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Research Article

Social Dynamics Model of Farmers' Acceptance and Behaviour in the Implementation of Owl House Innovation (Rubuha) to Control Sustainable Rat Pests

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Abstract: Using natural enemies to control rats through Owl Houses (Rubuha) in rice fields in Pidie Jaya Regency has faced challenges, including improper implementation that limits effectiveness. Specifically, the objectives of this research are (1) analyze farmers' the response to the Rubuha innovation, (2) analyze the role of strategic partners in the application of the Rubuha, (3) analyzing social reviews of farmers' acceptance and behavior of using the Rubuha innovation to control rice field rat pests. This study was a survey and action method (demplot) study to see the response of farmers, the role of partners, social review of farmer behavior in the application of the Rubuha paddy field innovation to achieve food security in Pidie Jaya Regency. Data were analyzed qualitatively with Likert scale indices and quantitatively using Structural Equation Modeling (SEM). Results showed farmers rated the innovation's relative advantage and compatibility as high, complexity and trialability as easy, and observability as high. Agricultural extension workers were critical in implementation, while local governments, farmer institutions, and universities provided moderate support. SEM analysis revealed that farmers' acceptance and behavior toward Rubuha were strongly influenced by their responses, partnership patterns, and acceptance of the innovation.

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1. Introduction

Farmers' cooperative and collaborative attitude with environmentally friendly technological innovations in eradicating pests such as rat pests in wet rice farming is needed not only to overcome yield vulnerability but also to increase sustainable crop productivity (Wynne-Jones, 2017), but implementation of innovations in the agricultural sector often faces challenges in terms of acceptance and adoption by farmers. One innovation that has received attention in recent years is the use of Owl Houses (Rubuha) as a natural method of controlling rat pests. This innovation not only offers an environmentally friendly ecological solution, but also has the potential to increase agricultural productivity. However, the adoption of innovations such as Rubuha is highly influenced by complex social dynamics, including farmers' perceptions, attitudes, and behaviors towards the new technology (Tey et al., 2014). Understanding the social dynamics in the acceptance of innovations among farmers is very important to ensure the successful implementation and sustainability of this technology. Factors such as community involvement, level of knowledge, previous experience with similar technologies, and support from the government and agricultural extension workers all play a role in determining the extent to which farmers are willing to adopt and implement Rubuha (Thanh and Yapwattanaphun, 2015). Farmers will adapt and accept new technologies when their relationship with the new technology results in tangible feedback that benefits them and the environment as a whole, but otherwise they will resist the ‘new’ (Apetrei et al., 2024). The success of extension innovation programs depends not only on technical aspects, but also to a large extent on the extent to which target groups are socially involved in the planning and implementation processes (Ofuoku et al., 2019; Erdoğan and Ulu, 2024).

Paddy cultivation plays a vital role in Aceh's agricultural sector. In 2020, the province recorded a harvested rice area of approximately 310 012.46 hectares, yielding around 1 714 437.60 tons, with an average productivity of 55.30 quintals per hectare. Among the regencies in Aceh, Pidie Jaya has significant potential in rice field development. As one of the province’s key rice-producing regions, Pidie Jaya reported a harvested area of 17 117 hectares, resulting 100 701 tons of rice at a productivity rate of 5.88 tons per hectare (Badan Pusat Statistik, 2022b).

Pidie Jaya Regency has eight sub-districts with varying harvest areas, production, and productivity. Table 1 presents data on harvest areas, production, and productivity of rice plants in Pidie Jaya Regency according to BPS data in 2023.

Table 1. Harvested area, production and productivity of rice by district in Pidie Jaya Regency 2023 (Badan Pusat Statistik, 2022a)

Sub-district	Harvested Area (ha)	Production (tons)	Productivity (ton/ha)
Meureudu	2297	14396	6.27
Meurah Dua	1161	7172	6.18
Bandar Dua	4524	26184	5.79
Jangka Buya	1201	7174	5.97
Ulim	1997	12626	6.32
Trienggadeng	2110	12380	5.87
Panteraja	570	3294	5.78
Bandar baru	3257	17475	5.37
Pidie Jaya	17117	100701	5.88

The data in Table 1 indicate that the average productivity remains considerably below the potential yield of paddy rice production. One of the causes of low productivity is due to attacks by rat pests that attack paddy rice farming businesses. The control of rat pests which is still individual in nature causes farmers to be unable to get effective results, even the population of rats that attack paddy fields is increasing (Primadani et al., 2020; Budi et al., 2021). The low level of knowledge of farmers regarding biological control and the biological characteristics of rats as well as inappropriate control strategies are factors that often cause inaccurate pest control measures carried out by farmers.

Based on data from one of the regencies in Pidie Jaya that has adopted the RUBUHA innovation in paddy farming is Meureudu District. The results obtained showed an increase in paddy production. Table 2 shows the increase in production in Meureudu District.

Table 2. Rice production, productivity, and economic value in Meureudu District, Pidie Jaya Regency, after the implementation of the Rubuha innovation (Research Results, 2024)

Year	Production (tons)	Productivity (ton/ha)	Economic Value (USD)
2019	13 213.48	5.74	4 804 901.82
2020	14 301.29	6.13	5 200 469.09
2021	14 396.00	6.27	5 234 909.09
2022	15 186.10	7.10	5 522 218.18

From Table 2, it can be seen that there was a significant increase in production in 2022, which was 15 186.10 tons from the previous 14 396.00. The implementation of the Rubuha innovation increased the economic value of rice production from USD 4.80 million in 2019 to USD 5.52 million in 2022, demonstrating its tangible contribution to both yield and farm-level income. This shows that after the use of Rubuha in controlling rat pests, it has an impact on increasing rice field production due to the reduced intensity of rat pest attacks that disrupt rice fields. In line with the research of Begg et al. (2017) which states that the use of natural enemies to control rats through the use of owl houses (Rubuha) in rice fields is faced with various problems, including limited farmer capital which causes the Rubuha made by farmers to still be very simple and does not meet the requirements both in terms of building structure and layout. The technology for utilizing owls is not easy for farmers to understand, so it is necessary to introduce gradually how to make an ideal owl house (Pusparini and Suratha, 2018).

Rat pest control efforts must be supported by synergistic partnerships between agricultural development actors, starting from universities, local governments, agricultural extension workers., institutions at the farmer (Budi et al., 2018). Wider involvement of stakeholders aims to strengthen the sustainability regulations and governance of the program (Flor et al., 2019).

Rat pests have very different characteristics compared to other types of pests. High adaptability causes these animals to spread easily, both in the highlands and in the lowlands (Wendt and Johnson, 2017). Rats make holes as shelters and breeding grounds, also make tunnels or paths along embankments and irrigation dikes (Simatupang, 2015). In addition, this mammal also has a well-developed brain. Therefore, controlling rat pests requires a different approach compared to rice pests from other insect groups (Abdullah et al., 2019). Rodents infest rice crops during both the vegetative and generative growth phases, leading to substantial economic damage (Tscharntke et al., 2007). When rice is in the vegetative phase, a rat has the ability to damage between 11-176 rice stalks per night. While in the generative phase (pregnant to harvest) it increases to 24-246 stalks per night. At a severe level of damage, usually only a few rows of plants remain, especially on the (Primadani et al., 2020).

Rodent infestations are a significant contributor to the decline in rice yields. These pests are capable of destroying between 60% and 70% of the total rice production and, in severe cases, may lead to complete crop failure (Nisa, 2022). The use of chemical control methods has shown limited effectiveness in mitigating the extent of crop damage, which in turn negatively impacts overall rice output (Johnson et al., 2018).

The Rubuha innovation is a form of hybrid innovation built on existing ecological knowledge, but developed locally and socially embedded in the farming community at the research site. The changes resulting from this study not only include increased productivity and income for rice farmers, but also the emergence of new communal practices in rat pest control in rice farming.

Ecological control strategies incorporating owls have demonstrated success in reducing rodent populations in rice fields through the implementation of the Rubuha innovation system (Johnson et al., 2010). The continued development of the RUBUHA approach is anticipated to serve as a sustainable model for managing rodent pests, offering tangible benefits to farmers (Baco, 2011).

The advantages of controlling rats with owls are: a) able to suppress the rat population effectively, b) does not have a negative impact on the environment, c) does not require large costs and energy, d) increases the efficiency of farmers' time and can be utilized by several farmers (Baco, 2011). Similarly, Pusparini and Suratha (2018) stated that owls have proven effective in controlling rats continuously below the economic threshold. Other research results also show that the high number of owls is followed by a decreasing number of active rat nests (Sudarmaji and Herawati, 2017; Lindell et al., 2018). The process of adaptation and acceptance of farmers with new technological innovations in rat pest control through the RUBUHA system requires best practice success shown in increased rice yields to then become a new sustainable communal practice.

2. Materials and Methods

The research site was in Pidie Jaya Regency, with 6 sub-districts implementing the Rubuha innovation to control rat pests in rice cultivation.

The study utilized primary and secondary data, involving 120 respondents from farmer groups at the research site, along with Focus Group Discussion (FGD) sessions conducted with relevant stakeholders (local government, agricultural extension workers, universities, and farmer organizations) regarding the development of a regulatory framework that supports the use of biological control agents for owls to control rice field rat pests. While secondary data was obtained from BPS, the Regency Agriculture and Food Service, references and scientific journals relevant to the research. The research data were analyzed qualitatively and quantitatively. Qualitative descriptive data analysis with Likert scale index measurements. This study also uses quantitative analysis using SEM (Structural Equation Modeling) model analysis which will depict the influence model and relationship of independent variables to dependent variables to analyze social dynamics of partnerships in the use of owls in controlling rice field rat pests: a social review of farmer acceptance and behavior in Aceh Province (Hair et al., 2021). The SEM model framework is as shown in Figure 1 below.

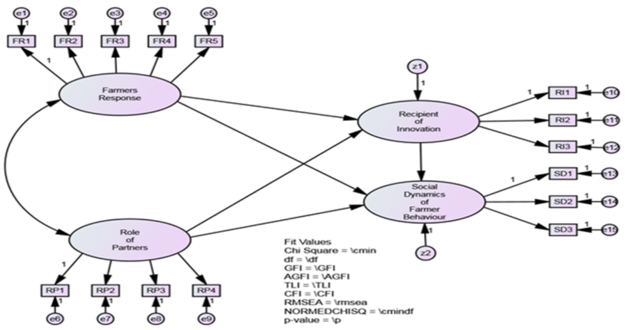

Figure 1. SEM model framework.

3. Results

The characteristics of rice farmers who joined in the implementation of the Owl House (RUBUHA) innovation activities observed were (1) Age, (2) formal education, paddy farming experience, (4) number of family dependents and (5) area of paddy field. Table 3 presents an overview of the characteristics.

Table 3. Distribution of characteristics of rice farmers

No	Characteristics of Paddy Farmers	Unit	Range		Average
			Low	Hight	
1	Age	Year	24	78	46.32
2	Formal education	Year	4	16	8.84
3	Paddy Farming Experience	Year	3	34	17.63
4	Number of Family Dependents	Soul	0	7	3.07
5	Area of Paddy Fields	Hectare (ha)	0.15	1.5	0.38

Table 3 shows that the average age of rice farmers falls within the productive age range, typically between 18 and 54 years for developing countries. Farmers within this age group generally possess the physical capacity and cognitive agility to manage rice farming activities effectively. Conversely, those outside the productive age range often face limitations that hinder their ability to perform agricultural tasks efficiently.

The average rice farmers have a Junior High School education level (SLTP) which is classified as low education. Basically, a farmer with a higher education will adopt innovation and technology more quickly. As a result, farmers tend to be more dynamic and efficient in doing their tasks. Although formal education levels may be low, extensive farming experience helps compensate; the longer farmers have been involved in rice cultivation, the better equipped they are to address challenges using the knowledge acquired over time.

The average number of family dependents falls within the medium category (more than three individuals per household). This factor significantly influences farming operations, particularly in rice cultivation. For farmer group members with a higher number of dependents who are also of working age, production costs can be reduced due to the availability of family labor. This reduction in labor expenses contributes to lowering overall production costs, thereby potentially increasing farmers' income. Although most rice farmers in the study area manage relatively small plots of land for rice cultivation, some also own additional agricultural land used for other farming activities beyond rice fields.

3.1. Farmers' response to owl house innovation

The indicators used to assess farmers' responses to the Owl House innovation include: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability and (5) observability. The index values obtained from the Likert scale results for each indicator of farmers' responses to the RUBUHA innovation are as shown in Table 4 below:

Table 4. Farmers' response to rubuha innovation (primary data (processed), 2024)

No	Farmers' Response to Rubuha Innovation	Index (%)	Interpretation
1	Relative advantage	86.53	Very high
2	Compatibility	89.34	Very suitable
3	Complexity	70.56	Easy
4	Triability	67.34	High
5	Observability	71.46	High

Relative advantage means that the implementation of the *Tyto alba* owl house innovation is considered by farmers to be more profitable than various other methods that have been applied in controlling rat pests. Relative advantage can be seen from the benefits obtained by farmers currently compared to the implementation of rat pest control that was previously applied. The Likert scale index value of the relative advantage indicator for the innovation of implementing the *Tyto alba* owl as a rat pest controller is dominated by the very high category (86.53%). This shows that the innovation of the *Tyto alba* owl as a rat pest controller in Pidie Jaya Regency provides benefits to farmers. The benefits obtained are in the form of effective rat pest control results, an increase in farmer income, cheaper expenses (costs) than previous innovations and can increase rice production.

The relative advantages of the Owl House (Rubuha) innovation compared to conventional rat pest control methods such as chemical poisons and mechanical traps. Based on field data we obtained from farmer respondents, the average cost of rat control using conventional methods reaches $60 per hectare per planting season, including the cost of purchasing poison, labor, and equipment replacement. Meanwhile, the construction of one Rubuha unit with an initial cost of $75 can be used to protect an average of 4 hectares for 4 years (8-10 growing seasons) without the need for routine operational costs, resulting in cost savings compared to conventional methods.

In addition to cost efficiency, the implementation of Rubuha also contributes to an indirect increase in crop yields. In our study, farmers who adopted Rubuha reported a 20-25% reduction in crop damage due to rat pests compared to farmers who did not implement the Rubuha innovation. This resulted in an average increase in rice productivity of 250 kg per hectare. The relative advantages of Rubuha include two main aspects: cost savings and increased income from rice production due to reduced rat infestation.

Compatibility shows that the implementation of the owl house innovation (*Tyto alba*) is consistent with existing values and the need for adoption. Compatibility of innovation can be seen from the suitability of the *Tyto alba* owl innovation as a rat pest controller with the conditions and environment at the research location. The compatibility index value with the values in the very appropriate category (89.34%). This shows that the innovation of implementing the *Tyto alba* owl is very appropriate and does not conflict with social, moral and environmental values (ecosystems) to control rat pests and maintain the owl ecosystem (*Tyto alba*). In terms of ecology, to date no significant negative impact on the balance of the ecosystem or livestock farming has been found as a result of the increase in the owl population. However, at one research site, swiftlet farmers reported owl attacks on farmed swifts. This indicates a potential conflict between owl conservation and swiftlet farming. Further research is needed to assess the impact of increasing owl populations on food chains and agroecological systems.

Complexity is the level of difficulty in implementing the innovation of owl houses as a rat pest controller in its application. The complexity of innovation can be seen from the complexity in implementing the innovation of *Tyto alba* owls as a rat pest controller. The level of complexity in implementing the innovation of *Tyto alba* owls as a rat pest controller is included in the easy category (70.56%). The easier the innovation is to implement, the lower the complexity, so that the innovation of implementing *Tyto alba* owls as a rat controller will be implemented more quickly by rice farmers. The among 120 research respondents in six subdistricts, approximately 76% of farmers have adopted the Rubuha innovation. The remaining farmers have not adopted it, mainly due to limited initial capital for development, lack of knowledge and technical skills regarding Rubuha management, and dependence on conventional pest control practices.

Triability is the degree of trial of the application of *Tyto alba* owls as a rat pest controller in a simple way. The triability of innovation can be seen from the ease of trying the *Tyto alba* owl innovation as a rat pest controller in farmers' rice fields. The triability of the innovation of the application of *Tyto alba* owls as a rat pest controller is included in the high category (67.34%). This shows that the innovation of the application of *Tyto alba* owls is easy to try based on the method and process of implementing the *Tyto alba* owl innovation.

Observability is the extent to which the use of *Tyto alba* owls as a rat pest controller is observed by others and communicated to others. Observability of innovation can be seen from the dissemination of *Tyto alba* owl innovation as a rat pest controller to others and is easily observed by others. Observability of *Tyto alba* owl innovation as a rat pest controller is included in the high category (71.46%). This shows that the results of the application of *Tyto alba* owls can be directly observed by others, including rice farmers.

3.2. Then partners in the implementation of rubuha innovation

The roles of partners involved in this research include; (1) Local government, (2) Agricultural extension workers, (3) Universities, (4) Farmer level institutions. An overview of the perception of the role of partners in implementing the Rubuha Innovation for controlling rat pests in rice field cultivation can be seen in the following table:

Table 5. The partner role index in implementing rubuha innovation (primary data (processed), 2024)

No	The Role of Partners	Index (%)	Interpretation
1	Local government	78.36	Playing a role
2	Agricultural Extension Officer	86.08	Very instrumental
3	Higher Education	52.72	Quite a Role
4	Farmer Institutions	72.37	Playing a role
	Average	72.38	Playing a role

The role of partners in implementing the Owl House (Rubuha) innovation to handle rat pests in rice fields in Pidie Regency, it can be seen that each partner has a different contribution. This innovation is designed as one of the solutions in controlling rat pests that disrupt rice farming productivity. In general, the partners involved consist of local governments, agricultural extension workers, universities, and farmer group institutions that have played a role in implementing the Rubuha innovation in controlling rice field rat pests at the research location.

Agricultural extension workers are considered to play a very important role in providing training and guidance to farmers on the right way to use Rubuha as a means of controlling rat pests (Danso-Abbeam et al., 2018). Through good extension, farmers' understanding of the benefits and technical implementation of this innovation can be increased, so that its success in the field is more assured (Anang et al., 2020). The role of the Regional Government includes providing funds for the construction of Rubuha, policies (regulations), and supporting facilities that enable the smooth running of the rat pest control program through the implementation of the Rubuha innovation. The local government provides technical and logistical support, including the construction of Rubuha using funds sourced from; APBK, OTSUS and Village Fund Allocation (ADG). The initial cost of installing Rubuha was indeed a challenge, especially for small farmers, hence the need for government support, which initially provided incentives based on farmer groups. After farmers felt the impact of the Rubuha innovation, rice farmers then took the initiative to build Rubuha for rat pest control.

Universities play a role in providing scientific studies (research) that support the effectiveness of Rubuha implementation. The role of universities also provides technical assistance to farmers and agricultural extension workers. Through socialization and training activities, FGDs, universities help improve farmers' understanding of ecosystem-based rat pest control. Farmer groups also play an important role in the education and socialization process for their members. Through various extension and training activities organized by the regional government through related agencies, agricultural extension workers, universities, they get information related to the benefits and how to apply the Rubuha innovation in controlling rice field rat pests. Farmer groups play a role as the main driver in the maintenance and monitoring of the effectiveness of Rubuha at the research location. This finding agrees with research by Budi et al. (2021).

3.3. Dynamics of farmers' acceptance and behavior towards rubuha innovation

In an effort to understand the dynamics of farmers' acceptance and behaviour towards Rubuha innovations, Structural Equation Modeling (SEM) analysis has been used to explore the relationships between the various variables that influence the adoption process. This SEM model provides a clear picture of the interactions between farmer responses, partner roles and social dynamics that contribute to innovation acceptance. By examining the goodness of fit (GoF) indices , the model shows good results, signifying that the hypothesis relationships between variables are relevant and support better decision-making in innovation adoption. Figure 2 below shows the full SEM model, followed by Table 4 which summary the GoF indices for the full model and Table 5 which presents relationship between exogenous and endogenous variables

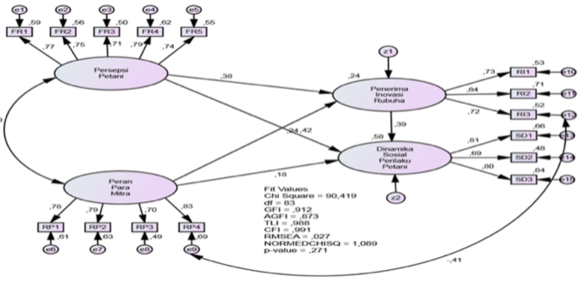

Figure 2. Full SEM model.

Table 6. GoF ındices for full model

GoF Indices	Cut-off Value	Analysis Results	Model Evaluation
χ^2Chi-Square Statistics	Expected Small	90.419	Good
Probability	>0.05	0.271	Good
CMIN/DF	<2.00	1.089	Good
GFI	>0.90	0.912	Good
AGFI	>0.90	0.873	Marginal
TLI	>0.95	0.988	Good
CFI	>0.95	0.991	Good
RMSEA	<0.08	0.027	Good

Table 7. The influence of exogenous variables on endogenous variables

			Estimate	S.E.	CR	P
Recipient of Innovation	⟵	Farmers_Response	0.371	0.107	3.463	0.0001
Recipient of Innovation	⟵	Role_of_Partners	0.238	0.103	2.304	0.021
Social Dynamics of Farmer Behavior	⟵	Role_of_Partners	0.207	0.104	1.982	0.047
Social Dynamics of Farmer Behavior	⟵	Farmers_Response	0.483	0.117	4.112	0.0001
Social Dynamics of Farmer Behavior	⟵	Recipient_of_Innovation	0.455	0.13	3.501	0.0001

The results of the SEM analysis show that farmer responses and the role of partners positively and significantly impact the acceptance of RUBUHA innovation. This finding is supported by the coefficient value and critical ratio that exceed the minimum limit, as well as a smaller probability than the specified error rate. This strengthens the findings of previous studies that emphasize the importance of active farmer participation and external partner support in increasing innovation adoption in the agricultural sector.

The acceptance of Rubuha innovation is significantly influenced by farmer response and the role of partners, which includes not only technical and economic aspects, but also social dimensions. Adopting farmers obtain tangible benefits in the form of cost efficiency, reduced crop losses, and strengthened social networks through farmer groups and extension activities. This collective mechanism encourages information exchange, shared responsibility, and joint monitoring, thereby strengthening the sustainability of ecology-based pest control.

In contrast, farmers who do not adopt the Rubuha innovation tend to operate individually with higher costs and limited access to new knowledge, which hinders the sustainability of long-term pest control practices. From a social dynamics perspective, the adoption of the Rubuha innovation not only represents an economic decision, but also a shift towards collective ecological management, where norms of cooperation, joint investment, and social accountability are important factors in embedding innovation sustainably in agricultural communities

In addition, the study also found that the recipient of innovation acts as a mediator in the relationship between farmer responses and the social dynamics of farmer behavior, although the influence of this mediation differs between the variables studied. This study makes a significant contribution to the understanding of how the adoption of innovations in the agricultural sector can change the social interactions and behavior of farmers in the field. These results are consistent with the broader literature, as explained by Rogers (2003) in the theory of diffusion of innovation, which emphasizes that the success of an innovation depends on a combination of end-user responses, social networks, and external support. In addition, successful practices of using new technological innovations from one farmer will become a model that is imitated by other farmers, thus encouraging the birth of new social practices collectively (Xu et al., 2020). These results emphasize that the social dynamics of farmer acceptance and behavior in implementing the owl house innovation in controlling rice field rat pests are greatly influenced by farmer responses, partnership patterns and farmer acceptance of the Rubuha innovation.

Conclusion

Farmers' responses to the implementation of Rubuha innovation based on the nature of the innovation in sequence are relative advantage and compatibility are in the very high category. Complexity and trialability are in the easy category while observability is in the high category. The role of partners, such as agricultural extension workers local governments and farmer institutions, in implementing Rubuha innovation is vital. The results of the SEM analysis show farmer responses and the role of partners positively and significantly affect the acceptance of the rubuha innovation in controlling rat pests. These results prove that the social dynamics of farmer acceptance and behavior in implementing the owl house innovation in controlling rice field rat pests are greatly influenced by farmer responses, partnership patterns and farmer acceptance of the owl house (Rubuha) innovation. The parties involved in the owl innovation implementation partnership to continue to increase their contributions to universities and farmer group institutions as well as agricultural extension workers so as to realise sustainable rat pest control. Farmers' resistance to new technological innovations in rat pest control ends when individual farmers successfully utilise new technological innovations in rat pest control through the achievement of increased yields. The success of Rubuha innovation is determined not only by its technical and economic benefits, but also by social interactions, institutional support, and collective adaptation among farmers. These social dynamics ensure that Rubuha functions as a community-based innovation, strengthening cooperation and social cohesion.

Ethical Statement

The authors declare that there were no animal or human studies were carried out in this study.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Author Contributions

S.B Initial proposal conceptualization-writing initial draft, processed the research data; NN supervision, methodology and data analysis; E.W data curation. All authors reviewed, edited, and approved the final manuscript.

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