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The role of institutional support and extension services in enhancing the adoption of dairy breeding technologies in Tanzania

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Abstract

This study examines the role of institutional support, extension services, and artificial insemination (AI) service providers in the adoption of improved dairy breeding technology in the Eastern Zone of Tanzania, focusing on Kinondoni and Bagamoyo districts. The findings reveal significant disparities in institutional support, with only 16.7% of respondents in Kinondoni reporting receipt of support compared to 34% in Bagamoyo. Extension services on AI were deemed adequate by 22% of respondents in Kinondoni and 31.3% in Bagamoyo, highlighting variability in service quality. The distribution of AI service providers showed a reliance on government institutions such as the National Artificial Insemination Center (NAIC), which accounted for 29.7% of respondents in Kinondoni and 10.9% in Bagamoyo, alongside private inseminators who served 39.9% and 29.7% of respondents in the respective districts. Notably, 36.2% of respondents in Kinondoni and 21.7% in Bagamoyo were unaware of AI services, underscoring significant gaps in outreach and awareness. These findings indicate that inadequate institutional support and limited extension services hinder the adoption of improved breeding technologies, while private sector contributions play a critical role in advancing these technologies. Addressing these challenges requires strengthened public-private partnerships, enhanced capacity-building initiatives, and targeted awareness campaigns. This study highlights the need for a comprehensive approach to improve dairy breeding technology adoption, which is essential for advancing the dairy industry and improving farmers' livelihoods in the region.

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Introduction

The agricultural sector, particularly livestock farming, is a cornerstone of economic development and food security in many low- and middle-income countries, including Tanzania (Lemma *et al.,* 2018; Herrero *et al.,* 2013; FAO, 2018). Within this sector, the dairy industry holds significant potential for improving household incomes, nutrition, and overall livelihoods (Brito, 2021).

However, low productivity among dairy cattle remains a persistent challenge, largely attributed to the use of low-yielding indigenous breeds and limited access to advanced breeding technologies (Gowane *et al.,* 2019; Raja and Sehgal, 2018). Improved dairy breeding technologies, such as artificial insemination (AI), represent a transformative opportunity for the agricultural sector, particularly in regions reliant on dairy farming for livelihood and economic development. These technologies offer a range of benefits that directly address some of the longstanding challenges in the dairy sector. By enabling farmers to improve herd genetics, AI contributes to higher milk yields, better disease resistance, and enhanced overall productivity (Ndimbo and Haulle, 2024);. Furthermore, improved dairy breeding technologies help farmers achieve consistent reproductive performance and reduce reliance on less predictable natural breeding methods. The ultimate outcome is not only improved productivity but also increased farmer incomes and strengthened food security.

These advancements align with broader developmental goals, such as boosting national dairy production, achieving food self-sufficiency, and promoting sustainable agricultural practices. Enhanced dairy productivity reduces the environmental footprint by optimizing resource utilization per unit of output (Kashoma *et al.*, 2024).

Despite the proven benefits of these technologies, their adoption by smallholder farmers in Tanzania remains suboptimal. Several factors, including socio-economic constraints, cultural practices, and limited institutional support, impede widespread uptake (Balana *et al.*, 2022).

Among these, institutional support services, such as agricultural extension services, financial resources, and access to relevant information, play a critical role in bridging the gap between technology availability and utilization (Alam *et al.*, 2024. These services equip farmers with the knowledge, technical expertise, and financial capacity necessary to adopt and sustain improved dairy breeding practices.

Extension services are particularly vital in this context, as they act as the primary conduit for transferring knowledge and skills to farmers (Danso-Abbeam *et al.,* 2018). They facilitate awareness of available technologies, provide training on their application, and offer advisory services to address challenges faced during implementation (Raji *et al.*, 2024). Additionally, access to institutional financial resources, such as credit facilities and subsidies, ensures that farmers can afford the initial costs associated with adopting advanced breeding technologies (Ullah *et al.*, 2020). This study explores the role of institutional support and extension services in enhancing the adoption of dairy breeding technologies in Tanzania, with a focus on the Eastern districts. By examining the interplay between institutional factors and farmer behavior, this research aims to provide insights into the barriers and enablers of technology adoption (Chindasombatcharoen *et al.,* 2024). The findings contribute to policy and practical strategies for strengthening institutional frameworks, promoting sustainable dairy farming, and ultimately improving livelihoods in rural communities (Mallinger *et al.*, 2024).

The primary objective of this study is to assess the role of institutional support and extension services in influencing the adoption of improved dairy breeding technologies in the Eastern Zone of Tanzania (Ogola *et al.*, 2023). The study focuses on identifying the key factors that contribute to successful adoption, such as the adequacy and quality of extension services, the

availability of institutional resources, and the effectiveness of public-private partnerships (Kassem *et al.*, 2021). The geographic scope of the study includes Kinondoni and Bagamoyo districts, which were selected to represent varying levels of institutional engagement and extension service delivery. Key areas of investigation include farmers' awareness and perceptions of AI technologies, the adequacy of extension support, and the role of government and private sector initiatives in promoting adoption (Osumba *et al.,* 2021). By examining these factors, the study aims to provide a comprehensive understanding of the enablers and barriers to technology adoption in the region (Jackson *et al.*, 2024). Ultimately, the study informs strategies to strengthen institutional frameworks, improve extension services, and foster collaborative approaches that maximize the benefits of improved dairy breeding technologies for farmers. This contributes not only to the growth of the dairy sector but also to broader goals of agricultural sustainability (Ravichandran *et al.*, 2020).

Materials and methods

Study area

This study was conducted in Eastern Zone districts (Kinondoni and Bagamoyo). Kinondoni is located at 6.7888° S, 39.2304° E while Bagamoyo is located at 6.4428° S, 38.9085° E.; The choice of studying dairy breeding technology in the Coastal Districts of Tanzania, specifically in Kinondoni and Bagamoyo Districts because Understanding the factors affecting the adoption of dairy breeding technologies in these districts can help to improve the productivity and quality of dairy cattle which will contribute to the overall economic development and income generation of local communities. Also, these districts have a substantial presence of dairy farmers and milk processing facilities. Therefore, studying dairy breeding technology in the districts was done to provide valuable insights into the factors affecting the adoption of these technologies, the relationship between their use and dairy cattle production, and the dynamics of institutional support services among smallholder dairy farmers. The choice of study areas

was also to gather insights that can inform future interventions and support systems tailored to the unique context of dairy breeding technologies and identify best practices for improving dairy production systems.

Research design

Cross-sectional research design was used from August to September 2023 to collect data in Kinondoni and Bagamoyo districts in Tanzania along the Indian Ocean where small holder dairying is an emerging enterprise. The mentioned research design was used in this study to collect data from a sample of smallholder dairy farmers (Wang and Cheng, 2020). This design enabled the study to examine the status of adoption of improved dairy breeding technologies and identify factors influencing adoption, such as age, education level, livestock size, training participation, ownership, and access to information and training (Korir *et al.*, 2023).

Target population and sample size

The target populations were 793 individuals in Kinondoni and 711 individuals in Bagamoyo. These consisted of small holder dairy farmers. An accurate sample size was calculated as a percentage of the population by analysing the variations between the population as described by Smith (2013). The determination of sample size was based on claims by (Ramakrishnan and Arokiasamy, 2019) that a sample of 10% to 30% of the target population is representative enough for the research study. Therefore, the optimal sample size for the present study was 10% to 30% of the target population for Kinondoni and Bagamoyo respectively. However, 10% of the population in each district was used as the study sample because this percentage was deemed sufficient to provide reliable insights while ensuring manageable data collection and analysis within the study's timeframe and resources. 10% of 793 being 79.3 = 79 for Kinondoni, and 10% of 711 being 71.1 = 71 for Bagamoyo, the total sample size for the study was, therefore, 150. The calculated sample size used was manageable and enabled greater validity of inferences and a greater generalization of findings.

Sampling method

Stratified random sampling was used. This involved dividing the target population into strata/associations based on relevant characteristics, such as each association's location. In this study, the population was divided into subgroups of association based on the location within the eastern zone of Tanzania, where the smallholder dairy farmers perform their dairy farming activities. Next, a stratified random sampling technique was used to select a proportionate number of participants from each stratum. This random sampling method ensured that each stratum/association of farmers was adequately represented in the sample, reducing the potential for bias. The use of stratified random sampling in this study helped to ensure that the sample was representative of the entire population and increased the generalizability of the study findings.

Data collection method

The Open Data Kit (ODK) mobile application (Kobo Collect Tool) was used to build and code the paperless questionnaire survey, which included both closed- and open-ended questions by interviewing the selected representative sample of smallholder dairy farmers in the study area. A questionnaire was developed on key aspects of dairy farming practices, and socio-economic factors influencing the adoption of improved dairy breeding technology and uploaded to the Kobo Collect Tool. Research assistants were trained on how to ask questions and the use of Kobo Collect app for use in the surveys to enable electronic capture of responses. Data quality was regularly monitored to minimize errors. Using the Kobo Collect Tool was compatible with a cross-sectional research design, facilitating the collection of a large amount of data.

Data analysis

Upon completion, data were exported to excel and later to the Statistical Package for Social Sciences (SPSS) Version 27 for data analysis. Descriptive statistics were used to summarize the characteristics of the study population, their adoption patterns, and the factors affecting their adoption decisions of a kind

of breeding technology such as farmer perceptions and institutional support services. Cross-tabulations in SPSS were used in data analysis and frequencies, and percentages were used to present the variables, such as age, marital status, education level, number of dairy cattle kept, access to and control of resources available for dairy production against the breeding methods used. Logistic regression was employed to predict the linear relationship between the socio-demographic and economic factors affecting the adoption of AI among dairy farmers. The Chi-square test (χ^2) was used to test the significant association between the socio-demographic and economic factors and the adoption of improved dairy breeding technology in the Eastern zone of Tanzania.

Results and discussion

Socio-demographic information of the respondents

Table 1 shows the demographic information of the respondents. In Kinondoni district, the gender distribution among respondents revealed a relatively balanced representation, with 27.3%; (41/79) male and 25.3%; (38/79) female. The age distribution showed a significant presence in the 41-60 age group, comprising 26.7%; (40/79) of the respondents. Regarding education levels, 21.3%; (32/79) attended primary education. Regarding cattle ownership, the results indicated this was shared among spouses. Regarding the average number of cows owned, 38%; (57/79) indicated that they kept 4 to 6 cows.

In Bagamoyo district, the gender distribution showed a relative balance, with 26.7%; (40/71) male and 20.7%; (31/71) female respondents. A majority of the respondents 24% (36/71) fell within the 41-60 age group, reflecting a mature demographic interested in adoption interventions. Education levels varied, with significant portions having attained primary 22%; (33/71) and secondary education 9.3%; (14/71), and some had attended college 14.7%; (22/71). About 34%; (51/71) of the respondents were married. Household sizes typically ranged between 4-6 members 28.7%; (43/71), and cattle ownership was primarily by husbands 18%; (27/71) or jointly 11.3%; (17/71), owning about 1-3 dairy cattle.

Table 1. Socio-demographic characteristics of respondents participated in study

Demographic information		Surveyed districts	
		Kinondoni	Bagamoyo
		f (%)	f (%)
Gender	Male	41(27.3)	40 (26.7)
	Female	38 (25.3)	31 (20.7)
Age	21-40 years	4 (2.7)	6 (4.0)
	41-60 years	40 (26.7)	36 (24.0)
	61-80 years	35 (23.3)	28 (18.7)
	over 80 years	0 (0.0)	1 (0.7)
Education level	No formal education	5 (3.3)	2 (1.3)
	Primary education	32 (21.3)	33 (22.0)
	Secondary education	27 (18.0)	14 (9.3)
	College	11 (7.3)	12 (8.0)
	University	4 (2.7)	10 (6.7)
Marital status	Single	4 (2.7)	3 (2.0)
	Married	62 (41.3)	51 (34.0)
	Divorced	4 (2.7)	5 (3.3)
	Widow	9 (6.0)	1 (28.0)
People household	1-3	5 (3.3)	24 (16.0)
	4-6	31 (20.7)	43 (28.7)
	7-8	39 (26.0)	3 (2.0)
	9-10	4 (2.7)	1 (0.7)
Cattle ownership	Husband	9 (6.0)	27 (18.0)
	Wife	26 (17.3)	27 (18.0)
	Both Husband and Wife	44(29.3)	17 (11.3)
Number of cows	1- 3 cows	21(14.0)	35 (23.3)
	4-6 cows	57(38.0)	27 (18.0)
	7-9 cows	1 (0.7)	8 (5.3)
	10- 11 cows	0 (0.0)	1 (0.7)

Table 2. Artificial insemination service providers in surveyed districts

Artificial insemination service providers	Surveyed districts			
	Kinondoni		Bagamoyo	
	N	%	n	%
Government through NAIC	41	29.7	15	10.9
Livestock extension staff	45	32.6	35	25.4
Private inseminators dealers	55	39.9	41	29.7
I am not aware	50	36.2	30	21.7

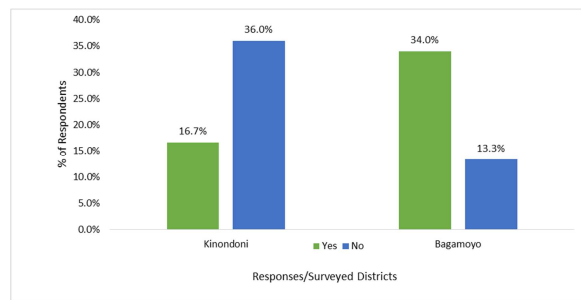*Institutional support by extension officers in introducing improved dairy breeding technology*

The findings reveal notable disparities in institutional support provided by extension officers for improved dairy breeding technologies in Kinondoni and Bagamoyo districts. In Kinondoni, only 16.7% of respondents reported receiving support, whereas 36% indicated a lack of institutional assistance. This limited support creates significant barriers for farmers in accessing knowledge, resources, and technical assistance necessary for adopting advanced breeding technologies. Conversely, in Bagamoyo, 34% of respondents acknowledged receiving support, while 13.3% reported no support. Despite better

institutional involvement in Bagamoyo, the support remains insufficient to guarantee widespread adoption. The low level of institutional support, particularly in Kinondoni, underscores the challenges farmers face in implementing improved breeding practices. This lack of assistance could hinder the region's progress in modernizing its dairy industry and improving productivity.
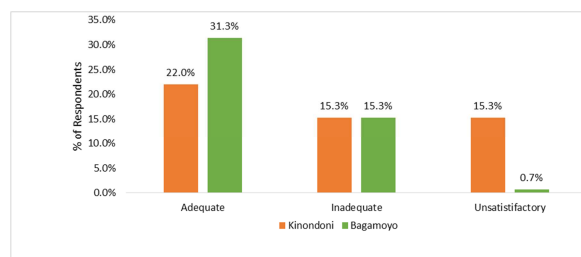
Extension services on artificial insemination (AI)

The adequacy of extension services for AI differed significantly between the two districts, influencing adoption rates. In Kinondoni, 22% of respondents rated the extension services on AI as adequate, while
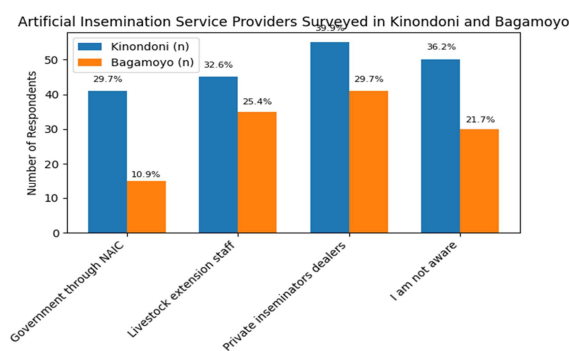
15.3% rated them inadequate, and another 15.3% found them unsatisfactory.

Fig. 1. Institutional support by extension officers

Fig. 2. Responses on the extension services/surveyed districts

Fig. 3. Artificial insemination service providers in surveyed districts

Figs 1, 2&3 highlight significant gaps in service quality and coverage. In contrast, Bagamoyo performed relatively better, with 31.3% of respondents rating the services as adequate, 15.3% as inadequate, and only 0.7% as unsatisfactory. Adequate extension services play a crucial role in disseminating knowledge, building farmers' capacities, and providing technical support for AI technology adoption. Inadequate or unsatisfactory services slow down adoption rates and hinder the dairy sector's overall progress.

Enhancing service delivery in Kinondoni and improving the quality of services in Bagamoyo are essential for boosting adoption rates and advancing the dairy industry.

Artificial insemination (AI) service providers
The distribution of AI service providers in Kinondoni and Bagamoyo districts revealed varied patterns that significantly affect the adoption of improved dairy breeding technologies. Government-provided services through the National Artificial Insemination Center (NAIC) accounted for 29.7% of respondents in Kinondoni, compared to only 10.9% in Bagamoyo, indicating a stronger reliance on public institutions in Kinondoni. Livestock extension staffs were highlighted by 32.6% of respondents in Kinondoni and 25.4% in Bagamoyo, emphasizing the critical role of government-supported services in disseminating breeding technologies (Table 2).

Private inseminators also emerged as significant contributors, with 39.9% of respondents in Kinondoni and 29.7% in Bagamoyo relying on their services. This underscores the growing role of the private sector in advancing breeding technologies. However, a substantial proportion of respondents—36.2% in Kinondoni and 21.7% in Bagamoyo—expressed unawareness of AI services. This lack of awareness poses a major challenge, highlighting the need for improved outreach and education efforts by both public and private stakeholders.

Statistical analysis
Descriptive statistics for the two regions show variations in adoption rates or performance in dairy breeding technologies. Kinondoni exhibited higher average scores (mean = 47.75) with a narrower range, indicating moderate variability. In contrast, Bagamoyo showed lower average scores (mean = 30.25) and a wider range, reflecting greater inconsistency. The chi-squared test (χ^2 = 4.90, p = 0.1789, df = 3) revealed no statistically significant difference between the regions regarding the adoption of dairy breeding technologies. This suggests that institutional support and extension services may not

differ substantially between the two districts. Factors such as socioeconomic conditions, farmer awareness, and market access could play a more critical role in influencing adoption rates.

Recommendations

To improve the adoption of improved dairy breeding technology in the Eastern Zone of Tanzania, several strategic measures are essential. Strengthening institutional support, particularly in Kinondoni, is a critical priority. This can be achieved by increasing funding for extension programs, providing advanced training for extension officers, and fostering active collaboration between extension officers and local farming communities. These efforts will ensure that support services are well-equipped to address the specific needs of farmers effectively.

Enhancing the quality of extension services is also crucial for both Kinondoni and Bagamoyo. Farmers need regular workshops, on-site training, and access to resources like AI equipment and technical manuals to fully understand and adopt artificial insemination (AI) technologies. Consistent follow-up mechanisms are necessary to monitor progress and address any challenges faced by farmers during implementation.

Conclusion

While the descriptive statistics reveal some differences between the two regions, the chi-squared test indicates no significant disparity in the adoption patterns based on institutional support and extension services. To better understand the impact of these services, additional data or variables might be required, along with targeted interventions tailored to each region's unique challenges.

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