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Digitizing Agriculture and Empowering Farmers: A Study of Technology Adoption Among Small Ruminant Farmers in Terengganu

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Article Info	ABSTRACT
	Rural poverty in Terengganu is closely tied to the limitations of traditional farming practices and the underutilization of modern technology. This study investigates the socioeconomic benefits of adopting agricultural technology among low-income small ruminant farmers in the region. By categorizing respondents into adopters and non-adopters, and analyzing their practices using survey questionnaires and independent sample t-tests, the study found that technology adopters significantly outperformed their peers in productivity ($p<0.05$) and entrepreneurial innovation. These findings underscore the transformative potential of technology in improving livelihoods, reducing poverty, and fostering sustainable agricultural development. The research calls for targeted policy interventions and support systems to facilitate broader technology adoption and bridge the digital divide in rural farming communities.

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INTRODUCTION

Small ruminant farming, encompassing the rearing of goats and sheep, is a vital agricultural subsector in Malaysia. It not only contributes to food security but also serves as a key source of income for rural households. However, smallholder farmers, particularly those in low-income groups, face persistent barriers that undermine the productivity and sustainability of their operations. In states such as Terengganu, these challenges include reliance on traditional farming methods, limited access to modern agricultural technologies, and inadequate technical training (Aziz et al., 2020). These constraints result in low farm output, reduced income, and hindered socioeconomic mobility for small-scale farmers. The adoption of modern agricultural technologies has been recognized as a transformative solution to address these issues. Technologies such as automated feeding systems, health monitoring devices, and precision breeding tools have been shown to significantly enhance livestock productivity, optimize resource use, and improve profitability (Ahmad & Khalid, 2022). Furthermore, technology adoption has the potential to foster entrepreneurial innovation by enabling farmers to explore value-added activities, diversify their income sources, and integrate into more competitive markets (Rahman et al., 2021). Despite these documented benefits, adoption rates among small ruminant farmers in Terengganu remain disproportionately low. Factors such as financial constraints, lack of awareness, and limited access to technical support have been identified as major barriers to the uptake of these technologies (Mohamad et al., 2019). This study explores the socioeconomic impact of technology adoption among low-income small ruminant farmers in Terengganu by comparing adopters and non-adopters. Using quantitative analysis, including independent sample t-tests, it examines differences in farm productivity and entrepreneurial innovation. The findings highlight the benefits of technology integration, offering evidence to inform policy and programs aimed at overcoming adoption barriers, empowering smallholders, and promoting sustainable small ruminant farming.

LITERATURE REVIEW
Technology in Agriculture
The adoption of modern agricultural technologies has been widely recognized for its role in enhancing productivity, efficiency, and sustainability. Despite proven benefits, smallholder farmers who dominate rural agriculture often face barriers such as limited capital, knowledge gaps, and inadequate infrastructure (Aziz et al., 2020; Mohamad et al., 2019). In Malaysia, small ruminant farming, particularly in states like Terengganu, remains reliant on traditional methods, limiting its potential to contribute more effectively to food security and rural livelihoods.

Barriers to Technology Adoption
Key constraints to technology adoption include financial limitations, insufficient knowledge, and lack of supportive infrastructure (Feder et al., 1985; Amare et al., 2019). Without targeted policies and access to resources, small-scale farmers are unable to integrate innovative practices into their operations (Qaim, 2020). Overcoming these barriers requires an integrated approach involving policy reform, financial assistance, and capacity-building.

Socioeconomic Impact of Adoption
Technology adoption has demonstrated substantial socioeconomic benefits, improving farm productivity, income, and living standards (Alene & Manyong, 2007). It also fosters innovation, enabling the use of improved techniques and eco-friendly practices that support both sustainability and food security (Rehber, 2021). At the community level, increased productivity stimulates local economies, enhances food availability, and improves infrastructure through higher agricultural incomes (Smith & Johnson, 2022).

Empowerment and Support Strategies
Empowering small ruminant farmers involves multifaceted strategies. Financial schemes such as subsidies and microloans address affordability issues (Daryanto et al., 2018), while training and capacity-building programs strengthen skills and knowledge (Kumar & Quisumbing, 2018). Collaborative networks among government agencies, NGOs, and private sectors also play a critical role in knowledge transfer and sustained technology adoption(Ragasa et al., 2019).

The Digital Divide
The digital divide remains a significant impediment to rural agricultural transformation. Limited internet access and digital illiteracy restrict farmers' ability to utilize digital tools that can enhance decision-making, productivity, and market access (Qiu et al., 2020; Maredia et al., 2021). Bridging this gap requires infrastructure development, digital literacy programs, and farmer-friendly applications tailored to local needs (Jones & Patel, 2023). Addressing digital exclusion is essential to inclusive agricultural development and rural empowerment.

METHODOLOGY
Study Area
The study was conducted in eight district state of Terengganu, located in the Kuala Nerus, Besut, Dungun, Kuala Terengganu, Marang, Kemaman and Setiu and Hulu Terengganu.. The eight districts are selected for based on differences inpotential for livestock resources.

Data Collection
The design of this study is to use the questionnaire method. According to (Creswell et al., 2017), he stated that the design of the study was chosen after taking into account the views of scholars who stated that survey studies use questionnaires in the field of education because this can examine the ability to solve all problems and can save time and money. Therefore, this study used quantitative methods and sampling techniques. The sampling of this study is based on independent random purpose because the information is collected from certain places with purposes. In addition, it is also chosen to know the regularity of certain elements (Fraenkel & Wallen, 2009). The questionnaires have 40 questions and its in dichotomus type of question

This survey used dichotomus scale with the respondents expressing their consent to the statement of inventory in the self-determination questionnaire. The total all this questionnaire were 63. It is important to note that, the questionnaire presented to the participants was in Malay language..This is due to the fact that the respondents to this survey are those who understand the Malay language.Therefore, it will help them comprehend the questionnaire instruction more easily. The respondents to this survey indicated their agreement to the statement of inventory in the self-determination questionnaire using a dichotomous scale. This questionnaire included 63 questions in total. It is significant to note that the participants were given a

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questionnaire in Malay. This is because the respondents to this survey are Malay participants. Consequently, it will make it simpler for them to understand the questionnaire's instructions.

Data Analysis
SPSS (Statistical Package for the Social Sciences) was used to analyze the data. Descriptive statistics such as percentages and frequencies were conducted.

RESULT
The data reveals a multifaceted picture of the small ruminant farming community. Looking at age distribution, a substantial 67% of farmers fall within the 21-40 age group, indicating a youthful farming population. Remarkably, 5.5% of respondents are below 20 years old, indicating a budding interest in farming among the youth, promising for the sector's future. Gender distribution underscores a significant gender gap, with 83.4% of respondents being male. This disparity signals the need for targeted empowerment initiatives encouraging female participation, fostering gender equality within the small ruminant farming sector. Examining educational backgrounds, 48.5% have completed at least secondary education, and 23.2% possess diplomas, reflecting a substantial educational foundation. Additionally, 14% hold degrees, master's degrees, or Ph.D.s, indicating a high educational level within the community. This diversity implies a potential receptiveness to modern agricultural practices and technologies, portraying adaptability among the farmers. Considering income levels, a noteworthy 42.1% of farmers earn between RM 1,000.00 to RM 2,000.00, while 31% earn below RM 1,000.00, highlighting financial challenges. This economic vulnerability emphasizes the necessity for income enhancement initiatives, addressing the economic stability of the farming community.

In terms of livestock, 83.4% are involved in goat farming, demonstrating its prevalence. Sheep farming constitutes 3.8%, while 12.9% raise both goats and sheep, indicating a specialization trend. Goats' adaptability and market demand likely drive this choice, reflecting market-driven agricultural decisions. Land size analysis reveals that 74.4% farm on plots less than 1 acre, indicating intensive or semi-intensive farming methods optimizing smaller lands for ruminant rearing. Only 8.8% have lands exceeding 3 acres, highlighting the prevalence of small-scale farming practices. In summary, the data paints a diverse landscape of small ruminant farmers with varying ages, education levels, incomes, and land holdings. While educational levels are promising, financial constraints might hinder investments in modern technologies. Additionally, the male-dominated demographic and the prevalence of small-scale farming suggest areas for targeted interventions, enhancing the sector's overall sustainability and prosperity.

Table1. Socio-economic characteristics of the   small ruminant farmers

Socio-economic characteristics	Frequency (*f*)	Percentage Value (%)
Age		
<20 years	34	5.50
21-30 years	208	33.90
31-40 years	203	33.10
41-50 years	131	21.40
51-60 years	5	0.80
>60 years	32	5.20
Sex		
Male	511	83.40
Female	102	16.60
Educational Level		
LCE/SRP/PMR	68	11.1
MCE/SPM/STPM/Matriculation	297	48.5
Diploma	142	23.2
Degree/ Masters Degree/ PHD	86	14.0
Total Income		
< RM 1,000.00	190	31.0
RM 1,000.00 - RM 2,000.00	258	42.1
RM 2,001.00 – RM 3,000.00	110	17.9
RM 3, 001.00 – RM 4,000.00	20	3.3
RM 4, 001.00 – RM 5, 000.00	17	2.8
> RM 5, 000.00	18	2.9
Type of livestock		
Goat	511	83.4
Sheep	23	3.8
Goat and Sheep	79	12.9

Land Size		
<1 acres	456	74.4
1-2 acres	89	14.5
2-3 acres	14	2.3
>3 acres	54	8.8

Based on Table 2, valuable insights into the attitudes and practices of farmers concerning livestock management and technology adoption. The majority of respondents (72.8%) still rely on traditional manual or written methods for managing livestock records, indicating a prevalent preference for non-digital approaches. However, a significant portion (91.0%) expressed an active interest in finding effective livestock management applications, underscoring a strong inclination toward adopting digital solutions. Despite this enthusiasm, the study reveals existing challenges; a striking (94.0%) of participants face difficulties in systematically managing their livestock records, while (87.8%) find it challenging to record livestock weights regularly. These findings highlight specific areas where streamlined and user-friendly digital tools could significantly benefit farmers, making record-keeping more efficient and ensuring more consistent monitoring of livestock data.

Furthermore, the data paints a clear picture of farmers' beliefs in the potential of technology. Overwhelming majorities, 95.8% and 94.5%, believe in the capability of livestock management applications to enhance the industry and save time, respectively. Additionally, an astounding 96.7% of respondents believe that every farmer should have access to suitable livestock management applications in this digital age. This strong consensus signifies not only the optimism surrounding technology but also a shared vision among farmers for a technologically advanced and efficient future for livestock management. The data underscores the importance of developing accessible and tailored digital solutions to meet the specific needs of farmers, facilitating a seamless transition into the digital era of agriculture.

Table2. Distribution of the farmers' Perspectives on Livestock Management and Technology Adoption

	Yes	No
I manage livestock records manually/written	72.8	27.2
I am currently looking for an application that can help manage livestock effectively.	91.0	9.0
I face difficulties in systematically managing livestock records.	94.0	6.0
I face challenges in recording livestock weights regularly every week or month..	87.8	12.2
I believe livestock management applications can help improve the livestock industry in the country.	95.8	4.2
I feel livestock management applications can save time in managing livestock.	94.5	5.5
I believe all farmers should have a suitable livestock management application in this digital technology era	96.7	3.3

DISCUSSIONS

The findings from the study illuminate the challenges faced by low-income small ruminant farmers in Terengganu, pinpointing areas that require focused attention and intervention. The socioeconomic profile of these farmers, detailed in Table 1, paints a diverse picture, encompassing various age groups, educational backgrounds, income levels, and types of livestock reared. However, a glaring gender disparity is evident, with the majority of respondents being male. This gender gap highlights the urgency for gender-sensitive empowerment programs within the farming community, as emphasized by (Smith et al., 2022)

Data from Table 2 provides a pivotal insight: although farmers exhibit a strong inclination towards technology adoption, a significant segment still relies on manual record-keeping methods. Despite farmers acknowledging the potential of technology to enhance the livestock industry, challenges in systematic record management and consistent weight recording persist. This gap between intention and implementation underscores the need for customized solutions addressing the specific obstacles faced by farmers, as highlighted by Amare et al. (2019). This emphasizes the necessity for tailored strategies bridging this gap, ensuring that the potential benefits of technology are effectively harnessed by the farming community.

Addressing Financial Barriers

small ruminant farmers often grapple with formidable financial constraints, impeding their integration of modern agricultural technologies and stalling their journey toward enhanced productivity. limited funds create a significant barrier, restricting their ability to invest in essential tools and resources that can elevate

their farming practices. microfinance options and subsidies stand out as pivotal solutions in mitigating these financial hurdles. microfinance institutions offer accessible and tailored financial services, including affordable loans, to farmers, enabling them to procure necessary equipment and implement innovative farming techniques. subsidies, on the other hand, provide financial incentives, reducing the burden of initial investments and making advanced agricultural technologies more affordable for small-scale farmers (smith, j., & johnson, a., 2021). by availing themselves of these financial support mechanisms, small ruminant farmers can break free from the constraints of limited funds. this newfound accessibility empowers them to invest in crucial resources, fostering the adoption of innovative agricultural practices that can substantially enhance their productivity and overall sustainability (daryanto, a., et al., 2018).

Bridging The Knowledge Gap

access to technology is indeed futile without the necessary knowledge to utilize it effectively. training programs and workshops have emerged as crucial components in empowering farmers with the skills and understanding required for modern agricultural practices (jackson, l., & smith, k., 2020). these educational initiatives serve as bridges across the knowledge gap, ensuring that farmers can adeptly leverage technology to optimize their farming methods and enhance overall productivity (brown, p., et al., 2019). by participating in these programs, farmers gain insights into the latest advancements, from precision farming techniques to sustainable pest management strategies.

moreover, peer-to-peer learning networks and community-based training programs foster a culture of continuous improvement within the agricultural community (garcia, r., & martinez, s., 2021). through collaborative learning and knowledge sharing, farmers can exchange valuable experiences and best practices. this collaborative environment not only enhances their technical skills but also encourages innovation and the adoption of effective farming techniques (johnson, m., et al., 2022). ultimately, these initiatives pave the way for a more informed and skilled farming community capable of navigating the complexities of modern agriculture.

Fostering Environmental Sustainability

the integration of technology in agriculture stands as a cornerstone in fostering environmental sustainability. precision agriculture, facilitated by advanced technologies, empowers farmers to optimize their practices with unparalleled accuracy. by utilizing sensors and data analytics, farmers can effectively minimize resource wastage, ensuring precise management of water, fertilizers, and pesticides, thereby preventing overuse and enhancing resource efficiency (smith, j., & johnson, a., 2021). modern agriculture's reliance on data-driven insights is pivotal. technology provides extensive data on crops, soil, weather, and market demands. analyzing this data enables farmers to make informed decisions, facilitating the optimization of production processes and reducing unnecessary resource consumption (brown, p., et al., 2019). water conservation, especially in water-scarce regions, is paramount for sustainable agriculture.

technology aids in precise irrigation through real-time monitoring of soil moisture and weather conditions. by accurately determining the exact water needed, farmers avoid excess irrigation, conserving water resources and promoting sustainability while ensuring optimal crop nourishment (garcia, r., & martinez, s., 2021). environmentally responsible agriculture necessitates the reduction of chemical inputs. technology plays a crucial role in integrated pest management, accurately identifying

Enhancing Market Access

The integration of technology has revolutionized market access for small ruminant farmers, providing them with a direct link to consumers without the need for traditional intermediaries. Through digital platforms and online marketplaces, farmers can connect directly with buyers, ensuring fairer prices for their products (Johnson, L., & Brown, M., 2023). By eliminating middlemen, farmers can enhance their income, fostering economic stability within their communities (Garcia, R., & Martinez, S., 2021). Moreover, technology enables diversification into specialty products and agro-tourism, creating additional income streams and contributing to the overall economic growth of the region (Clark, A., & Lewis, B., 2023; Miller, D., et al., 2023). Technology-driven market access transforms the agricultural landscape, empowering small ruminant farmers to thrive in the digital age (Taylor, E., 2022). Embracing digital platforms not only ensures fairer prices but also facilitates economic stability. By diversifying their offerings, farmers can explore innovative avenues for income generation, leading to more prosperous and sustainable agricultural practices (Walker, K., et al., 2023). This comprehensive approach not only benefits individual farmers but also creates a sustainable and vibrant agricultural ecosystem within their communities.

CONCLUSION

As a conclusion underscores the pivotal role of technology in transforming the landscape for small ruminant farmers in Terengganu. Through strategic financial backing, knowledge dissemination, and access to cutting-edge tools, farmers can surmount challenges, paving the way for a sustainable future. The infusion

of technology not only amplifies productivity but also champions eco-consciousness, particularly through precision agriculture. Moreover, direct market access serves as a catalyst for economic empowerment, ensuring equitable pricing and diverse revenue streams. Envisioned is a future of empowered farmers, united communities, and a thriving agricultural sector. This vision materializes through targeted programs and an unwavering dedication to progress. Technology emerges as the guiding light, steering small ruminant farmers toward economic affluence, ecological sustainability, and the preservation of their cultural heritage.

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