017). It therefore suffices to posit that increased population increases land demand for food production. As a result, uncontrolled population growth contributes to intensive land use and land degradation (Egger et al., 2020).

Given this nexus between population, land, and food production, this study embraced the Malthusian theory to explain the impact of land use patterns on food security. This theory acknowledges that while resources are finite, humans must live off them. Consequently, Malthus asserted that uncontrolled population growth is harmful because it pressures available land, outstripping the food supply and contributing to land use changes (Chowdhury and Hossain, 2019). The Malthusian theory, therefore, acknowledges that population growth contributes to land use changes that potentially impact food production (Egger et al., 2020). This is because, over time, and as the human population grows, there is increased encroachment on agricultural land for food production and human settlement (Winkler et al., 2021). This results in land fragmentation and changes in land use (Mhawish and Saba, 2016). According to Gupta (2019), intensive agriculture is primarily associated with soil erosion, a critical factor that limits land productivity. This necessitates a paradigm shift to improve food security (Mora et al., 2020).

Critics of this theory acknowledge that technology has had an enormous impact on increasing food production per person. Nevertheless, despite these technological advancements, food insecurity is still rising (O'Flynn, 2009). Therefore, the theory was still considered relevant in predicting the effect of human population pressure on land degradation and the ultimate impact on food security.

2 Methods

2.1 Study site

This study was conducted in Mwatate Sub-County, Taita Taveta County, Kenya. The sub-county is the second largest in the County, with a population of 81,659 people, and covers an area of approximately 2,722.6 km^2 (Kenya National Bureau of Statistics, 2019). It comprises five wards: Chawia, Kishamba, Bura, Mwatate and Ronge. Agriculture is the area's primary source of Livelihood (Munyao et al., 2020). Currently, the County is ranked as food-stressed (Wakesho et al., 2022). Moreover, Taita Taveta County harbors a critical global biodiversity hotspot (Abera et al., 2022) that has undergone tremendous land degradation over the years (Pellikka et al., 2013). Moreover, whereas 62% of the total land in Taita Taveta County is occupied by the Tsavo West and East National Parks, only 14% is utilized for agriculture and settlement (Funder and Marani, 2013).

2.2 Study design

This study was conceptualized as a survey and, hence, was interested in capturing the responses of household heads at a single time. Therefore, a cross-sectional survey research design was employed, given its ability to interview respondents on the go and further, owing to its versatility across the population (Olsen and St. George, 2004). Additionally, this design was selected because Setia (2016) acknowledges cross-sectional surveys as ideal for studying subjects once only at a given point in time.

2.3 Sample size determination

Selection of the sample for this study was based on Fisher's formula. This was more so based on the fact that the population in Mwatate Sub County was more than 10,000 people in line with Fisher's recommendation. Therefore, the study sample was determined to be 384 households, with one individual aged above 18 years being interviewed. Accordingly, given that voluntary participation was encouraged, a 78% response rate was reported, as 301 respondents were accessed. The sample size was calculated using the formula below.

$$n = \frac{Z^2 P(1-p)}{I^2}$$

$$n = \frac{1.96^2 0.5(1-0.5)}{0.05^2}$$

$$n = 384$$

Where;

n represented the sample size.

Z represented the normal distribution value.

P represented the population proportion with desired characteristics.

I represented the significance level.

2.4 Sampling procedures

This study adopted both proportionate stratified and simple random sampling procedures. As established by Munyao et al. (2020), majority of the households in Taita Taveta County engage in subsistence agriculture. Therefore, the inclusion criteria for a household was pegged on a household engaging in subsistence farming. Accordingly, the study focused on subsistence farmers in these as a target unit of analysis. Stratified sampling technique was administered where the sub-county was stratified alongside the existing wards that constituted the five strata. As stated above, the total sample size for this study was guided by the Fisher's formula, targeting to reach 384 households. Given that the population of each of the stratum is known, the sample for each ward was determined proportionately to the ward population, as shown in Table 1. This means that the sample size of each of the ward (stratum) was calculated as a proportion of the entire subcounty population with reference to the sample size predetermined using Fisher's formula. After establishing the sample size for each of the ward, households were randomly selected for as long as they engaged in subsistence farming. Accordingly, only the heads of the households selected were interviewed with only one interview per household. This study was conducted during the COVID-19 pandemic when many people were

TABLE 1 Distribution of sample size.

Administrative ward	Population	Target sample	Sample size reached
Ronge	12,311	59	60
Mwatate	19,089	89	61
Bura	2,315	109	69
Chawia	10,582	49	46
Kishamba	16,462	78	65
Total	81,659	384	301

not open to social interaction. Therefore, the interviews with farmers were conducted using a simple random technique to increase the chances of accessing respondents. Accordingly, a total sample of 301 households was interviewed.

2.5 Data collection

Data was collected using semi-structured interview guides. According to Ruslin et al. (2022), semi structured interviews increase the chances of acquiring in-depth data and enables researchers to probe the interviewees. Therefore, open-ended interview questions collected qualitative data from the demographic characteristics of households within the framework of Bourdieu's forms of social, cultural, economic, and symbolic capital. From these forms of capital, the researcher extracted qualitative data relating to land tenure that included land ownership, use, and control rights. Qualitative and quantitative methods in data collection enhance the quality and integrity of the data while providing insight into the quantitative traits observed from the study's findings.

Qualitative variables relating to food security included indicators influencing anxiety and uncertainty about household food supply and access and quality, food and social networks, and knowledge. Quantitative data, on the other hand, was collected from quantitative demographic and socioeconomic factors that explain physical access to food security and land use variables. These included income level, education, and total land size owned for each household.

2.6 Data validity

In order to ensure the validity of the data collected, various measures were employed. These included the use of a standardized and validated format of the Household Food Insecurity Access Scale. This is a universally tested and accepted scale that applies across many cultural contexts and was therefore very suitable for collecting data on household food security situations. The interview guides were designed with skip logic to prevent instances where ambiguous responses would be recorded. In order to ascertain the validity of the tool, the Cronbach's Alpha was conducted revealing a reliability index of 0.844. Moreover, the research assistants who helped in the data collection were trained in the use of the interview guides, and a specific focus was placed on the appropriate use of the HFIAS. The tool was equally translated into local language with the intention behind the questions in the HFIAS being cleared explained. To ensure objectivity in the data collection, the research assistants were trained on research ethics and techniques that foster neutral probing and reporting.

2.7 Data analysis

The data collected was entered and analyzed in SPSS version 23. Univariate analysis of quantitative data was done using descriptive frequencies presented as graphs and charts. On the other hand, qualitative data was thematized and formed the basis of developing narratives that provided more profound insights into food security prevalence and land use changes. Specifically, the study established the food security situation at the study site using data collected from the HFIA Scale. To calculate the food security index, the universal model that categorizes the various responses into food secure, moderate food security, mild food insecurity and food insecurity. On the other hand, land use changes were operationalized through five variables: use of fertilizers and pesticides, clearing forests for agriculture and human settlement, soil erosion and soil fertility loss.

Moreover, a chi-square test was conducted to establish the correlation between food security and land us changes. In preparing data for chi-square analysis, some of the variables had counts exceeding the 20% threshold of cells with a count of less than 5. Therefore, the data was recoded and categorized into fewer categories. The categories of food security were reduced from four to two, to reduce the outliers. Instead of the four categories (food secure, moderate, mild, and food insecure), this variable was recoded as either food secure or food insecure. Respondents who were reported to be food secure were combined with those who had mild food security to constitute the food secure category. On the other hand, respondents with moderate food insecurity were combined with those who had severe food insecurity to constitute food insecurity. This ensured that no cell had a count of less than 5.

According to Rana and Singhal (2015), chi-square tests can be deployed on data drawn from a random sample whose variables are mutually exclusive to test for data independence. In setting the instances of using this non-parametric test, McHugh (2013) observes that this statistical tool can be used on either nominal or ordinal data. Accordingly, the categorical data collected from food security indicators were transformed into food secure and food insecurity. Moreover, land tenure security indicators were operationalized into categories, with "yes" and "no" responses to land of ownership, access, and control of land rights. These two variables, which were categorical and in line with the assumptions of chi-square analysis, were then analyzed using the chi-square association test to establish their correlation.

2.8 Measurement of food security prevalence

The Household Food Access Scale (HFIAS) was used to assess the prevalence of food insecurity. HFIAS measures the occurrence and frequency of anxiety about food access, the quality of food diets, and the quantity of food households access. Therefore, it classifies food security as food secure, mild food security, moderate food security, and severe food insecurity. A household is food secure if it does not experience anxiety in accessing food. Mild food insecurity is observed when households have no option other than to consume monotonous diets. Additionally, moderate food insecurity was experienced when a household had to maintain a monotonous diet and sometimes had to reduce food quantity. Severe food insecurity occurs when a household frequently compromises the number and quantity of meals consumed, ran out of food, go for an entire day without food.

2.9 Ethical considerations

This study was conducted with strict adherence to ethical standards. Specifically, ethical review clearance and research permits were obtained prior to the commencement of the study. Additionally, ethical principles of professionalism, voluntary participation, confidentiality, anonymity of the respondents, respect, and informed consent were adhered to in the research. Interview guides had an introductory section explaining the study's objectives to the respondents. Accordingly, consent to participate in the study was obtained from the participants who voluntarily participated. The principle of Do No Harm was equally observed.

3 Findings

3.1 Demographic characteristics of the respondents

From the findings of Table 2, it is evident that most of the respondents were aged 50 years and below. Specifically, 15.6% were aged between 18 and 28 years, 27.6% of the respondents were between 29 and 39 years, and 24.1% were aged between 40 and 50 years. Additionally, the results further revealed that most respondents had attained a significantly low level of education. While 7% of the respondents reported not attending school, 55.4% reported receiving only primary education. Whereas 28.5% had attained secondary school education, only 9% had a tertiary educational level. Gender distribution revealed that whereas 61.3% were female, 36.1% were male, and 2.6 preferred not to disclose their gender. Additionally, most households (68.1%) had a monthly income of less than Ksh. 10,000, with 18.6% having between Ksh. 10,001 and 15,000, while only 13.3% had a monthly income of over Ksh. 15,000 cumulatively. Moreover, most households (68.1%) comprised five and below people, while 31.9 had more than five people.

3.2 Source of livelihood and land use patterns in Mwatate Sub County

The study endeavored to establish the source of livelihood for the households. Figure 1 shows the summary of the findings.

Findings in Figure 1 reveal that most households (81.6%) engaged in mono-crop subsistence farming compared to 13% who acknowledged practicing commercial agriculture. Further, most (42.5%) households revealed that they engaged in crop agriculture, with 33.3% reporting mixed agriculture entailing crop and livestock farming. Moreover, 14.6% of the respondents acknowledged that they had gainful formal employment as a source of livelihood, and only 4 and 3% reported engaging purely in livestock farming and mining, respectively. A further 2.2% acknowledged engaging in other activities, including charcoal burning and tree logging, for income, whereas 0.3% said they engaged in small-scale businesses.

3.3 Food security index

The food security prevalence index was established using the HFIAS; the findings are presented in Figure 2.

It was observed that most households were food insecure, whereby 39.5% of the households reported severe food insecurity, 16.3% had moderate food access, and 21.3% reported mild food security.

Interestingly, only 22.6% of the households recorded secure food access.

3.4 Land use changes in Mwatate Sub County

Having stablished the prevailing land use patterns at the study site, the study determined the land use changes due to these patterns. Figure 3 summarizes the results of our survey.

Our results revealed that 75.3% of households reported agricultural expansion in the study site. This was mainly observed by most (75.9%) households who noted increased clearing of bushes due to increased demand for agricultural land. Additionally, 69.9% reported increased rates of clearing of bushes in favor of human settlement. It is expected that increased agricultural activities coupled with other anthropogenic activities will result in agricultural land changes. Consequently, most (72.8%) households observed increased soil erosion incidences in the study site and admitted to frequently using fertilizers and pesticides. Moreover, most (75.5%) households reported that the soil quality for their agricultural land had lost its fertility over time. As a result, a majority (72.8%) of the households acknowledge using fertilizers and pesticides to boost their farms' soil quality and productivity.

3.5 Correlation between land use changes and food security

The following section presents the Chi-Square statistics establishing the correlation between land use changes and food security. The significance of association was established using a significance level of 5%. Land use changes were cross-tabulated against

TABLE 2 Respondents demographic characteristics.

Age distribution		Level of education		Gender		Monthly income (Ksh)		Household size	
Years	Percent	Level	Percent		Percent	Income	Percent	Number	Percent
18–28	15.6	Dint Attend School	7.0	Prefer not to say	2.6	≤ 10,000	68.1	5 Members and Below	68.1
29–39	27.6	Primary School	55.4	Male	36.1	10,001–15,000	18.6	Above 5 Members	31.9
40–50	24.1	Secondar y School	28.5	Female	61.3	15,001–20,000	9.1		
Above 51	32.7	Tertiary Education	9.0			>20,000	4.2		

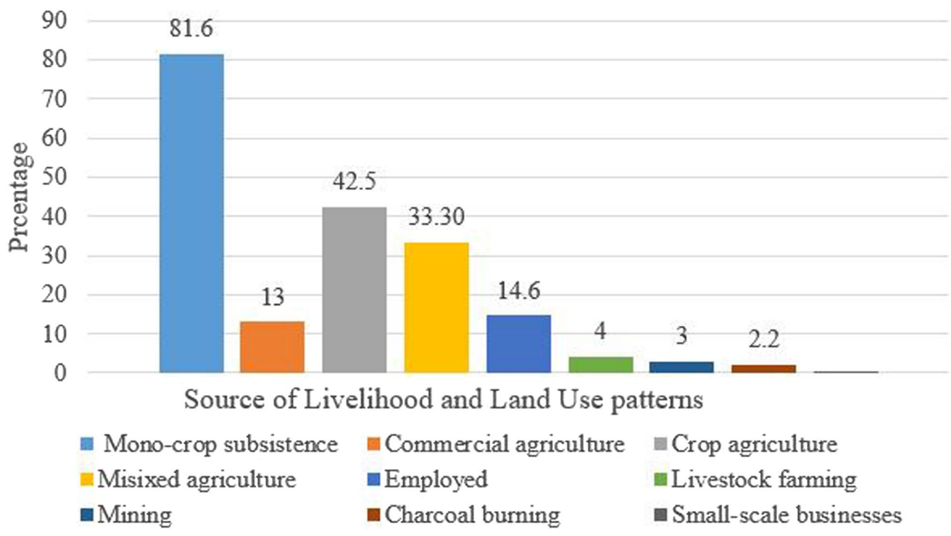

FIGURE 1
Source of livelihood and land use patterns.

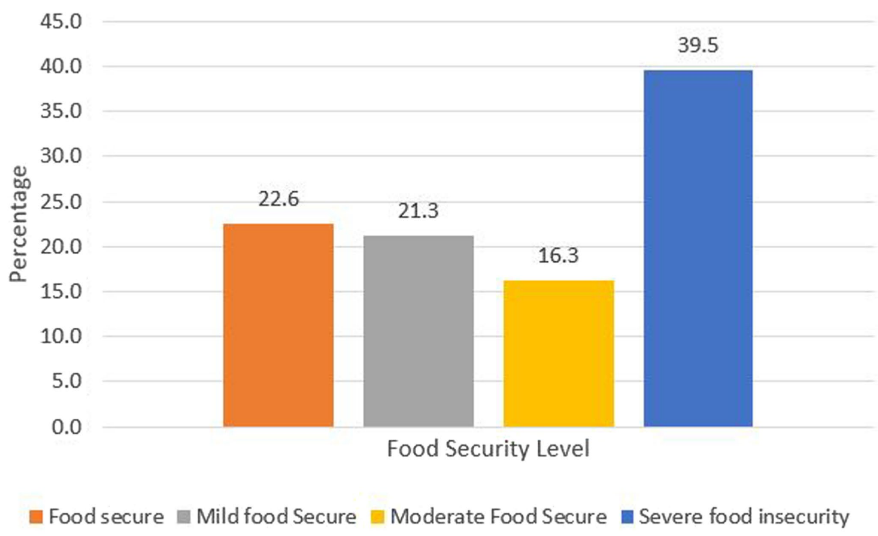

FIGURE 2
Household food security index.

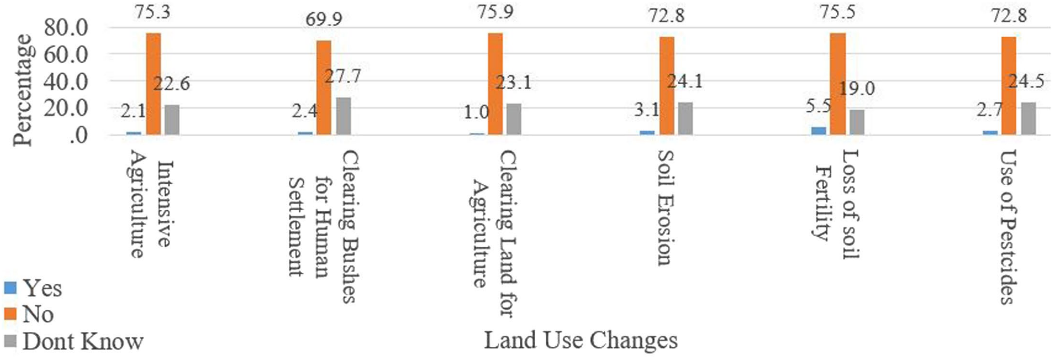

FIGURE 3
Land use changes.

the food security prevalence index, and the respective p-values were determined. A significant relationship was reported only when the value was equal to or less than the significance level. Furthermore, Crammers V was used to establish the strength of the association. The findings are summarized in Table 3.

Findings in Table 3 reveal that using fertilizers and pesticides was significantly associated with food security prevalence with chi-square values ($\chi^2 = 20.977$, $p = 0.013$). Crammers V depicts a weak association (15.2%) between the use of pesticides and food security. Additionally, clearing land for agricultural expansion was not significantly associated with food security. Moreover, the increased demand for land for human settlement correlated significantly with food security with a chi-square value of ($\chi^2 = 15.501$, $p = 0.017$). According to Crammers V, this association was weak, with an association strength of 16%. Nevertheless, our findings reveal that soil erosion was significantly associated with food security ($_\chi^2 = 32.774$, $p = 0.001$), and the loss in soil fertility equally had a significant association with food security ($_\chi^2 = 26.947$, $p = 0.029$). Soil erosion and loss of fertility 300 had an association strength to food security of 19.3 and 17.6%, respectively. In order to provide more insight into the correlation between land use changes and food security, data was disaggregated on the basis of gender, level of income and educational level. These variables were considered because past studies have highlighted their contribution to land use changes and food security.

Table 4 demonstrates that when disaggregated on the basis of gender, only soil erosion and loss of soil fertility were significantly associate with food security with p values of 0.008 and 0.031, respectively. However, it was further noted that the female gender had a significant influence on this association, testing significant for the use of pesticides, soil erosion and loss of soil fertility recording p values of 0.037, 0.021 and 0.002, respectively.

Table 5 presents the findings of disaggregated data based on the level of income of the households surveyed.

Findings in Table 5 reveal that soil erosion and loss of fertility were significantly associated with food security. However, it was observable that low income level had a more significant impact on this association as compared to high educational level. Among the households with a low level of income, it was established that use of fertilizers, soil erosion and loss of fertility had a significant association to food security with p values of 0.048, 0.006, and 0.035, respectively.

TABLE 3 Influence of land use changes on food security.

Land use	Pearson chi-square	p value	Crammers V
Use of fertilizers and pesticides	20.977	**0.013***	0.152
Clearing forests for agriculture	7.517	0.276	0.112
Clearing of forests for human settlement	15.501	**0.017***	0.16
Soil erosion	32.774	**0.001***	0.193
Soil fertility loss	26.947	**0.029***	0.176

*$p < 0.05$. The Bold asterisked values mean that the variables had a significant association with the dependent variable.

Education level is an important socio economic variable that entails the level of access to knowledge for improved decision making and choices. Table 6 provides a summary of the findings of disaggregated data showing the association of land use changes on the basis of educational attainment of the households.

The results in Table 6 show that when disaggregated on the basis of educational level, only soil erosion and loss of soil fertility significantly influenced food security, scoring p values of 0.007 and 0.031, respectively. Moreover, it was observed that households that had lower levels of education had a more pronounced impact on this association. This is because, other than loss of soil fertility and soil erosion, the use of fertilizers was found to significantly affect food security for this category.

4 Discussion

The results of this study established that, on the one hand, subsistence agriculture was the primary source of livelihood for most households. On the other hand, food security prevalence in Mwatate Sub County was established to be below Kenya's national food security index, where only 22.6% of households were found to be food secure. The findings further established that land use changes associated with

TABLE 4 Chi square disaggregation of findings based on gender distribution.

Land use changes	Male	Female	Overall
	p Value		
Use of fertilizers and pesticides	0.387	**0.037***	0.228
Clearing forests for agriculture	0.358	0.905	0.799
Clearing of forests for human settlement	0.985	0.578	0.857
Soil erosion	0.179	**0.021***	**0.008***
Soil fertility loss	0.445	**0.002***	**0.031***

The Bold asterisked values mean that the variables had a significant association with the dependent variable.

TABLE 5 Chi square disaggregation of findings based on income level distribution.

Land use changes	Low Income	High Income	Overall
	p Value		
Use of fertilizers and pesticides	**0.048***	0.897	0.228
Clearing forests for agriculture	0.608	0.082	0.799
Clearing of forests for human settlement	0.865	0.192	0.857
Soil erosion	**0.006***	0.279	**0.007***
Soil fertility loss	**0.035***	0.087	**0.031***

The Bold asterisked values mean that the variables had a significant association with the dependent variable.

TABLE 6 Chi square disaggregation of findings based on level of education.

Land use changes	Low education	Moderate education	High education	Overall
	p Value			
Use of fertilizers and pesticides	**0.001***	0.848	0.113	0.50
Clearing forests for agriculture	0.744	0.99	0.108	0.799
Clearing of forests for human settlement	0.117	0.766	0.142	0.857
Soil erosion	**0.009***	0.632	**0.050**	**0.007***
Soil fertility loss	**0.005***	0.648	0.460	**0.031***

The Bold asterisked values mean that the variables had a significant association with the dependent variable.

increased demand for more agricultural land and human settlement were noted.

Moreover, soil erosion, intensive agriculture, and loss of soil fertility were reported, which led to increased use of fertilizers and pesticides to maximize agricultural production of food. Consequently, chi-square revealed that land use changes correlated with food security because as the human population grows, available land shrinks, necessitating expansion or expansion of agriculture to boost food production.

According to Waceke and Kimenju (2007), subsistence agriculture entails farming crops and livestock with little chance of surplus production. Mono-crop subsistence farming, characterized by soil erosion and infertility, is prevalent in the tropics, exacerbating food security (Amberger, 2006). Therefore, its benefits can only be experienced in the short term, while in the long run, it prevents soil regeneration over time and frequently results in soil infertility and erosion (Ambagna et al., 2012). This implies that subsistence farming does not create a food surplus, and households are in a constant shortage of food. Ultimately, this situation necessitates intensive agriculture to compensate for reduced food demand. Given this position, it is not a surprise that food security is prevalent at the study site. While, on one hand, most households were subsistence farmers, results revealed an increased clearing of bushes for more land.

Land is a critical input in agriculture whose tenure determines the livelihood security of households (Abdillah et al., 2022; Le Mouël et al., 2018). Agriculture has many employment opportunities globally (Christiaensen et al., 2020), employing more than a billion people in developing countries (Davis et al., 2023). In these developing countries, food production is land-based Zeder (2011) and mainly for subsistence consumption (Hurni et al., 2008). Therefore, apart from being a primary source of Livelihood for many households in Kenya, agriculture is vital to achieving food security (Nyamwamu, 2016). This observation was consistent with the findings of this study, which showed that most households depended on mono-crop subsistence farming.

According to Seifert et al. (2022), Taita Taveta has undergone tremendous ecosystem destruction that contributes to soil erosion, drying of springs and loss of soil fertility. The county is further bedeviled by incessant land tenure insecurity that contributes to increased poor food production, since most households depend on subsistence agriculture (Obeka et al., 2024). The county has a unique land security situation in which over 60% of total available land is public land under a national Park. This limits the land available for households to practice agriculture. Coupled with human-wildlife conflict, food production is expected to be affected due to limited agricultural spaces and destruction of crops by wild animals, thereby contributing to food insecurity (Mukeka et al., 2022).

Consequently, land use changes were observed in increased agricultural expansion, soil erosion, and decreased soil fertility. These findings denoted increased land use intensity due to population increases to cater to living spaces. Ultimately, this encroachment reduces food for wildlife, leading to wild animals attacking farms, especially those near the parks. Our study revealed instances where elephants, monkeys, and baboons invaded farmlands and destroyed crops, increasing food insecurity. Nyamwamu (2016) posits a conflict between humans and wildlife over scarce resources.

The study's data was further disaggregated on the basis of gender, level of income and education. This categorization proved to be insightful for this study because there is increasing call for the feminization of agriculture owing to the immense contribution of women in agricultural food production. Women, play a critical role in household food security because they not only mainly work on family farms, but are directly responsible for preparing family meals. Therefore, the findings that the female gender significantly influenced the association between land use changes and food security ware consistent with existing literature.

Socio economic status of households influence land use changes (Simon et al., 2024). In a study conducted in Zambia by Handavu et al. (2019), households' wealth and educational level were significantly found to influence land use dynamics (Briassoulis, 2009). Income influences access to and demand for land and to a larger extent determine land use patterns. Low levels of income accelerates land degradation as households seek to intensify agricultural land use, so as to increase food production (Mootian, 2020). Therefore, it was not a surprise that the results of this study, revealing that majority of the households had a low income level, aligned with this observation.

Additionally, the results of this study established that majority of the households had a somewhat low level of education. Chi square tests revealed that this low level of education correlated with land use changes. In a study by Malaki (2018) in Kenya, it was established that educational attainment significantly influences land use changes. This observation is consistent with the findings of this study.

As the human population grows, land demand soars, disrupting land cover (Winkler et al., 2021). We established this trend in our findings, revealing increased land demand for human settlement and agriculture in the study site. According to the United Nations (2022a), increased demand for agricultural land is associated with ecosystem degradation. Muraoka et al. (2018) also posit that increasing and uncontrolled land use intensity is unsustainable and negatively influences agricultural productivity, affecting food security. Indeed, (Mhawish and Saba, 2016; van Dijk et al., 2013) note that agricultural expansion and intensification contribute to the loss of biodiversity and land use changes, resulting in land degradation. If land use changes are not controlled, this land degradation jeopardizes agricultural land productivity (Paz et al., 2020).

Moreover, as land-use intensity increases, the quality of agricultural land declines, calling for intervention that could boost the soil quality. On this basis, using fertilizers to raise soil quality is necessary. However, using chemical fertilizers and pesticides disrupts the soil fertility of agricultural land. According to Jefwa et al. (2012), fertilizers lower spore abundance in the soil, affecting the soil's ability to increase food productivity. Long-term use of pesticides and organic fertilizers contributes to declining soil fertility, reducing land's agricultural potential. Accordingly, our results drew a negative association between food security and the use of pesticides and fertilizers. Additionally, due to the cost of mono-cropping to soil quality, it was not a surprise that most households noted a decline in soil fertility necessitating fertilizers. This paints a grim picture of the food security situation at the study site.

Forests are crucial in controlling climate change and preserving biological diversity (Borges et al., 2020; Olagunju, 2015). Therefore, deforestation poses a global problem and threatens food security because it degrades soil and interferes with rain patterns and water catchment areas (Olagunju, 2015). Unfortunately, most of Sub-Saharan Africa's forests have been lost in favor of agricultural land (Pellikka et al., 2013). Kenya has lost over 30% of its forest cover to farmlands (Wekesa et al., 2019). The rainforests on Taita Hills that act as water catchment areas for rivers and springs have deteriorated over time due to deforestation (Hohenthal et al., 2015).

This deterioration is fueled by the demand for land for settlement and crop cultivation (Funder and Marani, 2013). Jefwa et al. (2012) note that intensive agricultural activities are prevalent, particularly in high-altitude areas of Taita Taveta County. This is in line with the results of our study. Located at higher altitudes, Chawia, Kishamba, and Bura wards were primarily involved in intensive crop agriculture. This, in turn, impacts the rising demand for agricultural land manifest through clearing forests and bushes. However, Mwatate and Ronge wards at the Taita Hills base reported a higher affinity toward livestock farming.

5 Conclusions and recommendations

Even though SDG 2 aims at reducing hunger through sustainable agriculture, the rising global population pressure has adverse effects on food security. While many factors are attributable to food security, the need to increase food supply through agriculture has exacerbated land use changes that further inequalities in food access. Accordingly, this study aimed at establishing the impact of land use changes on food security. Results revealed that most households were food insecure and that 39.5% experienced severe food security. The study utilized the HFIAS to study the household food security index. However, this method despite being useful, it does not delve into the implication of the food security situation of the households. Given that the study established generally low levels of food security at the study site, we recommend that future studies should be able to employ anthropometrical methods to establish the health impact of food insecurity in households. Moreover, agriculture was the primary source of livelihood for most households, where household practiced mono-crop subsistence and livestock farming, compared to a minority that ventured into other livelihood alternatives of business, formal employment and mining. Accordingly, the study established that changes in agricultural land use are present at the study site. A significant statistical correlation was established between food security and land use changes. Specifically, the findings revealed an increased demand for agricultural land contributed to increased deforestation, clearing of forests and bushes, soil erosion, soil fertility loss, and rivers drying. Therefore, statistical test demonstrated that agricultural land-use changes negatively influenced agricultural productivity, thereby accelerating food security in Mwatate Sub County.

The results revealed an interesting angle to understanding the association between land use changes and food security. The findings demonstrated that the gender, income, and educational level of the respondents had a critical bearing on shaping this association. Consequently, amid the growing human population and its effect on agricultural expansion, the study recommends adopting sustainable agricultural and farming practices that can boost agricultural food yield. Disaggregated analysis revealed that women's agricultural participation influenced land use changes. This study, therefore, recommends the need for deliberate effort through agricultural policy reforms to ensure increased participation of women in agriculture. This effort can be supplemented through agricultural extension education, where awareness on the contribution of women to agriculture can be emphasized and encourage the community to embrace women in agriculture given their immense contribution to the food system. Additionally, to supplement this, we draw the need to boost food security through food crop diversification beyond the maize farming that most households embraced. The findings of this study paint a picture in which there are accelerated land use changes at the study site. Coupled with the existing land use challenge, this study recommends a future study that can establish whether land tenure security has an impact on these land use changes at the study site. More so, such a recommended study could focus on a gendered dimension and evaluate whether the involvement of women in agriculture and securing their tenure rights can positively impact on land use and agricultural productivity.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: 10.6084/m9.figshare.21973346.

Ethics statement

The studies involving humans were approved by Pwani University Ethics Review Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

OB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. EW: Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Writing – review & editing, Writing – original draft. HS: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review & editing. WV: Methodology, Supervision, Validation, Writing – review & editing, Writing – original draft.

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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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