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Effect of participation in goat keeping on household food security: A case study of Dowa district, Malawi

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Abstract

Goat keeping is a common practice among rural farmers due to the adaptability of goats to harsh environments, their efficient forage conversion and rapid growth, and their multiple benefits, including the production of manure and high-quality milk. However, limited research has been done on the direct effect of participation in goat keeping on food security in Malawi. Therefore, this study investigated the effect of participation in goat keeping on household food security in Dowa district in Malawi using the propensity score-matching technique. The results reveal a positive correlation between goat farming and household food security. This was evident from the significant average treatment effect on the treated (ATT), which indicated a lower value of the Household Food Insecurity Access Scale (HFIAS) for goat keepers compared to non-keepers. These findings highlight the potential of goat farming to enhance food security among rural households, emphasising the importance of promoting this type of farming at the household level.

Key words: Household Food Insecurity Access Scale, food insecurity, propensity score matching, goat farming

1. Introduction

Food insecurity is a pervasive issue that affects a significant number of individuals worldwide, with approximately 800 million people, primarily from developing countries, suffering as a result (Ahmed *et al*. 2017). The challenge of addressing food insecurity remains a prominent concern for public policy in these developing nations (Pawlak & Kołodziejczak 2020). Climate change and the growing human population have placed immense pressure on natural resources, making it increasingly difficult to provide adequate nutrition to impoverished households (Albahri *et al*. 2023). Despite the constitutional right to access nutritionally sufficient and safe food, Malawi is not exempt from the problem of food insecurity. A staggering 50% of rural households in the country experience food shortages four to six months before the harvest, while 40% fail to meet their basic caloric requirements (Kakota *et al*. 2015). Furthermore, the prevalence of stunted growth among children under the age of five stands at nearly 37%, and approximately 6.7 million individuals required food assistance in the 2016/2017 production year (Ragasa *et al*. 2019). The fourth integrated household survey (IHS-4) report by the National Statistical Office (NSO) in 2017 revealed that 61% of Malawi's population experienced high levels of food insecurity in 2016 and 2017, with rural areas accounting for 66% of this figure (NSO 2017). In 2020, IHS-5 classified 62.9% of Malawi's population as having very low food security (NSO 2020). This alarming statistic highlights the lack of improvement in the situation and emphasises the urgent need for additional efforts to address it.

The Government of Malawi is actively promoting the integration of livestock into farming systems as a means of combating the growing problem of food insecurity, which is primarily caused by unpredictable rainfall and persistent droughts. The Food Security Action Plan (Government of Malawi [GoM] 2008) emphasises the importance of this approach. Furthermore, the government envisions a significant increase in livestock production by 2026 through the implementation of the National Livestock Development Policy (Ministry of Agriculture [MoA] 2021). This policy aims to achieve the sustainable integration of livestock into crop systems, intensification and diversification, as well as value addition throughout production and marketing chains. The livestock industry in Malawi currently contributes approximately 11% to the national gross domestic product, and about 36% to the agriculture GDP. At the household level, it is estimated that the sector's contribution to annual income ranges from 16% to 50%.

Kassa *et al*. (2008) highlight the significance of livestock production in enhancing household food security. Livestock play a crucial role in ensuring food security at the household level by providing animal protein and generating income through the sale of livestock and livestock products (Ragasa *et al*. 2019). In Malawi, the main livestock species that are domesticated include cattle, goats, sheep, poultry and pigs. Among these species, goats have consistently outnumbered other livestock species, second only to poultry, due to their adaptability and ease of management (GoM, 2018).

Goats are important livestock in Malawi, particularly because they mature early, require less initial investment, require low input, are easy to market, and have high prolificacy. Apart from providing meat, fibre and manure, goats can also efficiently survive on the available shrubs, grasses and trees, in comparison to other livestock species. They therefore require less or no land for producing feed, as is the case with cattle and other animals (Peacock *et al*., 2005). In addition, approximately two-thirds of feed energy required by goats is derived from materials that are undesirable, indigestible and inedible by humans.

Goats are well adapted to different climatic conditions and thus are less affected by climate change than other livestock. This enables them to maintain their production under extreme climatic conditions. Goats are also small animals compared to other livestock such as cattle, and can be raised on relatively small landholdings, making management easy for many households that do not have sufficient land. These characteristics mean that goat production has divergent economic and managerial advantages over other livestock (Kumar *et al*. 2010).

However, despite the potential of goats to contribute to household livelihoods, including food security and income, goat farming has received limited attention in terms of research and development at both the global and national level (Woldu *et al*. 2016). Although studies conducted in Ethiopia, India and Pakistan by Bashir *et al*. (2012), Singh *et al*. (2013) and Teufel *et al*. (1998) respectively have confirmed the role of goat production in enhancing household food security, this link has not been explored in the context of Malawi. Existing studies on goat production in Malawi have primarily focused on adoption and intensity (Kenamu & Tembo 2016), production systems, demand for goats, goat value chains, and markets (Chigwa 2012; Maganga *et al*. 2015).

Numerous studies have examined the relationship between goat production and its influence on household livelihoods, particularly in terms of food security (Kassa *et al*. 2008; Girei & Ayoola 2017). However, most of these studies have focused on a broader range of livestock species, which may lead to biased conclusions. It is important to recognise that different livestock species contribute differently to household food security. For instance, when larger animals like cattle are included in the analysis, the overall contribution of smaller animals may be overestimated, as the income generated from larger animals may not accurately reflect the value of smaller species (Bashir *et al*. 2012).

Furthermore, previous studies, such as those by Kassa *et al*. (2008), Bashir *et al*. (2012), and Girei and Ayoola (2017), have assumed that the adoption of a specific livestock species is random. In reality, however, households do not randomly participate in livestock production; they self-select based on various factors. In some cases, donor projects specifically target households that are suitable for goat production ventures. In addition, it is important to note that social science data collection methods differ from those used in crop and livestock sciences, as they do not involve experimental designs. Consequently, non-experimental impact analysis studies, in which programme participation is not random, often face challenges related to counterfactuals. Counterfactuals refer to the situation that participants would have experienced if they had not been exposed to the programme (Heinrich *et al*. 2010). Direct estimates from such studies are prone to selection bias, which can lead to biased results.

The objective of the current study was to estimate the effect of participation in goat keeping on the food security of rural households. To address the issue of selection bias, the study utilised the propensity score-matching technique (PSM). PSM selects participants based on observable factors only, effectively eliminating self-selection bias (Caliendo & Bonn 2008). This method matches participants with non-participants and compares the differences in the outcomes of interest between the two groups.

This research study enhances the limited literature on the role of goat keeping in improving household food security. The findings of this study will support intervention programmes, such as livestock pass-on initiatives, implemented by both government and non-governmental organisations in Malawi to align with national food security policies. The National Agriculture Policy (Ministry of Agriculture, Irrigation and Water Development 2016) emphasises the importance of sustainable livestock production and consumption, as well as ensuring food safety for all individuals in the country. These policy objectives are in line with regional and global development goals, including the sustainable development goals set to be achieved by 2030. The outcomes of this study will provide policymakers with evidence-based insights into the overall influence of participation in goat keeping on household food security.

2. Materials and methods

2.1 The sustainable livelihood framework

We used the lenses of the revised sustainable livelihood framework (SLF) to understand the effect of participation in goat farming on household food security. This framework, which was originally proposed by Scoones (1998) and later refined by Natarajan *et al*. (2022), considers how individuals use various aspects of their rural livelihoods, including assets and strategies, to secure their means of living. In the context of the current study, goat rearing can serve as both a livelihood asset and a strategy for rural households that not only provide food and income, but also resilience against shocks and stresses. Through an analysis of the interplay between these assets, strategies and outcomes, the SLF offers a holistic understanding of how goat production influences food security within rural communities. The framework facilitates the identification of pathways through which goat production can enhance or hinder food security, thus informing targeted interventions and policy decisions to maximise its positive impact on rural livelihoods.

2.2 Measuring food security

This research utilised a measurement called the Household Food Insecurity Access Scale (HFIAS). The HFIAS involves gathering information from households regarding the frequency and occurrence of specific behaviours and attitudes related to different aspects, or "domains", of the food insecurity experience. There are a total of nine questions, each asking about events within the past 30 days. Initially, respondents are asked if the condition in question happened during this period. If it did, a follow-up question asks about the frequency of occurrence. The responses are then categorised and coded as follows: (1) rarely (if the condition happened once or twice), (2) sometimes (if the condition occurred three to 10 times), and (3) often (if the condition happened more than 10 times) within the past four weeks. These responses are added together to calculate a continuous score ranging from 0 to 27, indicating the level of food insecurity. The HFIAS does not have a specific cut-off point, but higher values suggest greater food insecurity, while values closer to zero indicate more food-secure households (Coates & Rogers 2007).

2.3 Measuring the effect of participation in goat keeping: Propensity score matching

The propensity score-matching technique (PSM) was used to measure the effect of participation in goat keeping on household food security status. PSM creates a statistical comparison group based on the probability of participating in the treatment concerning observed characteristics. The mean difference in outcomes between participants and non-participants gives the average treatment effect of the programme (Caliendo & Bonn 2008). According to Heinrich *et al*. (2010), PSM is valid when the following conditions are satisfied: (a) conditional independence (the unobserved characters do not affect participation), and (b) sizable common support or overlap in propensity scores across both groups (only the subset of the comparison group that is comparable to the treatment group should be used in the analysis). Within the livelihood framework, propensity score analysis serves as a methodological tool to strengthen the understanding of the causal relationship between goat production and food security.

2.4 Model specification

The aim of the model used was to determine the contribution of goat production to household food security. According to Caliendo and Bonn (2008), the most prominent parameter for estimating the effect is the average treatment effect on the treated (ATT). This parameter focuses explicitly on the effect arising from the treatment for the participants only. Therefore, ATT was applied to measure the effect of goat rearing on household food security using PSM. ATT is given by:

$$\mathrm{ATT_{PSM}} = \mathrm{E}_{\mathrm{P(X)|D=1}}\{\mathrm{E}[\mathrm{Y_1}|\mathrm{D}=1, \mathrm{P(X)}] - \mathrm{E}[\mathrm{Y_0}|\mathrm{D}=0, \mathrm{P(X)}]\}, \quad (1)$$

where $\mathrm{Y_1}$ and $\mathrm{Y_0}$ are the outcome variables (food security) in goat production for participants and non-participants, respectively. D denotes participation and carries a value of 1 for participants and 0 for non-participants. $\mathrm{E}_{\mathrm{P(X)|D=1}}$ is the expected probability of the calculated propensity scores. Therefore, $\mathrm{ATT_{PSM}}$ gives the effect of participation on the outcome variable by showing the difference between the treated and non-treated groups, subject to the given set of covariates denoted by X in Equation (1).

2.5 The data

The study was conducted in the Dowa district of central Malawi, within the Nachisaka extension planning area (EPA). The district was chosen because it is one of the districts with a large goat population (Maganga *et al*. 2015). In addition, the district is not spared from the effects of climate change, such as floods and droughts that cause food insecurity problems. The primary sources of data were individual households, key informants, and focus group discussions. Quantitative analyses were done using the Stata statistical package. The study used a multistage sampling design. The first stage involved a purposive choice of the Nachisaka EPA, which has more goat farmers than the other EPAs. The selection of villages within the EPA was based on simple random sampling. The sample size from each village was determined by probability proportional to size (PPS) for non-adopters, and a combination of PPS and purposive sampling for goat farmers depending on their scale. The final selection of respondents was based on a simple random sampling technique, and a total sample size of 276 was obtained.

3. Results and discussion

3.1 Descriptive statistics of the sampled households

Table 1 presents the summary statistics for the households that were sampled. The mean age of the household head was 40.7 years, and there were notable variations in age between goat farmers and non-farmers. Among the sampled households, approximately 83% had married household heads, 6.52% were divorced, and 0.72% had never been married. However, there were no significant differences in marital status between participants and non-participants in goat farming. Male-headed households accounted for 70% of the sampled households, while female-headed households made up about 30%. On average, the household heads had spent six years acquiring formal education, and there was no significant disparity in schooling years between goat farmers and non-farmers. Only 20.7% of the households had access to credit, with 32% of them being goat farmers and 12% being non-farmers. In addition, approximately 60% of the respondents had access to extension services, with 77% of them being participants in goat farming and 46% being non-participants. The mean Household Food Insecurity Access Scale (HFIAS) for goat farmers was 4.5, while for non-farmers it was 6.5. This significant difference in mean HFIAS suggests that goat keepers were more food secure compared to non-keepers. On average, the households owned four goats, with the largest flock being 28 goats owned by a single household.

Table 1: Descriptive statistics by participation status

Variable(s)	Participants (%)	Non-participants (%)	Overall (%)	P-values
Participants in goat keeping	43.5	56.5	-	-
Number of goats owned	4	-	4	-
Mean HFIAS	4.49	6.49	5.62	0.0000
Mean age (years)	44.46	37.70	40.70	0.0002
Marital status				
Divorced	6.67	6.41	6.52	0.932
Married	86.67	80.13	82.97	0.152
Never married	0.83	0.64	0.72	0.852
Separated	4.17	3.13	4.71	0.709
Widowed	1.67	7.69	3.07	0.024
Gender				
Male	71.67	68.59	69.93	0.581
Female	28.33	31.41	30.07	
Mean years of schooling	6.06	6.30	6.20	0.5739
Mean HH size	4.8	4.2	4.5	0.0060
Monthly income				
Mean monthly income (MK)	38 140.88	25 441.72	30 963.1	0.0035
Median			20 512.5	
Access to credit				0.000
Yes	31.67	12.18	20.65	
No	68.33	87.82	79.35	
Access to extension				0.000
Yes	77.50	46.15	59.78	
No	22.50	53.85	40.22	

3.2 Effect of participation in goat keeping on household food security

3.2.1 Choosing a matching algorithm

Several matching algorithms exist, but this study tested kernel matching, nearest neighbour matching and calliper matching, which are commonly used estimators in the literature. The study followed the benchmarks proposed by Haji and Legesse (2017), namely that the best matching algorithm must produce a large, matched sample size, a large number of insignificant variables after matching, a small pseudo-R^2 after matching, and a small mean standardised bias. The study varied the bandwidth and radii in performing different algorithm tests, and the results are presented in Table 2. It is evident that the kernel estimator of bandwidth 0.09 adheres to the proposed criterion, hence it was selected for this study.

3.2.2 Matching quality

This step ensured that individuals from the treatment group were compared to individuals of similar characteristics from the control group, a condition known as common support. The general assumption in PSM is that participation cannot be predicted with exact precision (Haji & Legesse 2017). The density-distribution graph of the propensity scores was generated through PSMATCH2[1] and is presented in Figure 1. From the figure, the imbalance density distribution between the two groups is observed before matching. The visual inspection of the graph suggests a considerable

[1] PSMATCH2 is a Stata module used to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing.

overlap in the distribution of the estimated propensity scores between the two groups after matching, thereby implying quality matching.[2] It is also clear that there are no sizeable differences between maximum and minimum values of propensity score density distributions for both groups.

Table 2: Choosing a good matching algorithm

Algorithm	Number of insignificant variables after matching	Pseudo-R square	Matched sample size	Mean bias
Kernel				
Bandwidth 0.09	14	0.009	269	4.5
Bandwidth 0.1	14	0.009	269	4.6
Bandwidth 0.12	14	0.011	269	5.6
Nearest neighbour				
Integer 3	14	0.020	269	7.5
Integer 4	14	0.010	269	4.7
Integer 5	14	0.014	269	6.9
Calliper matching				
Radius 0.1	13	0.041	269	10.7
Radius 0.2	13	0.041	269	10.7
Radius 0.3	13	0.041	269	10.7

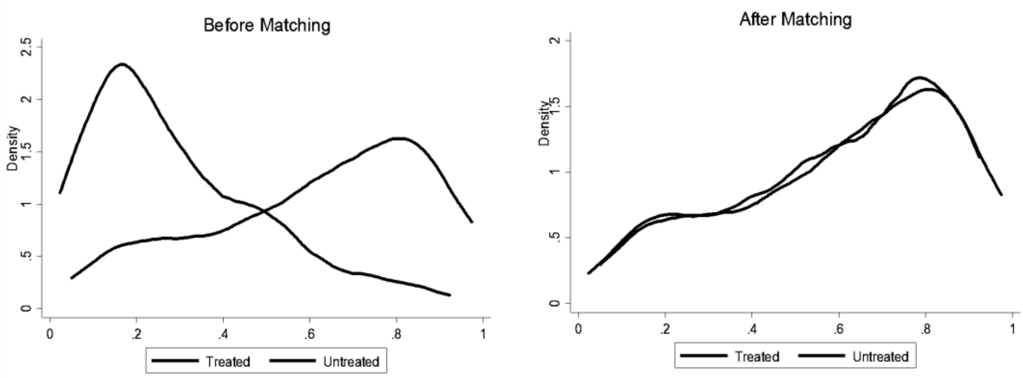

Figure 1: Propensity score distribution before and after matching
Source: Computed from study data

Another way of checking matching quality is by comparing the means of different covariates between the treated and the comparison groups before and after matching (Heinrich *et al*. 2010). If matching is successful, significant differences in means for variables are expected to be minimal. Table 3 shows that, before matching, participants and non-participants differed significantly on eight variables, namely land size, age of household head, household size, marital status, access to credit, access to extension, manure use and monthly income. After matching, goat-farming adopters and non-adopters did not differ significantly in any of the main household characteristics. This indicates that matching helped to reduce the bias associated with observable characteristics, and that each individual from the treated group was matched to individuals of similar characteristics from the control group.

[2] Matching is a method of sampling from a large number of potential controls to produce a control group of modest size in which the distribution of covariates is similar to their distribution in the group of participants.

Table 3: Balancing tests for participants and matched controls

Variable	Unmatched (U) Matched (M)	Mean		p-value
		Participants	Non-participants	
Age	U	44.467	37.731	0.000***
	M	44.467	43.803	0.728
Marital status	U	0.017	0.077	0.024**
	M	0.017	0.018	0.939
Gender	U	0.717	0.686	0.582
	M	0.717	0.753	0.525
Household size	U	4.8	4.205	0.006**
	M	4.8	4.715	0.712
Fisp beneficiary	U	0.367	0.333	0.566
	M	0.367	0.354	0.837
Access to credit	U	0.317	0.122	0.000***
	M	0.317	0.318	0.984
Access to extension	U	0.775	0.462	0.000***
	M	0.775	0.714	0.277
Years of education	U	6.058	6.308	0.574
	M	6.058	6.653	0.222
Sqrt_land	U	1.659	1.297	0.000***
	M	1.659	1.677	0.778
Manure use	U	0.567	0.436	0.031**
	M	0.567	0.540	0.687
Monthly income	U	9.922	9.311	0.004**
	M	9.922	9.915	0.977

***, ** and * represent significance at 1%, 5% and 10% respectively

3.2.3 Estimating the average treatment effect on the treated (ATT)

Before matching, the average Household Food Insecurity Access Scale for goat farmers and non-farmers was 4.492 and 6.487, respectively (Table 4). Following the matching process, the average HFIAS for goat farmers and non-farmers became 4.549 and 6.565. This suggests that, on average, non-farmers had a higher HFIAS than goat farmers by 1.995 before matching. After matching, non-farmers still had a higher HFIAS compared to farmers, with a difference of 2.02. In relative terms, non-farmers exhibited greater food insecurity compared to farmers, as indicated by the 2.02 difference in HFIAS after matching. Despite the existence of differences in HFIAS before treatment, the disparity in HFIAS after matching can be attributed to participation in goat farming, as all relevant factors were controlled for and their distribution was balanced between goat-farming participants and non-participants. The negative difference signifies that goat farming reduces HFIAS, thereby lowering household food insecurity levels. Consequently, the null hypothesis stating that there is no difference in food security status between goat farmers and non-goat farmers is rejected, and the study concludes that participation in goat keeping contributes to household food security.

Table 4: Average treatment effect on the treated

Outcome	Sample	Treated	Controls	Difference	Std. Error	t-value
HFIAS	Unmatched	4.492	6.487	-1.996	0.475	-4.20***
	ATT	4.549	6.565	-2.016	0.616	-3.28***

3.2.4 Sensitivity analysis

The final step in PSM involves checking the robustness of the estimated ATT results. From Table 5, it is evident that good matching quality was obtained. The mean standard bias after matching was 4.5%, compared to a mean bias of 29.1% before matching. The 84.5% reduction in mean bias is due to the reliability of the matching process. Besides the reduction, the mean bias of 4.5% is also within the acceptable range of 1% to 5% (Caliendo & Bonn 2008). Likewise, only seven cases were lost to on-support restriction, representing a 2.5% loss. Collectively, the within-range mean bias, low pseudo-R^2 after matching, seven cases being lost, and the high reduction in mean standard bias after matching produced good matching results.

The sensitivity results given by the value of gamma (G) from the Rosenbaum bounds (rbounds) are also included in Table 5. The results indicate that the critical value of G for the influence of participation in goat keeping on the access scale for household food insecurity varies between 1.1 and 1.7. This implies that the unobserved variables would have to increase the odds ratio of participation in goat farming by 10% to 70% before it would refute the estimated results. The study therefore concludes that the influence of participation in goat keeping on household food insecurity is still robust amidst the considerable presence of unobserved heterogeneity.

Table 5: Indicators of matching quality and robustness of results

Outcome variable	$SB_{\text{unmatched sample}}$	$SB_{\text{-matched sample}}$	Cases lost	Pseudo-R^2	Critical values of gamma (Γ)
HFIAS	29.1	4.5	7	0.014	1.1 – 1.7

4. Conclusion

The primary aim of this research was to assess the effect of participation in goat keeping on food security among households in the Dowa district of central Malawi. The study utilised the propensity score-matching technique to examine the contribution of goat farming to food security. The findings reveal that participation in goat keeping has a positive effect on household food security, as indicated by the average treatment effect on the treated (ATT) from PSM. The ATT difference in the HFIAS between goat keepers and non-keepers was -2.02, which is statistically significant at the 1% level of significance. Given the evidence that participation in goat keeping enhances household food security, policymakers and other stakeholders should promote the adoption of goat keeping as a means to improve food security at the household level.

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