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UTILIZATION OF SOCIOTECHNICAL APPROACHES IN THE APPLICATION OF AGRICULTURAL BIOTECHNOLOGY: A STUDY OF FARMER BEHAVIOR TOWARDS BIOENGINEERED PRODUCTS IN MAGETAN REGENCY

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Abstract

This research aims to understand the behavior of farmers in responding to bioengineering-based agricultural biotechnology products through a sociotechnical approach in Magetan Regency. This approach is used to analyze how the interaction between technology and social context affects the acceptance of innovation at the farmer level. The method used is qualitative with in-depth interview techniques, observations, and directed group discussions (FGD). The results of the study show that farmers' perception of bioengineered products is greatly influenced by the level of knowledge, experience, and social influence of farmer group figures. The information received by farmers tends to be minimal and biased, especially due to the weak role of agricultural extension workers and the dominance of private distributors in the delivery of information. In addition, local cultural norms and values also shape farmers' attitudes towards technology that is considered unnatural. The sociotechnical approach has proven to be able to be a bridge between technology and the social needs of farming communities, by emphasizing participatory involvement and two-way communication. Therefore, the application of agricultural technology must take into account social structures and local values to guarantee the success and sustainability of its adoption.

Keywords: Sociotechnical Approach, Agricultural Biotechnology, Farmer Behavior, Bioengineering, Magetan Regency.

INTRODUCTION

Agriculture in Indonesia is a sector that not only plays a role as the backbone of the national economy, but also as a cultural heritage that is firmly rooted in people's lives, especially in rural areas (Kusumaningrum, 2019). Over time, the agricultural sector faces various challenges such as land degradation, climate change, and increasing food demand pressures due to population growth (Ibnu, 2024). To answer these challenges, technological advances have given birth to various innovations in the agricultural sector, one of which is biotechnology (Surasmi et al., 2022). Agricultural biotechnology, especially in the form of bioengineered products such as GMO crops and genetically modified superior seeds, has been developed with the aim of increasing crop productivity and resistance to pests and extreme environmental conditions (Jumiono et al., 2024). However, the application of this technology does not always run smoothly, especially at the farmer level who are the main actors in the agricultural production process (Lestari et al., 2019). This is where the importance of a sociotechnical approach comes in, which not only views technology as a product of science, but also as part of a complex social system.

The socio-technical approach combines social, cultural, economic, and political aspects in designing and implementing technology to better suit the needs and conditions of the user community (Marsini, 2025). In many regions, the mismatch between technology and the social context of society is often the main cause of failure to adopt innovation, including in agriculture. Magetan Regency in East Java is one of the agricultural areas that is trying to develop the agricultural sector through the use of cutting-edge technology (Gustami, 2009). With the distinctive and heterogeneous socio-cultural characteristics of farming communities, Magetan is an interesting location to study how socio-technical approaches can affect farmers' behavior towards biotechnology products. The acceptance of bioengineered products by farmers is not only influenced by technical aspects such as productivity and efficiency, but also by the perceptions, knowledge, beliefs, and social values they adopt. For example, concerns about

environmental impacts, health, and dependence on seed companies are important factors in the decision-making process of farmers (Lubis, 2024). In this context, it is important to understand that technology is not neutral; It is shaped and interpreted by the social context in which it is developed and used. Therefore, a study is needed that is able to uncover the social dynamics that occur behind the application of biotechnology-based agricultural technology. This kind of study will not only provide a more holistic understanding, but also help in formulating a more inclusive and sustainable technology implementation strategy. In the midst of the dominance of top-down approaches in agricultural policy, the use of sociotechnical approaches offers a more participatory alternative and sensitive to local needs. Through this approach, farmers are no longer positioned as mere recipients of technology, but rather as active actors involved in the innovation process. This is crucial in building farmers' trust and commitment to the new technology offered. This study aims to explore how the behavior of farmers in Magetan Regency in responding to agricultural biotechnology products through a sociotechnical approach that considers local social and cultural factors. By understanding the interaction between technology and society more deeply, it is hoped that the results of this research can be the basis for more effective policy-making in the application of agricultural biotechnology in Indonesia.

RESEARCH METHODS

This research uses a qualitative approach with a case study type, as it aims to deeply understand the behavior and response of farmers to biotechnology products in the context of local social, cultural, and economic (Ilhami et al., 2024). The study also adopts the principle of a sociotechnical approach, which views that technology is inseparable from the social networks of users and their environment.

1. Research Location

The research was conducted in Magetan Regency, East Java, which is one of the agricultural areas with a significant farmer population and began to recognize several bioengineered products such as superior GMO seeds and other biotechnology products.

2. Research Subject

The subjects in this study are farmers who:

- Using or having used agricultural biotechnology products (e.g. GMO seeds, microbial fertilizers, etc.),
- Do not use biotechnology products but have knowledge or perception of them.
- In addition to farmers, key informants also include agricultural extension workers, community leaders, village officials, and representatives of local agriculture offices.

3. Data Collection Techniques

Data collection techniques are carried out in several ways, including (Scott, 2017):

- In-depth interview: Conducted in a semi-structured manner to explore farmers' views, knowledge, attitudes, and practices related to agricultural biotechnology.
- Participatory observation: The researcher also observed the interaction of farmers in agricultural activities, such as seed use, farmer group discussions, and decision-making.
- Focus Group Discussions (FGDs): Used to explore social dynamics between farmers and their collective perceptions of bioengineering technologies.
- Documentation study: Examine local documents such as extension records, village agricultural reports, and local government policies.

4. Informant Selection Techniques

The selection of informants was carried out purposively using the snowball sampling technique (Retnawati, 2017). The initial informant was determined based on recommendations from agricultural extension workers and village heads, then developed by referring to farmers' social networks.

5. Data Analysis

The data obtained were analyzed using thematic analysis methods (Saleh, 2017). The process includes:

- Transcription of interview and observation data,
- Data coding (open coding, axial coding),
- Identify key themes such as risk perception, trust in technology providers, institutional support, and farmer group dynamics.

The analysis is carried out by considering technical and social aspects simultaneously, as well as sociotechnical principles.

6. Data Validity

To ensure the validity of the data, triangulation techniques are used both sources and methods. Source triangulation is carried out by comparing information from various informants, while method triangulation is carried out by comparing data from interviews, observations, and documentation.

RESULTS OF RESEARCH AND DISCUSSION

1. Farmers' Knowledge and Perception of Bioengineered Products

The results show that the level of knowledge of farmers about biotechnology products, especially bioengineered products such as GMO seeds, still varies greatly. Most farmers are familiar with the term "superior seeds" but do not understand that some of these seeds are the result of genetic engineering. For farmers who have experience using the product, the perception is generally positive in terms of increased yield and resistance to pests. However, there are also concerns about the long-term impact on the environment and health. These concerns mostly stem from informal information circulating in farmer groups or social media. Farmers who do not use biotechnology products tend to have negative perceptions, due to the lack of access to official information and the lack of the role of extension workers in explaining the benefits and risks objectively.

This study shows that farmers' knowledge of biotechnology products in Magetan Regency is still limited and uneven. This is in line with the theory of innovation adoption from (Rogers, 2003a) which states that the technology adoption process is greatly influenced by the individual's initial knowledge of the innovation. Farmers who have a sufficient understanding of the benefits and risks of bioengineered products tend to be more open and adaptive. On the contrary, limited information can trigger fear, misinformation, and rejection. In this context, peasant perceptions are shaped not only by factual information, but also by group opinions, past experiences, and inherent social values. Social Construction of Technology (SCOT) Theory by (BIJKER & PINCH, 2014) explained that the perception of technology is greatly influenced by the social interpretation of the user. Biotechnology products are not seen as mere technical entities, but rather as something that is "interpreted" within the cultural and social framework of the farming community.

2. Social and Cultural Factors in Farmers' Decision Making

Farmers' decisions to accept or reject bioengineered products are influenced not only by technical factors such as price and productivity, but also by local social norms and cultural values. In the Agrarian society of Magetan, agricultural decisions are often collective, following the views of farmer group leaders or the experiences of senior farmers. In addition, local values that prioritize harmony with nature make some farmers feel skeptical of technology that is considered "too sophisticated" or "unnatural". In some cases, farmers also attribute poor crop yields to spiritual errors due to the use of technology that is considered unfamiliar. The findings suggest that social and cultural factors play an important role in farmers' decision-making processes. In this regard, the sociotechnical approach becomes very relevant, since he views technology not as stand-alone, but part of a complex social system. Sociotechnical system theory emphasizes the interaction between the components of technology and the social structure of users (Trist, 1981). In Magetan, agricultural decisions are often collective and influenced by social actors such as farmer group leaders, community leaders, or even traditional beliefs. This is consistent with the normative idea of isomorphism from (DiMaggio & Powell, 1983), that in agrarian societies, individual decisions are often standardized due to social pressures and group norms. The strength of local cultural values, such as belief in the harmony of nature, also influences farmers' perceptions of bioengineering technology. In this case, the ecocentric values held by some farmers are the initial clash against the acceptance of technology that is considered to "intervene" the natural processes of plants.

3. The Role of Institutions and Extension Workers in Technology Distribution

The results of the study revealed that agricultural institutions and extension workers have an important, but not optimal, role in distributing understanding of biotechnology. Many agricultural extension workers do not specifically explain the difference between conventional seeds and bioengineered seeds. Some farmers state that information about the type of seed is limited to brands and the lure of high yields, with no clarity on the seed production process or the potential side effects. The reliance on private seed distributors also makes the information received highly commercial and biased.

Table 1. Findings on information sources and farmers' level of understanding

Resources	Number of Farmers (N=30)	Level of Comprehension	Note
Agricultural Extension Worker	9	Keep	Generally technical in nature without detailed explanations
Merchant / Distributor	12	Low–bias	Tendency to promote without critical education
Farmer Group	5	Vary	Influenced by group leaders
Social Media / Internet	4	Low–concussion	Lots of disinformation or hoaxes

The limited role of agricultural extension workers and formal institutions in explaining biotechnology shows that there is a communication gap between innovators and users. This reinforces the findings (Rogers, 2003b) about the importance of the role of change agents in accelerating the diffusion of innovation. An effective change agent not only conveys technology, but is also able to translate technology according to local language and values. Unfortunately, the distribution of information is still largely controlled by private distributors who emphasize the commercial aspect rather than the educational aspect. This creates information inequality and magnifies the potential for misinformation, as described in the concept of information asymmetry by (Akerlof, 1978). When farmers are unable to objectively assess the information conveyed, trust in technology decreases. The table of research results shows that the main sources of information for farmers are distributors and extension workers, but both have not conveyed knowledge with an in-depth and critical approach. This condition reinforces the importance of reformulating the role of government agencies and extension workers in order to be able to act as a reliable social bridge between technology and farmers.

4. Integration of Sociotechnical Approaches in Agricultural Innovation

The study suggests that sociotechnical approaches can help bridge the gap between technological innovation and traditional agricultural practices. In the focus group discussion (FGD), it was revealed that farmers will be more receptive to new technologies if they are given space to participate in the adoption process and there is the involvement of local figures as facilitators. When farmers are invited to discuss and be given contextual understanding—for example, with a comparative study between farmer groups—they tend to show interest and ownership in the technology. This proves that the success of the application of biotechnology is not solely about technological sophistication, but also the way it is delivered and received in the existing social system. The results of this study confirm that a sociotechnical approach can be an effective strategy in strengthening the adoption of agricultural technology. This approach departs from the assumption that technology cannot be imposed in a linear (top-down) manner, but needs to be incorporated into the existing social structure through a process of co-construction between innovators and users. When farmers are invited to discuss, be heard, and be involved in the process of introducing technology, resistance tends to decrease. This supports the concept of participatory technology development (PTD) introduced by (Chambers, 1997), which states that innovation will only be effective when developed in conjunction with the user community. Thus, the application of bioengineered products in the agricultural sector is not just a matter of technology transfer, but how it is contextualized into a living, moving, and meaningful

social system. In this regard, interventions based on a sociotechnical approach not only allow for wider acceptance, but also strengthen the sustainability and independence of farmers in the long term.

CONCLUSION

This study shows that the use of sociotechnical approaches in the application of agricultural biotechnology provides a more comprehensive understanding of the dynamics of technology acceptance by farmers in Magetan Regency. Farmers' knowledge and perception of bioengineered products still varies widely, influenced by their level of education, experience, and access to accurate information. Many farmers still do not fully understand that the products they use are genetically engineered, and their perceptions are shaped more by field experience and social opinion than by scientific understanding. Farmers' decisions in accepting or rejecting technology are not only based on technical aspects such as crop yields or crop resilience, but are also influenced by social, cultural, and local beliefs. In many cases, the views of farmer groups or traditional leaders play an important role in determining farmers' collective attitudes towards new technologies. This shows that the adoption of agricultural technology is greatly influenced by social networks and norms that apply in society. The role of institutions, especially agricultural extension workers, is still not optimal in providing critical and comprehensive education about biotechnology products. The information that farmers receive is often promotional and does not adequately answer fundamental questions related to the benefits and risks of technology. This information gap strengthens the resistance of some farmers to agricultural innovation. Using a sociotechnical approach, this study proves that the involvement of farmers in the innovation process in a participatory manner can increase trust and acceptance of technology. Agricultural technologies that are designed and disseminated with consideration of the social, cultural, and local contexts of farmers will be more likely to be accepted and implemented in a sustainable manner. Therefore, the integration between technical and social aspects is key in the development and dissemination of effective and equitable agricultural technology.

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