Research Article

Socioeconomic and Technical Responses of Farmers Toward Agroecological Knowledge and Innovations in Java, Indonesia

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Abstract | A package of agroecological technologies has been developed and disseminated to the farming community to make intensive farming practices sustainable. This paper evaluates farmers' socioeconomic and technical responses to the introduction of agroecological knowledge and innovation related to agricultural resilience and sustainability, transferred through participatory training models. The evaluation was based on the concept of input-saving technological change. In 2022, data were compiled from Indonesian agricultural offices that surveyed using individual and group surveys across Central Java and East Java Provinces. The individual survey interview randomly selected 250 trained farmers and 250 counterparts. A clustered survey was conducted using participatory and interactive methods. Each cluster consisted of 10-15 farmers. Non-parametric statistical approaches were employed to analyse the effects. This study found that the agroecological knowledge and innovations transferred via the training constructively enhanced the resilience and sustainability of vegetable farming. Production, sales, and income increased, while production costs decreased. The training has successfully delivered agroecological technology and innovations, and updated skills in farming practices. Farmers responded positively to the training sessions and provided constructive feedback to improve future training.

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Introduction

Vegetable production significantly contributes to the national economies of emerging countries, including Indonesia. However, vegetable cultivation practices tend to harm the agroecosystem. The strong indications of such a trend are the steady increase in the unwise use of agrochemicals that harm healthy life, human health, and the environment (Bhandari, 2019; Ngowi *et al.*, 2007; Nguyen *et al.*, 2018). Based on the facts, strong recommendations have been raised regarding community-based training and education, jointly executed by local, national, and international institutions and agricultural production and food safety groups. The intervention would be cost-effective in mitigating the adverse impacts and improving food safety. Farmers are expected to respond positively to the intervention based on behavioural economic perception. Knowledge and innovation are closely linked to agroecology, which conserves vegetable agroecosystems through field demonstrations and participatory training programs. Agroecology is perceived as the marriage of agriculture and ecology and has evolved to embrace whole food systems, including production, economics, environmental impacts, and social implications of change. The field demonstrations on the agroecological approach comprised verified agronomic aspects and crop protection technologies delivered through participatory training. The technologies are particularly targeted at mitigating adverse impacts caused by climate change. Enhancement of farmers' capacity via the training is expected to update agroecological knowledge and innovations. The training participation of farmers is expected to equip them with a package of agroecological technologies that can be used to mitigate the adverse impact of climate change.

The research questions related to the above rationales are to what extent farmers accept and adopt the technological packages and how they perceive them. Based on the research question, this study appraises the behavioural responses of farmers to training programs delivering agroecological knowledge and innovations, the enhancement of farmer-perceived capacity, and the expected impacts. The novelty of this study relates to the subjects of agroecological knowledge and innovation perceived by farmers and their impact on farming performance. Furthermore, the study also assessed farmers' self-evaluations, which are commonly ignored in several training programs. The assumption that farmers seek to maximise profit or income from adopting a technological package holds, as farmers' motivation for new technology is economic.

Material and Methods

Theoretical framework

Cognitive psychology holds that cognition is the process by which individuals collect, develop, retain, and apply knowledge. A behavioral response is considered a farmer's decision made through a thorough analysis of the internal and external environments, informed by cognitive intelligence. Thus, the establishment of farmer behaviour depends on his/her cognitive ability, and different cognitive levels will lead to diverse behavioural responses (Zhang *et al*., 2021).

Many studies show that economic motives play an important role in farmers' adoption behaviour regarding new ecological knowledge and innovation (Hou *et al*., 2019; Huang *et al*., 2019; Yang *et al*., 2020). Thus, the fundamental theory used in this analysis is microeconomic production theory, in which producers seek to maximise income from farming (Jehle and Reny, 2011; Mankiw, 2017; Nicholson and Snyder, 2016; Pindyck and Rubinfeld, 2017; Varian, 2014). The producers gain improved knowledge and technology through training, enhancing farm performance.

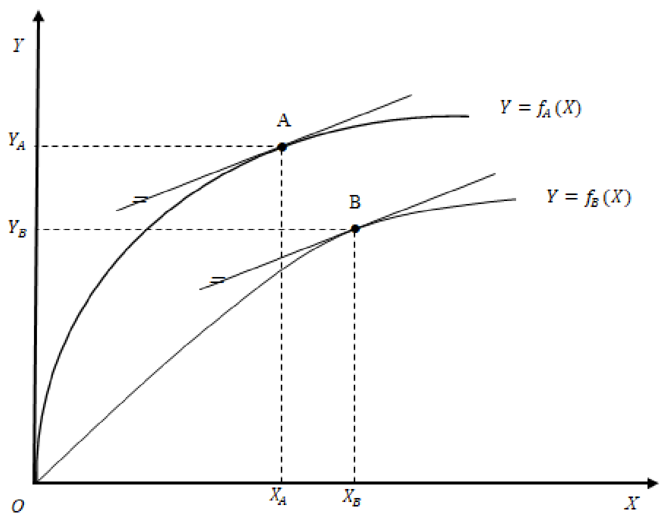

Figure 1: *Economic improvement of farming performance*
Note: *O is origin;* ***Y*** *is output;* ***X*** *is input; $Y=f_B(X)$ is production function before new technology; $Y=f_A(X)$ is the production function after new technology; points B and A are the optimal conditions before and after new technology, respectively; X_B and X_A optimal input allocation before and after new technology, respectively; Y_B and Y_A are output levels before and after new technology respectively.*

Figure 1 graphically illustrates the mechanisms underlying improved farming performance. Suppose that *Y* is produced using *X* in the plane of Y production and X input. At the initial condition, the *Y* production level follows the production curve f_B(X) before farmers participate in training. The straight line that touches the curve represents the output-to-input price ratio. Producers maximise income by allocating input at X_B, which results in output at Y_B, where at point B, the marginal product of input *X* is exactly the same as the price ratio of output and input. Now, suppose the farmers acquire agricultural knowledge and technology through training. After completing the training, the farmers apply such knowledge and innovation to their farming, and the production curve changes to become $f_A(X)$. With the current production curve, farmers adjust the allocation of input from X_B toX_A, and the production level changes from Y_B to Y_A. At point A, the same marginal product is reached with a lower input level after applying knowledge and innovation acquired from training. At the same time, the output level after knowledge and innovation is higher than before.

According to the microeconomic production explanation, the impact of introducing agricultural knowledge and technology is observable to farmers. The level of production increases, and the level of input decreases, and the result of both changes is an improvement in income (De and Tamang, 2023). Theoretically, the phenomenon is called input-saving technological changes. The phenomenon is expected to happen because the training introduced the agroecological concept of integrated crop management. Various aspects of the agroecological concept include land preparation, seed and seedling management, soil fertility and balanced fertiliser management, water irrigation management, and crop protection using locally available resources. When the input is detrimental to human health and the environment, such technological change leads to sustainable production that provides high net social benefit.

Empirical work

The data of this study were compiled in 2022 from two agricultural offices in Central and East Java provinces that conducted a series of surveys. This study was carried out to recognise and approximate the outcomes of training implementation related to farmers' skills, knowledge, and innovations in vegetables; farming practices; adoption of agricultural inputs; and the profitability of vegetable farming in Central and East Java provinces of Indonesia. This study examined tomato and chilli cultivation as the basis of agribusiness and farmers' perceptions of the training implementation. The training process during a crop cycle was documented, and the impact assessment was carried out 2-3 years after the training was completed.

This study adopted a mixed-methods approach, combining quantitative and qualitative research methods (Creswell, 2014), to analyse farmers' behavioural responses to the implemented interventions. In the quantitative approach, farmers' subjective perceptions of a state of well-being, knowledge, and innovations were encompassed in the structured questionnaires. Selected farmers as respondents were questioned to place a value on comparing and contrasting the conditions before and after training for different aspects of agricultural practices in vegetable farming. These aspects included production and sales, cost, net revenue, agroecological knowledge, and innovations. A score of 6 symbolises the best condition after training, while a score of 1 symbolises the worst condition after training. The number of respondents for this activity varied from 9 to 15. As mentioned above, the interview involved two participant groups: farmers and training facilitators.

Furthermore, this study utilises additional quantitative information collected through the structured questionnaire from 250 participating farmers and 250 non-participating farmers as counterparts. The differences in aspects were tested using a Wilcoxon rank-sum test to compare the two sample groups. The test was performed using STATA statistical software (StataCorp, 2013).

The data compiled from such an approach are close enough to the actual condition in the community. During this data collection process, each selected farmer provides information on standard agricultural practices and community perceptions. When one informant provides misleading information, others encounter the correct information. If a dispute still exists, the participants vote and agree on the average numbers. This study followed several approaches developed by Janis (2009) for this purpose. Reputable scholars (e.g., Krippendorff, 2004; Mancini and Jiggins, 2008; Purushotham and Paani, 2016) endorse the approach to qualitative studies.

Data collection for the qualitative approach in this study consisted of two main activities: focus group discussions (FGDs) and in-depth interviews in each project area. Four FGDs were conducted, two in Central Java and two in East Java. Due to this approach's limitations in eliciting detailed, quantitative information, the FGD focused on only three issues. First, farmers' knowledge and innovations from the training and its benefit; second, the continuity of implementing the knowledge and innovations. Finally, the future needs of farmers for knowledge and innovations in farming.

Figure 2: *The targeted areas of study sites*
Note: *The study sites were two districts each in East Java and Central Java, indicated by the black circles*.

The interview process was designed to collect data on farmers' knowledge and innovations in the program, as well as their motivations for joining the training. In addition to sampled farmers, training facilitators were also interviewed to complement responses. Information collected from this respondent group included their knowledge and innovations about the program, the program's benefits (particularly training), and their approach to delivering this knowledge and innovation to the farmers.

Four FGDs were held in two provinces. Two units were conducted in East Java: Blitar and Kediri; two were in Central Java: Tegal and Brebes (see Figure 2). The participants in each FDG varied from 10 to 15 farmers. Selected participating farmers represented all groups

Table 1: *Farmer assessment in valuing the conditions before and after training*

Conditions before and after training	Perceived by	Farmer-perceived measurement (%) [a]						z-value [b]
		Significantly worse			Significantly better			
		1	2	3	4	5	6	
Income	Participants	0.42	3.62	25.3	50.9	26.3	9.39	1.82*
	Counterparts	0.00	5.63	26.7	33.5	23.7	10.4	
Production and sales	Participants	0.00	7.64	41.7	40.4	10.3	0.43	2.39 **
	Counterparts	0.43	6.82	35.7	34.7	18.5	4.46	
Production costs	Participants	1.21	11.6	26.4	48.7	12.4	3.44	1.74*
	Counterparts	2.41	13.6	36.8	29.7	12.4	4.23	
Changes in knowledge and innovations:								
Field observation	Participants	0.00	0.81	13.2	46.2	36.3	3.23	5.36 ***
	Counterparts	0.44	6.33	28.3	42.4	18.9	4.43	
Pest and disease management	Participants	0.43	0.43	16.4	46.2	30.7	6.22	3.14 ***
	Counterparts	0.43	4.32	28.4	35.7	28.3	3.22	
Pesticide effectiveness	Participants	0.00	5.23	27.2	42.3	22.4	3.21	2.72 ***
	Counterparts	0.81	7.24	38.4	32.5	18.2	2.83	
Border crops	Participants	0.82	6.81	27.2	44.7	19.3	1.24	4.40 ***
	Counterparts	3.21	15.2	42.2	18.9	18.2	2.42	
Improved cultivars	Participants	0.00	2.21	17.6	48.7	30.2	1.24	3.30 ***
	Counterparts	0.83	2.12	32.1	41.5	20.3	3.22	
Starter solution technology	Participants	0.00	2.22	21.4	43.3	31.7	2.32	7.75 ***
	Counterparts	11.3	11.2	36.3	22.3	17.5	1.62	
Fertilisers application	Participants	0.00	13.2	26.7	36.9	21.1	2.34	1.80 *
	Counterparts	1.64	12.4	37.3	28.7	18.9	1.63	
Mulching technology	Participants	0.00	17.2	42.3	25.1	14.2	1.62	5.10 ***
	Counterparts	15.4	18.4	40.2	19.4	4.82	2.41	

Note: *Selected farmers were requested to provide a value of the present and previous conditions, where 1 denotes the condition after training is substantially worse. In comparison, 6 denotes that the condition after training is substantially better than before training. The number represents the proportion of farmers answering a specific value for each group and aspect.* [b] *z-value presents the two-sample Wilcoxon rank-sum of the Mann-Whitney test to compare the distribution in training participant and their counterparts.* *= p <0.1; ** = p <0.05; *** = p <0.01.

engaged in the training activities. Similar to FGD, the one-on-one interview was also conducted in four areas. Chilli and tomato were selected as the primary targets because they are vegetable commodities primarily cultivated in Indonesian farming.

Results and Discussion

Significant findings from this study relate to respondents' perceptions of the impacts of agroecological technologies resulting from the training implementation. The study found that the program's training implementation has provided farmers with many advantages, especially in knowledge and innovation and, eventually, in economic aspects. The results were presented in tables and figures.

Table 1 shows that non-participating and participating farmers perceived their income was relatively higher after training than before. The participating farmers, on average, value higher or feel better than their counterparts. The difference is statistically significant at a 90% confidence interval level. This finding suggests a difference in their perception of the increase in their income level. This same conclusion also applies to their perceptions of total costs: participating groups feel better off, and there is a significant difference between them. The perception of sales differs significantly at a 95% confidence interval. Logically, the participating farmers are more satisfied with their current condition than their counterparts. Farmers who acquire agroecological knowledge and innovations are ready to face climate change. Farming is resilient to climate change when applied with agroecological knowledge and innovations. These findings align with studies by Wijaya *et al.* (2021a; 2021b), which found that farmers gained additional income from growing vegetables. Mariyono *et al.* (2020) support the findings in technology and innovation applicable to vegetable farming to improve sales.

Remarkable results are shown in perceptions of farmers' state of knowledge and innovations. At the same time, farmers were impressed that their knowledge of agricultural practices and innovations had been upgraded. One crucial finding from the field survey is the importance of knowledge and innovation. Most respondents, who accounted for 92%, admitted they would continue implementing knowledge and innovations. This study's finding is supported by Indrarosa *et al.* (2024; 2025a; 2025b) who found that training on specific subjects enhances participants' knowledge and performance.

As shown in Table 2, the farmer placed greater value on training materials for different crops, such as plant observation and pest control. The study found that farmers perceived different values in the materials or subjects given in training, since agroecological knowledge and innovations are functional. Meanwhile, specific training materials or techniques, such as mulching, are perceived as low-value. Some factors clarified the low value of the specific technology and innovations perceived by the participating farmers. Firdauzi *et al.* (2024) highlight that technology supporting environmentally friendly farming is strongly associated with farmers' perceptions of sustainable or organic farming.

Table 2: *The most useful subjects for farmers*

Subjects transferred through the training	Farmer responses (%)	
	Most beneficial innovation	Second most valuable innovation
Pest and disease management	40.1	24.5
Direct field observation	24.3	26.9
Starter solution technology	6.9	16.3
Selection of cultivars and seeds	4.5	11.8
Mulching technology	3.2	3.3
Insect pest trapping methods	2.0	12.2
Fertiliser management	1.6	4.1
Others	8.5	0.8

Source: *authors' analysis of the survey data*

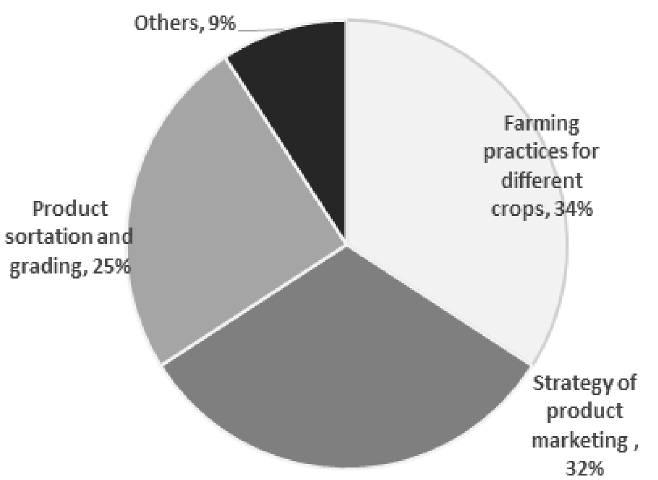

Figure 3: *Farmers' responses toward training subjects required in future*

The farmers will continually adopt new technologies and innovations if they increase income. Regrettably, farmers' income is heavily dependent on commodity prices (Mariyono *et al*., 2020), and these prices often fluctuate. Therefore, farmers proposed that future training should focus on post-harvest handling. They believed that knowledge and innovations in post-harvest handling would enable them to obtain reasonable product prices (Figure 3).

Table 3: *Farmer-perceived determinant of training materials*

Determinants	Farmers' response (%)		
	Overall	Central Java	East Java
The decision from the field facilitators	54.5	30.6	77.6
The need of farmers	44.7	68.5	21.6
Other	0.8	0.8	0.8

Source: *authors' analysis of the survey data*

One essential piece of information collected from interviews with training facilitators concerns knowledge and innovation transfer. Before delivering the knowledge and innovations to the farmers, facilitators received several pieces of training. The training curriculum was about farming techniques that were later passed on to farmers. So, the materials are determined by the program. This condition reduces the program's flexibility. As a result, some farmers complained that they needed to receive the necessary knowledge and innovations.

This finding is supported by the quantitative study results shown in Table 3, which indicate that around 54% of respondents reported that the field facilitators determined the training materials. This condition reduces the flexibility to meet farmers' demands, which is a concern for farmers. The primary purpose of the training was to educate farmers about the benefits of mulching technology, increase demand for this technology, and encourage them to access its benefits. However, it could create farmers' dependence on the seller and lead to the same problem with fertilisers, where farmers are highly dependent on them.

This obstruction to the transfer of knowledge and innovation among farmers can be due to farmers' limited willingness to adopt knowledge and innovations. One possible explanation for this condition could be related to the motivation to participate in the training. Figure 4 shows that economic motives dominate the reasons. This is a normal phenomenon. Another finding is that about 36% of farmers reported participating because their group nominated them. This feature could mean that participation could be just a responsibility of the group. Nevertheless, another large majority of the farmers (21%) participated in the training to increase their farming knowledge and innovations, which was a strong motivation.

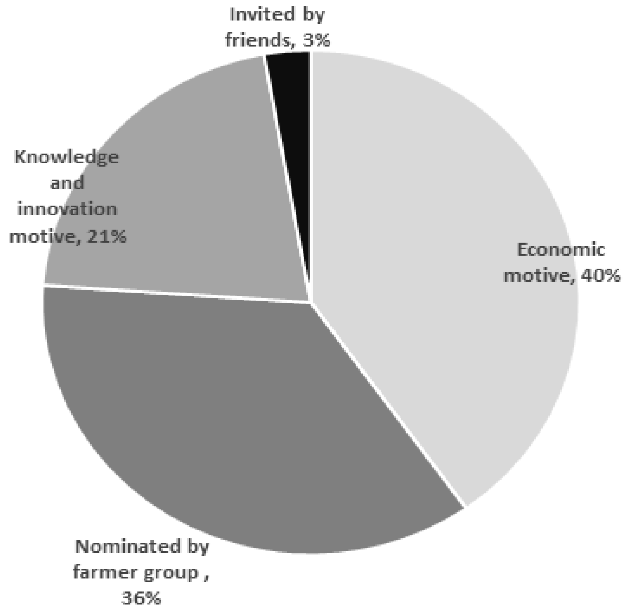

Figure 4: *Farmers' response to the motivation for training participation*

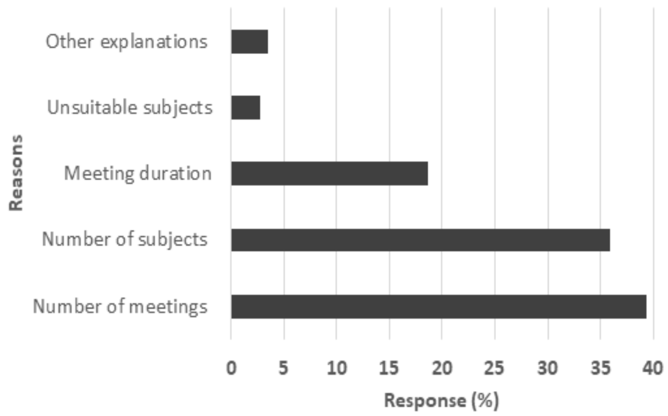

Figure 5: *Reasons for the inadequacy of the subjects of training*

Another significant factor in the transfer of knowledge and innovation is the duration of the program. Farmers perceived that the training duration could be longer. About 39% of farmers who claimed that the training materials were insufficient said that the frequency of meetings should be increased, while about 19% said that the duration for each session should be longer (Figure 5). Another possible factor is related to the program's flexibility. As mentioned previously, more participation is needed at the implementation level. As a result, around 36% of the participants perceived that more learning materials were needed than were provided by the training.

It has been indicated that the participating farmers experienced significantly better conditions than their counterparts. This statement was considered authentic for knowledge and innovations focused on agroecology, including mulching technology, stater solution technology, and direct field observation. This finding strengthens other findings that training activities have increased farmers' capacity for farm management. Furthermore, participating farmers were more convinced of the value of knowledge and innovation and learned more significant training subjects than their counterparts.

The participating farmers perceived that the training had delivered valuable knowledge and innovations applicable to tomato and chilli farming. Farmers can cultivate more vegetable crops through this knowledge and innovations. The respondents stated that the training covered several subjects, knowledge, and innovations. The knowledge and innovations that the farmer receives from training, in general, can be clustered as follows: field observation of plants, pest control methods, seed selection, soil fertility and fertiliser management, and unique mulching technology. Several farmers suggested that the cropping rotation system needs to be included in the training. This is a good idea since it is one of the components of agroecology. Prasetyo *et al*. (2024) suggest that long-term crop rotation, as a component of agroecology, may help farmers achieve optimal vegetable production performance.

The results of the FGD also indicate that farmers stated they had known similar techniques transferred during training and already had specific names for them. For example, using the starter solution of fertilisers was already called '*kocoran*'. Meanwhile, '*naungan*' is the name farmers recognise for the plastic rain shelters. The existing local terminologies indicate that knowledge and innovations are familiar. This statement demonstrates that farmers needed to catch up on the fundamental knowledge and innovations of the new technologies. For instance, the essence of starter solution technology is determining the proper concentration of the fertiliser solution to be applied immediately after seedlings are transplanted into the beds. This particular technology has been validated to improve plant vigour.

There is an accepted view that applying the fertiliser solution immediately after transplanting will cause the plants to wilt. Some participating farmers admitted they had acquired analogous knowledge and innovations from the training facilitator, except for mulching technology. Nonetheless, the training has contributed to an improved understanding of technology and innovation, as a farmer in Brebes noted: farmers usually use the technique based on common custom, with no specific knowledge or skill; through the training, they understand how to implement it correctly.

Table 2 suggests that farmers still need clarification on implementing new technologies, and that innovations can automatically lead to higher income. For example, in the case of mulching technology, some farmers in Kediri think that new technology increases farming costs; as a farmer from Kediri mentioned, they are not cultivating tomatoes right now. However, after gaining knowledge and innovations about mulching, they planted a few seeds. They face the cost of producing seedlings. In another case, a farmer reported that implementing a new technique slightly increased production. A farmer in Tegal revealed that after implementing formulated starter solution technology, he found no significant impact on his crop productivity. It only increases by about 0.5 kg per crop; however, he still needs to understand more about the technology in the future, since he only observed it once.

This statement demonstrated the need to help farmers understand the importance of calculating production costs to determine the most profitable practice. Although the starter solution technology does not increase yield, it reduces the total fertiliser requirement, significantly lowering production costs and eventually increasing profit. A male farmer in Blitar stated that income from farming had become an essential concern for farmers; furthermore, they are very enthusiastic about their income, as they always try to find ways to increase it. From the training, he observed an opportunity to increase his income and looked forward to harvesting his crops in the following growing season.

Another reason for farmers' reluctance to adopt new knowledge and innovations is the complexity of implementing them. Some farmers still believe that some of the knowledge and innovations delivered in training could be more practical. A woman farmer in Blitar said she had not tried fertiliser and pest control techniques because there is still a misunderstanding between her and her husband. Her husband wants a practical technique, and she wants to apply instant insecticides.

The quantitative study results confirmed the outcome that around 37% of selected respondents did not adopt some training subjects because they still perceived some techniques delivered in the training program as complicated and undoable. The benefits of training are not only in knowledge and innovation, but also in other benefits for farmers. One key benefit is improved networking among farmers. Farmers can strengthen cohesion and relationships through scheduled regular meetings. One of the participating farmers from Brebes admitted that they could meet some relatives they had not seen for so long by joining the training. The farmer association is now active, and they can network and exchange experiences and information related to vegetable farming. Mariyono *et al*. (2013) report a similar phenomenon: the cohesion of farmers' associations in Aceh Province, Indonesia, becomes stronger after completing participatory training. The finding supports the conditions in other developing countries. Duveskog *et al*. (2011) stated that participatory training had strengthened the relationship between farmers in Kenya and their counterparts.

Another advantage of training is the extensive impact of knowledge and innovations. The study showed that the training had created an encouraging externality for farmers. This study found that knowledge and innovations were conveyed to other farmers who did not participate. Some selected respondents reported that they were pleased to share the knowledge and innovations gained from the training with other farmers, both within and outside the farmer group. This sharing of knowledge and innovations is inevitable since the participants represented existing farmer groups, as revealed by a farmer in Kediri who has so far shared his knowledge from the training with at least three farmers. However, he only shares when asked, since each farmer has their own principles for farming techniques.

Despite its benefits, the implementation of training also has several areas for improvement, as perceived by the participants. Farmers perceived a weakness in the participation issue. Some respondents admitted that the field facilitators had already prepared training materials that were not based on farmers' needs. Somehow, this participatory approach did not reach the farmers' level of satisfaction during implementation. Farmers did not actively participate in deciding the main content of the training, namely the learning materials. Nevertheless, farmers' needs were still accommodated at some levels, such as deciding the schedule and duration of activities.

Training activities have successfully increased farmers' knowledge and innovation, thereby improving the farming system. These findings align with those in Malawi, which show that adopting agroecology in the semi-humid tropics enables households to diversify their crops and diets, with substantial implications for improved food security, good nutrition, and human health (Nyantakyi-Frimpong *et al*., 2017; Kansanga *et al*., 2021). In Ecuador, a study by Deaconu *et al*. (2021), 152 clearly reveals that

"Stronger nutrient adequacy is likely related to agroecological farmers' higher production diversity as well as the social and human capital developed within their networks, while stronger dietary moderation is likely related to their greater consumption of foods obtained through own-production and the social economy. Dietary differences between agroecological and reference farmers occur despite similar incomes and other socioeconomic characteristics, and in fact, agroecological farmers achieve healthier diets while spending less money to purchase foods. Agroecology-based farmers' networks may thus hold promise for integrating nutritional health priorities into sustainable food systems."

Many other studies show positive impacts of agroecological technology. With such evidence, agroecological concepts in sustainable agricultural development have become a concern (Deaconu *et al*., 2019; Mariyono, 2009; Mariyono *et al*., 2010). As mentioned by Altieri (2002) and Altieri and Toledo (2011), agroecology provides the scientific basis for producing from a biodiverse agroecosystem that sustains its own functioning. The latest advances in agroecological research are reviewed to define more clearly the elements of a research agenda in natural resource management compatible with the needs and aspirations of peasants. Lanka *et al*. (2017) also suggest that the agroecological approach supports agricultural biodiversity while promoting sustainable livelihoods, as farmers can reduce their reliance on external inputs. This study provides evidence of the role of government policy and practice in disseminating the agroecological approaches.

Conclusions and Recommendations

Vegetable farming is profitable and can increase the income of farmer households in rural areas. With substantial progress in agricultural technology and innovation, farmers need more knowledge, which leads them to refrain from adopting these technologies and innovations. Farmers were sent to training on agroecological knowledge and innovation related to vegetables, and after completing the training, the benefits were evaluated. By using a mix of quantitative and qualitative approaches, this study provided robust, clear evidence that the training interventions have increased farmers' knowledge and innovation, ultimately affecting their well-being. The findings indicate that knowledge and innovations obtained from the training were understood to be helpful and at least partially adopted by the majority of participating farmers. The training activities also made participants more confident in their knowledge and innovations in farming practices. Thus, transferring knowledge and innovations through participatory training could be adequate and significantly impact the medium- and long-term.

Recommendations resulting from this study are as follows. Since the training has enhanced farmers' capacity through upgraded technology and innovations in vegetable farming, sending other farmers to similar training is needed to continue. As local governments have a regular budget for regional development, it is strongly recommended that a fraction of that budget be allocated to improve farmers' capacity. It should be noted that the follow-up of the completed training is also recommended. The impacts would be more noticeable when some of the observed shortcomings throughout the organisation and in the execution of training are addressed, ensuring a high participation rate, flexibility to accommodate different conditions, and continuous learning.

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Novelty Statement

The novelty of this article lies in the self-assessment of farmers regarding agroecological technology applicable to vegetable farming, and in the underlying microeconomic theory that explains the economic motives for adopting agricultural technology.

Author's Contributions

Joko Mariyono, Wulan Sumekar, Kadhung Prayoga, Agus Subhan Prasetyo, and Siwi Gayatri: Conceptualised the research framework and conducted field surveys.
Joko Mariyono: conducted database management, statistical analysis, and prepared the initial draft of the manuscript.
Agus Subhan Prasetyo, Kadhung Prayoga, Siwi Gayatri and Wulan Sumekar: Assisted the analysis and reviewed and edited the final draft.

Generative AI or AI assisted technology statement
The authors declare that there is no generative AI or AI assisted technology in this manuscript.

Conflict of interest
The authors have no conflict of interest.

References

Altieri, M.A. 2002. Agroecology: the science of natural resource management for poor farmers in marginal environments. Agric. Ecosyst. Env., 93(1-3): 1–24. https://doi.org/10.1016/S0167-8809(02)00085-3

Altieri, M.A. and V.M. Toledo. 2011. The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants. J. Peasant Stud., 38(3): 587–612. https://doi.org/10.1080/03066150.2

011.582947
Bhandari, L.R. 2019. Increasing trend of pesticides' use in vegetable farming and its impact for human health a case study of Bharatpur Metropolitan City, Nepal. J. Multidiscip. Res., 2(3): 50-67. doi. https://doi.org/10.3126/njmr.v2i3.26975
Creswell, J.W. 2014. Research Design: Qualitative, Quantitative, and Mixed Methods approach. 4th ed. Sage, Los Angeles.
De, U.K. and R.K. Tamang. 2023. Pattern of agricultural progress in India's North-East and the contributing factors: an econometric analysis. J. Tekirdağ Agric. Fac., 20(3): 509-527. https://doi.org/10.33462/jotaf.1114386
Deaconu, A., G. Mercille and M. Batal. 2019. The agroecological farmer's pathways from agriculture to nutrition: a practice-based case from Ecuador's highlands. Ecol. Food Nutrit., 58(2): 142–165. https://doi.org/10.1080/03670244.2019.1570179
Deaconu, A., P.R. Berti, D.C. Cole, G. Mercille and M. Batal 2021. Agroecology and nutritional health: A comparison of agroecological farmers and their neighbors in the Ecuadorian highlands. Food Pol., 101(102034): 1 -14. https://doi.org/10.1016/j.foodpol.2021.102034
Duveskog, D., E. Friis-Hansen and E.W. Taylor. 2011. Farmer field schools in rural Kenya: a transformative learning experience. J. Dev. Stud., 47(10): 1529-1544. https://doi.org/10.1080/00220388.2011.561328
Firdauzi, A., T. Ekowati, A.S. Prasetyo and J. Mariyono. 2024. Factor determining the smallholder farmer's perception on organic farming: a case of Makmur Sejahtera Farmers Group, Batu City, Indonesia. J. Tekirdag Agric. Fac., 21(3): 722–731. https://doi.org/10.33462/jotaf.1357614
Hou, L., X. Chen, L., Kuhn and J. Huang. 2019. The effectiveness of regulations and technologies on sustainable use of crop residue in Northeast China. Energy Econ., 81: 519–527. doi: https://doi.org/10.1016/j.eneco.2019.04.015
Huang, X., L. Cheng, H. Chien, H. Jiang, X. Yang and C. Yin. 2019. Sustainability of returning wheat straw to field in Hebei, Shandong and Jiangsu provinces: a contingent valuation method. J. Cleaner Prod., 213: 1290–1298. https://doi.org/10.1016/j.jclepro.2018.12.242
Indrarosa, D., J. Mariyono, S.I. Santoso and Sutaryo. 2024. Factors determining knowledge acquisition in livestock waste management training held by Animal Husbandry Training Centre at Songgoriti, Batu – Indonesia. IOP Conference Series: Earth Env. Sci., 1364(1): 1-6. https://doi.org/10.1088/1755-1315/1364/1/012026
Indrarosa, D., J. Mariyono, S.I. Santoso, and S. Sutaryo. 2025a. Assessing the effectiveness of livestock waste management training in promoting technology adoption among farmers. J. Adv. Vet. Res., 15(5): 547-553.
Indrarosa, D., J. Mariyono, S.I. Santoso, and S. Sutaryo. 2025b. The effectiveness of community-based eco-farm waste management training on enhancing farmers' environmental awareness: The role of government support and sustainability attitudes. Cleaner Waste Syst., 12(100394): 1-8. https://doi.org/10.1016/j.clwas.2025.100394
Janis, I. 2009. The problem of validating content analysis. In: K. Krippendorff and M.A. Bock (Eds), The Content Analysis Reader, pp. 358-366, Los Angeles CA: Sage.
Jehle, G.A. and P.J. Reny. 2011. Advanced Microeconomic Theory, Pearson, London.
Kansanga, M.M., J. Kangmennaang, R.B. Kerr, F. Lupafya, L. Dakishoni and I. Luginaah. 2021. Agroecology and household production diversity and dietary diversity: Evidence from a five-year agroecological intervention in rural Malawi. Soc. Sci. Med., 28(8): 1-15. https://doi.org/10.1016/j.socscimed.2020.113550
Krippendorff, K. 2004. Content Analysis: An Introduction to Its Methodology, 2nd ed., Thousand Oaks CA: Sage.
Lanka, S.V., I. Khadaroo and S. Böhm. 2017. Agroecology accounting: biodiversity and sustainable livelihoods from the margins. Account. Audit. Accountabil. J., 30(7): 1592-1613. https://doi.org/10.1108/AAAJ-12-2015-2363
Mancini, F. and J. Jiggins. 2008. Appraisal of methods to evaluate farmer field schools. Dev. Pract., 18(4–5): 539–550. https://doi.org/10.1080/09614520802181277
Mankiw, N.G. 2017. Principles of Microeconomics 8th Edition, Cengage Learning, Boston.
Mariyono, J. 2009. Socially inefficient use of pesticides due to negative externalities: a case of Indonesian rice agriculture. Internat. J. of

Ecol. and Dev., 13(S09): 93-107.

Mariyono, J., T. Kompas, R.Q. Grafton. 2010. Shifting from Green Revolution to environmentally sound policies: Technological change in Indonesian rice agriculture. J. As. Pac. Econ., 15(2): 128–147. https://doi.org/10.1080/13547861003700109

Mariyono, J., G.C. Luther, M. Bhattarai, M. Ferizal, R. Jaya and N. Fitriana. 2013. Farmer field Schools on chili peppers in Aceh, Indonesia: activities and impacts. Agroecol. Sust. Food Syst., 37(9): 1063-1077. https://doi.org/10.1080/21683565.2013.819827

Mariyono, J., J. Waskito, A. Kuntariningsih, G. Gunistiyo, and S. Sumarno. 2020. Distribution channels of vegetable industry in Indonesia: impact on business performance. Int. J. Prod. Perf. Man., 69(5): 963-987. https://doi.org/10.1108/IJPPM-11-2018-0382

Ngowi, A.V.F., T.J. Mbise, A.S.M. Ijani, L. London and O.C. Ajayi. 2007. Smallholder vegetable farmers in Northern Tanzania: Pesticides use practices, perceptions, cost and health effects. Crop Protect., 26(11): 1617-1624. https://doi.org/10.1016/j.cropro.2007.01.008

Nguyen, T.M., N.T.T. Le, J. Havukainen and D.B. Hannaway. 2018. Pesticide use in vegetable production: A survey of Vietnamese farmers' knowledge. Plant Protect. Sci., 54(4): 203-214 https://doi.org/10.17221/69/2017-PPS.

Nicholson, W. and C.M. Snyder. 2016. Microeconomic Theory: Basic Principles and Extensions, Cengage Learning, Boston, MA.

Nyantakyi-Frimpong, H., J. Kangmennaang, R.B. Kerr, I. Luginaah, L. Dakishoni, E. Lupafya, L. Shumba and M. Katundua. 2017. Agroecology and healthy food systems in semi-humid tropical Africa: Participatory research with vulnerable farming households in Malawi. Acta Tropica., 175: 42–49. https://doi.org/10.1016/j.actatropica.2016.10.022

Pindyck, R.S. and D.L. Rubinfeld. 2017. Microeconomics, Pearson, London.

Prasetyo, A.S., T. Dalmiyatun, S. Gayatri, , K. Prayoga, W. Sumekar and J. Mariyono. 2024. Performance analysis of shallot farming under glebagan system in Central Java, Indonesia. Pakistan J. Agric. Res., 37(2): 158–164. https://doi.org/10.17582/journal.pjar/2024/37.2.158.164

Purushotham, P. and B.S. Paani. 2016. Strengthening rural livelihoods in Bundelkhand. J. Rural Dev., 35(1): 1-16.

StataCorp. 2013. Stata: Release 13 Statistical Software, StataCorp LP, College Station, TX.

Tittonell, P. 2015. Food security and ecosystem services in a changing world: it is time for agroecology. Agroecology for food security and nutrition. Proceedings of the FAO International Symposium, Rome.

Varian, H.R. 2014. Intermediate Microeconomics – A Modern Approach, W. W. Norton and Company, New York.

Wijaya, A.F., A. Kuntariningsih, S. Sarwono and A. Suryono. 2021a. Role and contribution of vegetables in mitigating malnutrition through a sustainable food reserve program. Internat. J. Veg. Sci. 27(1): 65-75. https://doi.org/10.1080/19315260.2019.1703872

Wijaya, A.F., A. Kuntariningsih, S. Sarwono and A. Suryono. 2021b. Malnutrition mitigation and community empowerment through the sustainable food reserve programme in Indonesia. Dev. Pract., 31(1): 37-48. https://doi.org/10.1080/09614524.2020.1782845

Yang, X., L. Cheng, X. Huang, Y. Zhang, C. Yin, and P. Lebailly. 2020. Incentive mechanism to promote corn stalk return sustainably in Henan, China. Sci. Total Environ., 738(139775): 1-15. doi: https://doi.org/10.1016/j.scitotenv.2020.139775

Zhang, H.T., L. Wang, S. Yu, Z. Zhao, and H. Shi. 2021. Identifying government and farmers' roles in soil erosion management in a rural area of southern China with social network analysis. J. Cleaner Prod., 278(123499): 1-15. doi: https://doi.org/10.1016/j.jclepro.2020.123499.