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Transforming livestock production: unraveling the impact of socioeconomic dynamics and land use changes in Khost Province

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ABSTRACT

This study examines the impact of socio-economic factors and land-use changes on livestock production among rural communities in Khost Province, Afghanistan. Data were collected from 687 livestock owners across five districts (Gurbuz, Khost 'Matun,' Mandozayi, Musakhel, and Qalandar) using a structured questionnaire. Analytical techniques, including Univariate ANOVA, MANOVA, and binary logistic regression, were applied. Findings reveal that key socio-economic factors—such as age, household size, homeownership, and income—significantly influence livestock farming. Farmers with access to modern infrastructure and experiencing natural land-use shifts reported positive effects on livestock production. The study highlights that cows, sheep, goats, donkeys, horses, and fish are integral to farming practices, with cow and fish owners primarily viewing their livestock as income sources. These insights underscore the need for targeted interventions by the government and development organizations to enhance sustainable livestock farming, ultimately improving livelihoods and economic stability in rural Afghanistan.

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Afghanistan; Khost province; land use change; livestock production; socioeconomic dynamics

Introduction

Socioeconomic factors and land use changes altogether determine the way farmers allocate their land and adopt practices for sustainable livestock production. In Afghanistan, particularly in Khost province, agroforestry activities play a significant role, constituting around 60% of the economy, with a focus on agroforestry activities (World Bank, 2018). Agroforestry is globally acknowledged as a vital land-use strategy, promoting sustainable development and resistance to climate change (Bhattacharya, 2024; Jhariya et al., 2019). However, its implementation in Afghanistan remains limited to specific geographic areas within the country with better security situations and to selected species (Ahmad et al., 2022; NEPA, 2019). Remarkably, a substantial portion of the rural Afghan

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population (about 41%) experiences low dietary diversity due to the limited productivity of livestock (CSO, 2014; Poole et al., 2019). Several studies have investigated how socioeconomic factors impact agriculture, forestry, and livestock production across diverse agricultural settings and countries (Hadush et al., 2019; Khoza et al., 2019; Kumar et al., 2015; Kyryliuk et al., 2020; Nkonki-Mandleni et al., 2019; Safi, 2023; Salamula et al., 2017; Yang et al., 2022). These factors also play a significant role in farmers' willingness to adapt to change, decisions regarding the adoption of advanced technologies and fertilizers, and other related aspects of agroforestry production (Elahi et al., 2021; Perez et al., 2015). Nonetheless, the extent to which socio-economic factors influence livestock production in dependent communities within Khost Province, Afghanistan, remains largely unexplored.

Several studies assessed the role of socioeconomic factors in livestock production in several countries. Kyryliuk et al. (2020) found that in Ukraine, household producers are the primary contributors to livestock product output, yet they often lack access to high-quality technologies for animal care, feeding, veterinary services, and compliance with Hazard Analysis Critical Control Point (HACCP) principles. This deficiency stems mainly from capital limitations and reduced profitability caused by rapid price inflation in the country. Additionally, the substandard quality of livestock products is linked to poor socioeconomic conditions, such as inadequate living standards and low household incomes among Ukrainian farmers (Kyryliuk et al., 2020). Similarly, in Alabama, socioeconomic factors exert varied influences on different aspects of livestock production practices. For example, farming status significantly impacts rotational grazing, while education and income levels affect parasite issues, and age influences access to veterinary services. Moreover, factors like race or ethnicity and education significantly affect record-keeping practices in livestock farming (Tackie et al., 2016). Therefore, the significance of socioeconomic factors in shaping livestock production cannot be overlooked, particularly in agroforestry regions (Safi et al., 2024).

Kumar et al. (2015) examined the socioeconomic status and the role of livestock in enhancing the livelihoods of tribes in Jharkhand, India, and found that livestock contribute more annual income to tribes compared to other sources such as wages, remittances, or shop-keeping. They noted that extension services and exposure to mass media assist tribes in overcoming social isolation resulting from their remote, isolated geographic. In Kyrgyzstan, the expansion of livestock husbandry has had spatial spillover effects, leading to increased sales of animal livestock and influencing neighboring regions (Yang et al., 2022). Market dynamics and environmental factors, including market prices, non-herding income, and current livestock inventory, along with socioeconomic factors such as education levels and a higher proportion of rural residents, have strongly contributed to the rise in animal livestock sales in Kyrgyzstan (Yang et al., 2022). Although the socioeconomic factors influencing livestock production or agroforestry, in general, were widely researched, each country has different socioeconomic profiles and, hence, would have different effects on livestock production within Afghanistan.

Reintegrating specialized intensive crop and livestock systems offers economies of scale in production, reduces nutrient surpluses at farm, regional, and national levels, and enhances soil quality in intensive cropping systems (Schut et al., 2021). This reintegration enables farmers to explore the co-benefits and overcome barriers to mixed farm systems by expanding crop rotations, utilizing organic inputs, reducing reliance on synthetic fertilizers and biocides, and managing manure processing costs, thereby further intensifying land use (Schut et al., 2021). Keesing et al. (2018) underscored the ecological benefits of integrating livestock and wildlife, including tick reduction and improved forage, alongside economic benefits such as increased income from wildlife tourism and livestock meat and dairy production. Thus, integrating livestock and other agroforestry products offers farmers ecological and economic advantages. The study will fill in a research gap within the existing literature by assessing the differences in the perception and satisfaction of livestock owners on factors relating to land use changes. Although the barriers and benefits of livestock and agroforestry are widely researched, the study also contributes to the existing literature by examining the role of perception and satisfaction relating to land use changes on livestock production among livestock owners. Land use changes may occur based on the suitability of soil

nutrients and soil fertility (Willy et al., 2019). Lands with rich soil nutrients and high fertility are more likely to be used for agricultural purposes, while areas with low soil fertility often cultivate drought-resistant crops like sorghum and millet, with extensive livestock production being a key economic activity (Willy et al., 2019). Hence, it is important to determine the extent to which factors related to land use change affect livestock production in dependent communities of Khost Province, Afghanistan. Therefore, the objectives of the study are twofold: (i) to evaluate the socio-economic factors influencing livestock production among rural communities in Khost Province, Afghanistan; and (ii) to evaluate the alterations in land utilization influence livestock farming among rural communities in Khost Province, Afghanistan. For this purpose, a quantitative study was conducted, in which farmers from five districts of Khost province, Afghanistan, including Gurbuz, Khost 'Matun', Mandozayi, Musakhel, and Qalandar, were surveyed about their socioeconomic factors and opinions regarding satisfaction with facilities and infrastructure in the residential area, knowledge of land use changes, satisfaction with land resources, and perception of land use trade-offs.

Methodology

The study was conducted in Khost Province, Afghanistan, covering five districts: Gurbuz, Khost 'Matun', Mandozayi, Musakhel, and Qalandar (Figure 1). The total population of the region is approximately 574,582. The climate is categorized as humid subtropical with no distinct dry season. The elevation is recorded at 3805.64 feet above sea level. The total forested area covers 365.82 square kilometers, while agricultural land occupies 7.2% of the total land area.

The study employed the population identification theory to explain the combined social and economic effects of livestock on dependent communities in Khost Province, Afghanistan. Population identification entailed 'increasing the density of population on a fixed area of land,'

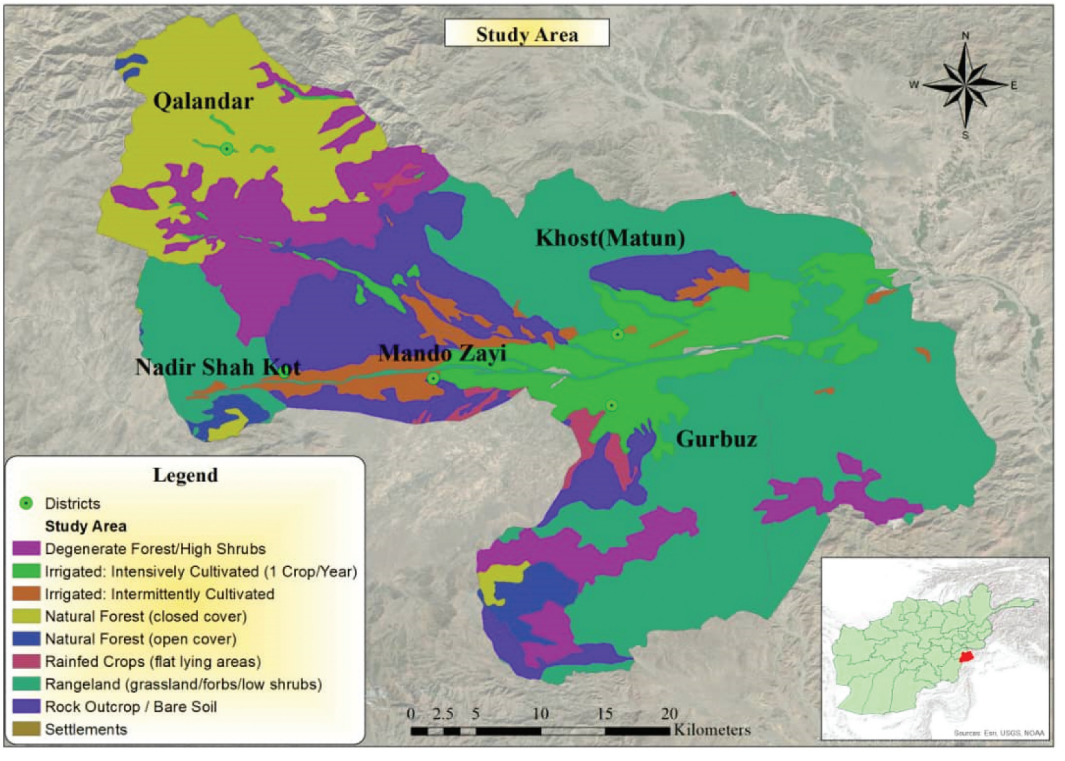

Figure 1. Location of the study area – Southeastern Afghanistan.

solely through natural increase, excluding migration or conquest (Caldwell, 2006). Identification also involved the heightened utilization of external inputs and services to enhance output quantity and/or value per unit input (Bebe et al., 2002). This theory aided in understanding how advanced management techniques were applied to enhance production per animal and labour unit (Udo et al., 2011).

According to Hadush et al. (2019), empirical findings supported both Malthus and Boserup's theories. Following Malthus's theory, high population pressure correlated with smaller farm and herd sizes, profoundly affecting technology use and output supply. Conversely, following Boserup's theory, an increase in population pressure also escalated the utilization of modern inputs and output supply. However, it might have led to a decline in the use of modern inputs and output supply once population densities surpassed a critical threshold level.

Sampling techniques

The study employed a cross-sectional and correlational research design to analyze the impact of socioeconomic factors and land use changes on livestock production. As opposed to longitudinal research design that surveys the population over an extended timeframe, cross-sectional research design allows collecting the data at a single point in time (Fischer et al., 2023). Similarly, with correlational research design, the study seeks to assess the association between variables under study, not just describing the study population or topic at hand (Gupta & Gupta, 2022). The research was conducted in five districts of Khost Province: Gurbuz, Khost 'Matun,' Mandozayi, Musakhel, and Qalandar. Following Ahmad et al. (2022) and the World Bank (2018), (Rahim, 2018), these districts were chosen based on their agroforestry and livestock farming activities, as well as the declining socioeconomic status of farmers in the area. Stratified sampling technique was applied for sample selection, wherein the target population was divided into strata representing the five districts, and then a sample was randomly selected from each stratum. This technique was better than quota sampling, as it determines the number of respondents to be surveyed from each district based on their population, rather than having predetermined, equal sample size for all districts (Creswell & Creswell, 2022). It was also better than purposive sampling, as it serves the purpose of the study while proportioning sampling population on an articulated rate (Creswell & Creswell, 2022). For applying stratified sampling technique, the sample size for each stratum (Gurbuz, Khost 'Matun,' Mandozayi, Musakhel, and Qalandar) was determined using the Krejcie and Morgan (1970) – stratification formula (Equation 1). Given that the population of each stratum was 161,780, 66020, 30670, 48000, and 11,970 respectively, the Krejcie and Morgan (1970) – stratification formula generated the respective sample sizes of 63, 337, 137, 120, and 30, respectively, totaling 687 participants.

$$n = \frac{\chi^2 Np(1-p)}{e^2(N-1) + \chi^2 p(1-p)} \tag{1}$$

whereby,

n = sample size
N = population size
e = acceptable sampling error
χ^2 = chi-square of degree of freedom 1 and confidence 95% = 3.841
p = proportion of population [if unknown, 0.5]

It should be noted that limited population access in Afghanistan may affect the study findings, as the country has a rigid culture, lacks infrastructure, and most importantly, has high-security risk and threat of terrorist attacks (Braithwaite & Wardak, 2013; Lamberti-Castronuovo et al., 2024), which restricts the access to the entire population. This may lead to sampling bias, create a non-

representative sample, and reduce the generalizability of results to the entire population of Afghanistan. Hence, following Hirschauer et al. (2020) approach, due to the lack of a random sample, no correction for selection bias, and lack of producing inductive generalized inferences from sample to population, the study only reported summary statistics of sample, including effect size and odds ratio, to answer the research question.

Research instrument

The study developed a self-administered questionnaire with the assistance of nine experts from Kabul University and three experts from the Ministry of Agriculture, which was then validated by 12 professors at Kabul University. The questionnaire comprised two sections. Section 1 inquiries into socioeconomic factors, including age, gender, marital status, household size, member of any association, education level, working experience, monthly income, and monthly household income. Section 2 inquiries about factors of land use changes, which is comprised of four sub-dimensions: (i) satisfaction with facilities and infrastructure (7 items), (ii) knowledge of land use changes (6 items), (iii) satisfaction with land resources (6 items), and (iv) perception of land use trade-offs (13 items). Satisfaction with facilities and infrastructure measures farmers' satisfaction with the available resources that enhance and preserve natural land and support their livestock farming activities. An example item would be 'Having electricity supply'. Knowledge of land use changes assesses the farmers' awareness level of land changes for different purposes due to human activities, natural processes, or both. An example item would be 'I feel that my area is getting warmer now due to land use change.' Satisfaction with land resources measures farmers' satisfaction with the available natural and artificial land resources for their livestock farming. An example item would be 'development of hydroelectric dam'. Perception of land use trade-offs assesses how farmers perceive the trade-offs between barriers and economic benefits of utilizing land. An example item would be 'herbs are getting difficult to find.' For inquiring about respondents' agreement with each statement, these statements in Section 2 were measured on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). Lastly, a list of livestock products was provided with a Yes/No scale to ask the respondents which products they and their families were producing and engaged in. For this purpose, the livestock products surveyed include cows, sheep, goats, horses, donkeys, chickens, and fish.

Data analysis

Descriptive statistical analysis was conducted to describe the composition of respondents across socioeconomic characteristics. For inferential statistical analysis, exploratory factor analysis was conducted to identify a unique set of variables based on the relationships and patterns identified in the data. Once factors were extracted, Univariate Analysis of Variance (Univariate ANOVA) and Multivariate Analysis of Variance (MANOVA) were conducted to compare the identified factors across various livestock products. According to Saharan et al. (2024), if an identified factor has a single dimension, Univariate ANOVA was applied, and if identified factors have two or more dimensions, MANOVA was applied. Such assessment was conducted to identify which livestock products, if sufficiently produced, might have different levels of farmers' satisfaction, knowledge, perception of land use change, and land use trade-offs. This would be useful in directing farmers' attention to whose production can be improved through enhancing or mitigating significantly different products. Furthermore, binary logistic regression analysis was conducted to assess the impact of socioeconomic factors and factors associated with land use change on livestock production. Here, livestock production is considered as a binary variable with Yes (1 = if produced by a respondent/farmer) or No (0 = if not produced by a respondent/farmer) scale. Such analysis can identify the socioeconomic factors and factors relating to land use changes that would affect the growth of livestock

production and would be altered to optimize livestock production. All analyses were performed using SPSS version 29.0.

Ethical consideration

To achieve confidentiality of the participants' information, all data was accessible to the researcher only. To maintain privacy and trust, informed consent regarding their participation was taken from the respondents; they have the full right to participate voluntarily or leave the survey at any point in time. No physical or mental harm was made to agroforestry products or participants during the execution of the study. To ensure transparency, the project objectives and questions were clearly defined, as well as the roles of participants and researchers in the projects. All participants were given equal opportunity to participate in the survey.

Results

Demographic profiling

Descriptive and socioeconomic profiling of surveyed respondents were shown in Table 1. The results showed that approximately 70.9% of respondents fell within the age range of 15–34 years, with 68.6% being married. Moreover, a significant majority of respondents, comprising 92%, were male. In terms of income, nearly half of the respondents (42.1%) had an income of below AFG 5,000, which indicated that most farmers were earning less than the minimum wage set by the

Table 1. Descriptive and socioeconomic profile in total and across districts.

Variables	Categories	Gurbuz (*N* = 63) %	Khost "Matun" (*N* = 237) %	Mandozayi (*N* = 137) %	Musakhel (*N* = 120) %	Qalandar (*N* = 130) %	Total (*N* = 687) %
Age	15–24 years	25.4%	24.9%	28.5%	44.2%	58.5%	35.4%
	25–34 years	41.3%	40.5%	44.5%	29.2%	20.0%	35.5%
	35–44 years	15.9%	20.3%	21.9%	16.7%	8.5%	17.3%
	45–54 years	14.3%	10.5%	3.6%	9.2%	13.1%	9.8%
	55 years and above	1.6%	3.4%	1.5%	0.8%	0.0%	2.0%
Gender	Male	100.0%	93.7%	82.5%	87.5%	96.9%	91.6%
	Female	0.0%	6.3%	17.5%	12.5%	3.1%	8.4%
Marital Status	Single	12.7%	32.1%	32.1%	21.7%	40.0%	30.0%
	Married	87.3%	67.1%	67.9%	74.2%	57.7%	68.6%
	Divorced	0.0%	0.8%	0.0%	4.2%	2.3%	1.5%
Income	AFG 5000 and below	22.2%	40.9%	53.3%	35.8%	47.7%	42.1%
	AFG 6000–8000	12.7%	28.7%	18.2%	27.5%	23.8%	24.0%
	AFG 9000–10000	25.4%	14.8%	19.7%	18.3%	13.8%	17.2%
	AFG11000–15000	23.8%	7.2%	5.8%	16.7%	10.0%	10.6%
	AFG16000 and above	15.9%	8.4%	2.9%	1.7%	4.6%	6.1%
Educational Level	No Formal Education	11.1%	27.0%	30.7%	23.3%	13.1%	23.0%
	Primary School	7.9%	13.9%	12.4%	12.5%	15.4%	13.1%
	Secondary School	33.3%	28.3%	28.5%	31.7%	48.5%	33.2%
	College/University	30.2%	18.1%	26.3%	30.8%	23.1%	24.0%
	Master	17.5%	12.2%	1.5%	1.7%	0.0%	6.4%
	Ph. D.		0.4%	0.7%	0.0%	0.0%	0.3%
Household Size	1–4	1.6%	9.7%	27.7%	14.2%	2.3%	11.9%
	5–9	28.6%	30.8%	19.0%	10.8%	16.2%	22.0%
	10–14	25.4%	24.9%	27.0%	25.0%	31.5%	26.6%
	20 and above	15.9%	13.9%	0.0%	6.7%	15.4%	29.1%
House Ownership	1	74.6%	79.3%	79.6%	85.0%	96.9%	83.3%
	2	25.4%	20.7%	20.4%	15.0%	3.1%	16.7%
Member of any Association	Yes	31.7%	18.1%	39.4%	27.5%	22.3%	26.1%
	No	68.3%	81.9%	60.6%	72.5%	77.7%	73.9%

Afghan government. In terms of education, about one-third of the respondents had completed their education up to the secondary school level (33.2%). Regarding household size, a considerable proportion of respondents reported having more than 20 household members (29.1%). Additionally, the majority of respondents owned a single house (83.3%). Lastly, it was observed that a substantial portion of respondents did not hold membership in any association, constituting 73.9% of the sample.

Exploratory factor analysis and reliability test

Exploratory factor analysis using the principal component method as the extraction method and Varimax as the rotation method was conducted to determine the factors of all variables under study (Table 2). All items falling under each factor and construct had factor loadings higher than the threshold level of 0.60 and were included in the factor extraction matrix. All items explained more than 60% of the variance in their respective constructs.

Table 2. Results of the exploratory factor analysis and reliability analysis.

Factors Extracted	Items Falling under Each Factor	% Variances Explained
Satisfaction with Facilities & Infrastructure		
Satisfaction with Basic Facilities	Home accommodation	52.1%
	Clean water source	
	Education facility	
Satisfaction with Advanced Facilities	Electricity facility	13.9%
	Road accessibility	
	Health facility	
	Religious-building mosque	
	Sport facility	
	Communication facility	
Knowledge about Land Use Change		
Knowledge about Land Use Change	Rapid change in forest	61.1%
	Forest changes due to extreme human activities	
	Reduced wildlife habitat	
	Reduced wildlife numbers	
	Warmer area due to land use change	
	Awareness of land use change	
Satisfaction with Land Resources		
Natural Factors	Logging	53.5%
Artificial Factors	Development of planted forest	20.3%
	Development of hydroelectric dam	
	Agricultural activities	
	Government policy	
Perception of Land Use Trade-Offs		
Barriers	Difficult to find herbs	54.1%
	Difficult to find rattan/bamboo	
	Difficult to find wild fruits	
	Difficult to find food	
	Difficult to find wild animals	
	Difficult to find river sources	
Economic Benefits	Elevating the price of local handicrafts	14.5%
	Increasing sales of local handicrafts	
	Elevating the price of forest produce	
	Increasing sales of forest produce	
	Increasing sales of agricultural products	
	Increasing income	
	Increasing job opportunities for the local community	

Table 3. Comparison of satisfaction with facilities and infrastructure, knowledge of land use changes, satisfaction with land resources, and perception of land use trade-offs across livestock products ($n = 687$).

	Satisfaction with Facilities and Infrastructure		Knowledge of Land Use Changes	Satisfaction with Land Resources		Perception of Land Use Trade-Offs	
	Basic Facilities	Advanced Facilities		Natural Resources	Artificial Resources	Barriers	Economic Benefits
Production of Livestock Products (% of Total Sample Size Engaged in a Certain Product)	MANOVA effect size (partial η^2)		Univariate ANOVA effect size (partial η^2)	MANOVA effect size (partial η^2)		MANOVA effect size (partial η^2)	
Cows (29%)	**0.014**	0.006	0.004	**0.014**	0.000	0.009	**0.010**
Sheep (21.1%)	0.007	0.008	0.001	**0.020**	**0.010**	0.001	0.008
Goats (22.7%)	**0.015**	**0.010**	0.003	**0.013**	0.009	0.000	0.006
Horses (21.5%)	0.000	**0.019**	0.000	**0.031**	**0.019**	0.001	0.010
Donkeys (21.3%)	0.003	0.001	0.001	**0.020**	**0.014**	0.006	0.001
Chicken (21.3%)	0.000	0.009	0.000	0.009	0.002	0.001	0.004
Fish (20.2%)	0.000	**0.011**	0.000	**0.024**	**0.011**	0.000	**0.015**

Partial η^2 : partial eta squared.
Partial η2 : Small effect size = 0.01; Medium effect size = 0.06; Large effect size = 0.14 or higher.

Comparison of factors relating to land use change among livestock products

Univariate ANOVA analysis was conducted to compare the knowledge of land use changes and its impacts on livestock products, considering its one dimension (Table 3). However, MANOVA was used to compare satisfaction with the level of facilities and infrastructure, satisfaction with land resources, and perception of land use trade-off across different livestock products, considering two dimensions (Table 3).

The assumptions of homogeneity of covariances and multivariate normality were met ($p > 0.05$), allowing the analysis to proceed. Results revealed that only farmers who owned cows and goats reported a small effect on satisfaction with basic facilities and infrastructure (Cows: $\eta^2 = 0.014$; Goat: $\eta^2 = 0.015$). Whilst goat, horse, and fish owners showed a small effect on satisfaction with advanced facilities and infrastructure (Goat: $\eta^2 = 0.010$; Horse: $\eta^2 = 0.019$;

Table 3 also showed that regarding satisfaction with land resources, only farmers who own cows, sheep, goats, horses, donkeys, and fish reported a small effect on natural resources (Cows: $\eta^2 = 0.011$; Sheep: $\eta^2 = 0.020$; Goat: $\eta^2 = 0.013$; Horse: $\eta^2 = 0.031$; Donkey: $\eta^2 = 0.020$; Fish: $\eta^2 = 0.024$), while farmers who own sheep, horse, and fish reported a small effect on artificial resources (Sheep: $\eta^2 = 0.010$; Horse: $\eta^2 = 0.019$; Donkey: $\eta^2 = 0.014$; Fish: $\eta^2 = 0.011$). Regarding the perception of land use trade-offs, none of the livestock products had no effect on barriers of land use ($\eta^2 < 0.010$), while only farmers who own cows and fish reported a small effect on economic benefits (Cows: $\eta^2 = 0.010$; Fish: $\eta^2 = 0.015$).

A clustered bar chart was designed to graphically compare factors of land use change across livestock products (Figure 2). Each factor showing significance in comparison between having and not having a particular livestock indicated that having livestock leads to a higher score in that factor. For instance, owners of cows, sheep, goats, horses, donkeys, and fish were more satisfied with natural resources like logging than livestock owners without these animals.

Impact of socioeconomic factors & factors relating to land use change on livestock production

Binary logistic regression analysis was conducted to examine the influence of socioeconomic factors and factors related to land use change on livestock production in dependent communities of Khost Province, Afghanistan (Table 4). Initially, the assumptions of binary logistic regression analysis were assessed (Harris, 2021): (i) independence of observations; (ii) absence of multicollinearity among

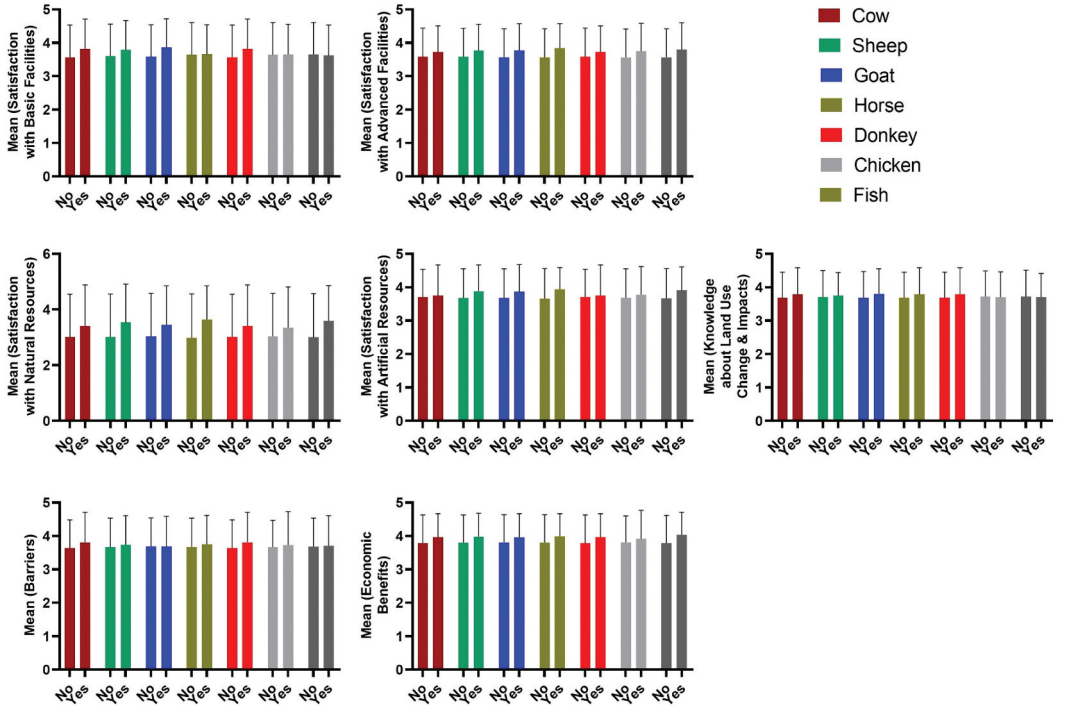

Figure 2. Clustered bar chart. Fish: $\eta^2 = 0.011$). Furthermore, regarding knowledge of land use changes, all livestock products had no effect ($\eta^2 < 0.010$).

independent variables, confirmed by Variance Inflation Factor (VIF) scores less than 10 and tolerance scores higher than 0.20; and (iii) linear relationship between continuous predictors and a transformed version of the dependent variable, verified by the non-significance of interactions between continuous variables and their log transformations with respect to livestock production ($p > 0.05$). With all assumptions met, the binary logistic regression analysis proceeded.

Results from binary logistic regression analysis revealed that the Hosmer and Lemeshow test was not significant at the 5% level (χ^2 (8) = 10.207, $p = 0.251$), indicating a good fit of the model with the data. The model explained 28.2% (Nagelkerke R^2) of the variance in livestock production and correctly classified 70.9% of cases. In terms of socioeconomic factors, results from the odds ratio indicated that increasing age was associated with an increase in the likelihood of livestock production. Relative to single farmers, the odds ratio of married and divorced farmers was very small in magnitude, which suggested that marital status did not influence livestock production. Relative to farmers having one to four family members, the odds ratio of farmers having five to nine family members was large in magnitude but lower than 1, indicating such shift in household size undermines livestock production. However, the relative odds ratio of larger household size was close to 1, indicating no effect. Relative to farmers with household income less than AFG15,000, farmers having household income ranging between AFG21,000 to AFG40,000 have an odds ratio less than and distant from 1, which indicated that higher household income reduced the likelihood of livestock production. Furthermore, house ownership reduces farmers' chances of producing livestock by 0.36 points. However, membership in an association, education, working experience, and monthly income were found to have no effect on livestock production.

Table 4. Binary logistic regression analysis – impact of socioeconomic factors and factors relating to land use change on livestock production.

	OR
Constant	0.049
Age: 15 to 24 years old	Reference Category
Age: 25 to 34 years old	0.634
Age: 35 to 44 years old	0.631
Age: 45 to 54 years old	0.367
Age: 55 to 64 years old	1.072
Age: 65 years and above	16.597
Gender: Male	Reference Category
Gender: Female	1.382
Marital Status: Single	Reference Category
Marital Status: Married	1.265
Marital Status: Divorced	1.509
Household Size: 1–4	Reference Category
Household Size: 5–9	0.301
Household Size: 10–14	1.093
Household Size: 15–19	0.496
Household Size: 20 and above	0.599
Member of any Association: No	Reference Category
Member of any Association: Yes	1.153
Education Level: No Formal Education	Reference Category
Education Level: Primary School	1.789
Education Level: Secondary School	0.709
Education Level: College/University	1.443
Education Level: Master	0.910
Education Level: Ph. D.	1.237
Working Experience: 1–5 years	Reference Category
Working Experience: 6–10 years	1.483
Working Experience: 11–15 years	1.500
Working Experience: 16 years and above	0.436
Monthly Income: AFG5000 and below	Reference Category
Monthly Income: AFG6000 – AFG8000	1.122
Monthly Income: AFG9000 – AFG10000	0.681
Monthly Income: AFG11000 – AFG15000	0.690
Monthly Income: AFG16000 and above	0.908
Household Income: AFG15000 and below	Reference Category
Household Income: AFG16000 – AFG20000	0.845
Household Income: AFG21000 – AFG25000	0.433
Household Income: AFG26000 – AFG30000	0.339
Household Income: AFG31000 – AFG35000	0.398
Household Income: AFG36000 – AFG40000	0.287
Household Income: AFG41000 and above	0.901
House Ownership: No	Reference Category
House Ownership: Yes	0.641
Satisfaction with Basic Facilities and Infrastructure	0.968
Satisfaction with Advanced Facilities and Infrastructure	1.578
Knowledge of Land Use Change	0.889
Natural Factors of Land Use Change	1.287
Artificial Factors of Land Use Change	1.002
Barriers	1.411
Economic Benefits	1.126
Omnibus Tests of Model Coefficients (χ^2/p-value)	162.673 (< 0.001)
Hosmer and Lemeshow Test (χ^2)	10.207 (0.251)
Negelkerke R-square	0.282

Concerning factors of land use changes, results indicated that farmers who were satisfied with advanced facilities and infrastructure, satisfied with the natural factors of land use change, and faced barriers showed an odds ratio higher than and distant from 1. This indicated that enhancing these factors lead to an increase in livestock production.

Discussion

Key study findings

The study was conducted in communities within Khost Province, Afghanistan, and identified several influential factors affecting livestock production, including age, household size, house ownership, farmer's household income, satisfaction with advanced facilities and infrastructure, satisfaction with natural land resources, and perceptions of barriers to land use. This aligned with prior research emphasizing the significance of socioeconomic factors in shaping livestock production outcomes. For instance, Kumar et al. (2015), Góngora et al. (2019), and Maina et al. (2020) found that farmers with old age displayed a preference for livestock farming in Jharkhand, while Sultana et al. (2016), Sanchez-Sabate and Sabaté (2019), and Elahi et al. (2021) demonstrated the adverse effects of age and education on milk production and water utilization. Moreover, Ozcatalbas et al. (2010), Salamula et al. (2017), and Jha and Gupta (2021) emphasized the importance of factors such as farm size, experience, and household size in influencing decisions related to livestock production. Nkonki-Mandleni et al. (2019) assessed the influence of socioeconomic factors on livestock production among smallholder farmers in South Africa and identified, consistent with this study's findings, that location, advice/training, and household size were common influencing factors, besides land conditions, veterinary services, planted pastures, purchase of dosing products, and sales per year. Liu et al. (2023) also supported the study findings at the global level that country of origin, in interaction with the level of meat consumption, income, and area of work, affects consumers' perception of livestock production and meat consumption. Overall, livestock production leads to smallholder farmers' participation in the agro-processing industry (Khoza et al., 2019) and agroforestry adoption (Bekele et al., 2024) as well.

The study also conducted an extensive comparison of factors related to land use change, including satisfaction with basic and advanced facilities, knowledge about land use change and impacts, satisfaction with natural and artificial land resources, and perception of land use trade-offs, across livestock production. Consistent with Williams et al. (2017), the study found that cow and goat owners requires basic facilities such as water availability to increase its production. In line with Kamran et al. (2022) and Nyboer et al. (2022), donkey, horse, and fish owners who have electricity, road, communication, and health facilities can maintain their cattle for a longer time. Consistent with Hassanuur et al. (2020), cow, sheep, goat, horse, donkey, and fish owners often look for natural resources such as logging and water resources in order to maintain their livestock. Past literature (Choudhary & Garkoti, 2024; Qasim, 2024; Rajaei et al., 2021) also supported the study findings that sheep, horse, and fish owners often preferred to possess artificial resources such as dams, planted forest, agricultural policy, and government policy. Consistent with Inatimi (2023), the study found that horse and donkey owners maintain their livestock upon the degradation of forests' vegetables. In line of Acosta et al. (2024) and Eriksson et al. (2019), the study found that cow and fish owners perceive and get economic benefits through increased prices and sales. As a whole, the study identified specific livestock products that can be maintained through the availability of natural resources and basic facilities and by mitigating barriers to land use changes.

The study also found that the availability of advanced facilities and infrastructure, favorable perceptions regarding natural factors influencing land use change, and perception of barriers of land use changes contributed to increase the likelihood of livestock production. This finding is consistent with the studies of Guanghui (2019), Morshed et al. (2024), Mushwani et al. (2024), Odintsov Vaintrub et al. (2021), and Wang et al. (2016) where they highlighted the essential role played by advanced technologies, healthcare facilities, and improved accessibility in enhancing livestock productivity and welfare. Conversely, Ahmed and Ambinakudige (2023) and Sejian et al. (2015) stated that specific natural factors associated with land use change, such as soil waterlogging, could have adverse effects on livestock production. Piponiot et al. (2019) and Poudyal et al. (2020) also emphasized that only selectively logging or reduced-impact logging can reduce logging damage and enhance the environmental value of logged forests. Furthermore, while the negative

consequences of land use change, such as the depletion of wild resources, might serve as incentives for livestock production, they also pose considerable threats to ecological equilibrium, as highlighted by Perez et al. (2015) and Rajaei et al. (2021). Socioeconomic factors and perceptions of land use change significantly impact livestock production in Khost Province, Afghanistan. Addressing these factors can enhance livestock productivity and livelihoods in the region, requiring targeted interventions and policy measures.

Implications for practice and policy

The study has several implications: Firstly, livestock owners can utilize the findings of this study by focusing on significant socioeconomic factors and factors relating to alteration to land utilization that would improve their livestock production. Thus, providing education and gaining from the expertise of the younger generation provides a better understanding of how livestock production can be increased and maintained. Secondly, policymakers and government can also utilize the study findings by designing policies to promote education, create awareness of potential barriers and economic benefits, and develop advanced infrastructure such as accessibility of electricity, roads, communication infrastructure, and healthcare facilities. Thirdly, livestock owners, government, and other governing bodies can develop and follow strict food safety and quality standards to maintain the health of livestock. Lastly, national and local managers can develop a new animal husbandry production system that could improve the adaptability and reproductive efficiency of livestock. Such a system would include water accessibility, accessibility of advanced facilities, and a positive perception of resource availability and effectiveness of marketing strategies.

Limitations & future research

Limitations and corresponding recommendations for future research are discussed as follows: Firstly, within stratified sampling, the study seeks to apply random sampling within each stratum. However, there is a potential bias in data collection and representativeness of the sample due to a lack of physical connectivity to the entire population at once. Future studies can be conducted at a smaller scale or can apply other forms of sampling, such as quota sampling or purposive sampling, to avoid this limitation. Secondly, the study utilized a cross-sectional research design to collect data via questionnaire at a single point in time. Future studies can collect secondary data and assess the changes in socioeconomic factors and factors relating to land use/land cover across livestock production over a longer period. Thirdly, the study did not consider any cross-cultural impacts or influence from diverse farmers' personalities in livestock production. Future research can be conducted to assess these specific components and their impact on livestock and other forms of agroforestry products. Fourthly, the study did not consider sustainability as a possible outcome of livestock production and agroforestry. Future studies can assess the factors influencing sustainable agroforestry and livestock production that can contribute to the prevailing issue of environmental pollution and ethics. Lastly, the study did not consider environmental, economic, and social sustainability factors, such as quality and living conditions of livestock, farmers' autonomy in farming activities, and the well-being of farmers and their families that would affect the livestock farming. Future studies can assess how these sustainability factors can be achieved in livestock farming.

Conclusion

The study indicates a clear association between various socio-economic factors and land use change with livestock production in Khost Province, Afghanistan. Specifically, age, education, household size, access to advanced facilities and infrastructure, satisfaction with advanced facilities and infrastructure, experiences with natural factors of land use change, and economic barriers to livestock

production were significant influencers on livestock production. Particularly, the perception of land use trade-offs, including barriers and economic benefits, was most significantly associated with the production of cows, horses, donkeys, and fish. Hence, the study findings imply that these cattle can support their owners in generating high household income while addressing the barriers to land use. Farmers with better access to resources and infrastructure tended to experience positive impacts on livestock production. This emphasizes the importance of addressing these factors to enhance livestock production and improve livelihoods in the region. Therefore, policymakers and stakeholders should prioritize interventions aimed at improving access to education, infrastructure, and resources while also implementing strategies to mitigate the negative impacts of land use change on livestock production. Overall, these efforts can contribute to sustainable development and resilience in dependent communities relying on livestock production in Khost Province.

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