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Adoption Patterns of Paddle Wheel Technology in the Mina Taruna Fish Cultivation Group

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ABSTRACT

This study aims to examine the assessments, considerations, and adoption patterns of paddle wheel technology by the Mina Taruna Fish Farmers Group. The approach used is qualitative with data collection techniques through in-depth interviews, observation, and documentation. Data analysis was conducted using the interactive model of Miles and Huberman, which includes data reduction, data presentation, and conclusion drawing. The results show that members' assessments of paddle wheel technology covers aspects of relative advantage, suitability, complexity, ease of testing, and visibility of results. Members considered paddle wheel technology to be beneficial because it could increase stocking density, production yield, fish quality, and harvesting time efficiency, despite increased operational costs. Considerations for adoption were divided into four categories: accept permanently, accept temporarily, reject temporarily, and reject permanently. The decision to adopt is influenced by production benefits, market conditions, technical capabilities, and capital availability. Meanwhile, rejection is generally caused by limited facilities, pond conditions, and low business motivation. Overall, the results of the study show that the adoption of paddle wheel technology is determined by the interaction between perceived benefits, resource capabilities, and the socio-economic context of group members. These findings confirm that the successful implementation of technological innovations in fish farming is highly dependent on the compatibility between technical and social factors at the farmer level.

INTRODUCTION

Aquaculture or fish farming is defined as the production of aquatic organisms through controlled maintenance, breeding, and environmental management processes to increase productivity and business sustainability (Effendi, 2004; Direktorat Pembinaan SMK, 2013). Fish farming is an important sector in supporting food security and improving community welfare. Through the provision of high-quality animal protein sources, job creation, and strengthening of the local economy, this sector makes a significant contribution to sustainable development. The sustainability of fish farming is highly dependent on the ability of farmers to adopt technologies that are suitable for local conditions. Therefore, technological innovation in fish farming is key to improving the efficiency, productivity, and competitiveness of the fisheries sector (Karjuan, 2024).

One important innovation in intensive fish farming systems is the use of paddle wheel technology. This technology serves to increase the level of dissolved oxygen in the water, maintain water circulation, and stabilize the quality of the aquatic environment. Paddle wheels also help collect feed residues and waste to the center of the pond and maintain an even distribution of plankton, thereby increasing fish growth, feed efficiency, and the survival of farmed organisms. However, not all farmers immediately accept or apply this paddle wheel technology innovation in their business activities.

However, not all fish farmers directly accept and apply water wheel technology innovations in their business activities. This condition can be understood through the Diffusion of Innovations theory framework proposed by Rogers (2003) which states that the decision to adopt innovations is influenced by perceptions of relative advantage, compatibility, complexity, ease of trial, and ease of observing results. In the context of fish farming, water wheels have clear relative advantages and results that are easy to observe through pond conditions and increased yields. However, the adoption of this technology is not uniform because farmers' decisions are also influenced by perceptions of operational complexity, operational costs, business risks, and the suitability of the technology to pond conditions and individual farmer capacity. This shows that innovation adoption is not only determined by the technical characteristics of the technology, but also by economic, social, and psychological factors within the social system of the farming community.

Although Rogers (2003) and Soekartawi (1995) have outlined various factors that influence innovation adoption decisions, most previous studies still place adoption as a linear process and focus on individual characteristics and technological attributes. This approach does not fully capture the complexity of the adoption process that takes place in the context of a group of farmers, especially when the innovation has been implemented for a relatively long period of time. In addition, studies that reveal the phenomenon of dis adoption and variations in the sustainability of adoption among group members are still limited, especially in the aquaculture sector. Therefore, this study aims to fill this gap by analysing the patterns of water wheel technology adoption in KPI Mina Taruna through a qualitative approach, emphasising the role of group dynamics, the empirical experiences of fish farmers, and the institutional context in shaping technology adoption decisions.

The success of a technological innovation is determined not only by its technical aspects, but also by the social dynamics and decision-making within the farming community. The phenomenon of adoption variation also occurs in the Mina Taruna Fish Farmers Group (KPI) in Sleman Regency, which has been familiar with paddle wheel technology since 2016 through the Sleman Agriculture, Food, and Fisheries Agency's aquaculture technology development program. Some members have adopted this technology on an ongoing basis, while others are still hesitant or have not yet implemented it due to economic constraints, technical knowledge, or perceptions of the benefits of paddle wheel technology. The novelty of this study is about the dynamics of adoption of fisheries cultivation technology among group members. Therefore, this study is important to understand how group members assess the benefits of paddle wheel technology, the factors that influence their decisions, and the adoption patterns that have formed in KPI Mina Taruna.

RESEARCH METHODOLOGY

The research was conducted on the Mina Taruna Fish Farmers Group in Padukuhan Kembang, Wonokerto Village, Turi District, Sleman Regency. The research was conducted from November 2024 to June 2025. This research used a qualitative approach. According to Sugiyono (2013) qualitative research is a research method based on post-positivism philosophy used to study natural conditions where the researcher is the key instrument. The type of research used was case studies. According to Lincoln & Guba (1985) in Abdussamad (2021), a case study is an in-depth and detailed study of everything related to the research subject. The purpose of a case study is to gain a deep understanding of a case, or to gain an understanding that goes beyond a mere description of the phenomenon (Abdussamad, 2021). Informants in this study consisted of key informants, primary informants, and supporting informants selected using purposive sampling techniques. Key informants included the chairperson and administrators of KPI Mina Taruna who played strategic roles in decision-making and group management. Primary informants are members of the fish farming group who have direct experience in using water wheel technology, whether they still adopt it, have stopped using it, or do not adopt it. Meanwhile, supporting informants come from parties related to the group's activities, such as fisheries extension workers or other related parties who understand the development of water wheel technology

application in KPI Mina Taruna. The data collection techniques used in this study were observation, interviews, and documentation. Data validity was tested using source triangulation and time triangulation. According to Moelong (2014), triangulation is a technique for examining data validity that utilizes components other than the data itself to perform checks and comparisons with the data. The data analysis technique used in this study is the Miles and Huberman model. According to Miles & Huberman (1992), there are three stages that must be carried out in analyzing qualitative research data, namely: data reduction, data display, and conclusion drawing/verification.

RESULTS AND DISCUSSION

Group Members' Assessment of Paddle Wheel Technology

The adoption of paddle wheel technology in fish farming by members of the Mina Taruna Fish Farmers Group is influenced by a number of key characteristics that determine the speed of acceptance of this paddle wheel technology. According to Rogers (2003) the main characteristics in adoption include relative advantage, compatibility, complexity, trialability, and observability. The assessment of the Mina Taruna Fish Farmers Group members on paddle wheel technology is shown in Table 1.

Table 1. Assessment of Mina Taruna Fish Farmers Group Members on Paddle Wheel Technology.

No.	Characteristics	Description
1	Relative advantage	Increase in stocking density from 5–10 fish/m² to 40–50 fish/m², increase in production yield from 1–2 kg per meter to 8–10 kg, water wheels increase dissolved oxygen and remove toxic gases, fish size is more uniform, two harvests are sufficient; the second harvest is only 10–20% of the population, and operational costs increase (feed, electricity ±Rp300 thousand/cycle), profits depend on feed and fish prices (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)
2	Compatibility	Paddle wheel technology is needed to increase fish production, Compatibility with the group's objectives, which are to increase production and welfare, and Technically easy to implement because it does not require special expertise (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)
3	Complexity	Ease of operation and simple maintenance (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)
4	Triability	The trialability of paddle wheel technology at Mina Taruna is observational: it has not been internally tested, but confidence has grown through real evidence from official trials (Mina Arum) using a 200m2 pond area and the experience of pioneers (Mr. Suko) (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)
5	Observability	Fish grow larger faster, are healthier, move more actively, have better meat quality, are more uniform in size, pond water quality is odorless, circulation is better to support fish life, and fish are more resistant to disease (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)

Source: Data Processing Results (2025).

Based on Table 1, relative advantages include an increase in stocking density from 5–10 fish/m² to 40–50 fish/m², an increase in production yield from 1–2 kg per meter to 8–10 kg, water wheels adding dissolved oxygen and removing toxic gases, more uniform fish size, and sufficient harvest twice a year. the second harvest is only 10–20% of the population, but it increases operational costs (feed, electricity ±Rp300 thousand/cycle) and profits depend on feed and fish prices. This shows that the perception of relative profit is not only measured by production output, but also by the balance between costs and perceived economic benefits. This means that for members with limited capital, the benefits of technology are not yet fully felt as real profits. The compatibility of paddle wheel technology is needed to increase fish production, which is in line with the group's goal of increasing fish production and is technically easy to implement. Technically, the use of paddle wheels is considered to require no special expertise, making it easy for anyone to implement. This compatibility is not only seen from a technical perspective, but also in terms of social values and the collective goals of the group, which are oriented towards increasing crop yields. However, for some members who have not yet adopted it, compatibility is still questionable due to limited production facilities and capital capacity. This shows that the suitability of innovation in the context of the group is not only determined by technical suitability, but also by suitability with the socio-economic conditions of the farmers. The level of complexity of paddle wheel technology is considered easy to operate and maintain. This means that most members do not experience significant difficulties in using it. However, technical ease does not necessarily correspond to a willingness to adopt the technology, as the decision to use it is also influenced by considerations of electricity costs and business priorities. Thus, a simplistic view of paddle wheel technology does not automatically encourage all members to use it continuously. The trialability aspect of the Mina Taruna Group is indirect. Members do not conduct trials independently, but gain confidence through observing the results of trials in other groups (Mina Arum) and the experience of pioneers in the group, namely Mr. Suko. This pattern shows that the testing process in a social group context occurs through observational learning, not individual experimentation. This approach shows that trust in innovation grows from tangible evidence observed in the group's social network. The observability of results is an important factor that strengthens members' belief in the effectiveness of paddle wheel technology. Members can directly observe faster fish growth, uniform size, better meat quality, and cleaner water conditions. Visual evidence in the form of differences in pond conditions and harvest yields serves as a means of social learning among group members, whereby farmers acquire knowledge and confidence in the use of water wheels through the process of observing and comparing the practices of fellow members. This process is a form of social learning as described by Bandura (1977) in which individuals learn through observing the actual practices of others, and is in line with the concept of observability in Rogers' Diffusion of Innovations theory (2003), which emphasises the importance of easily observable innovation outcomes in encouraging adoption decisions.

The results of this study are in line with Juniarti (2015), who found that the suitability of innovation to individual needs influences the level of adoption. In the context of the Mina Taruna Group, the compatibility of windmill technology with the group's objectives and the farmers' experience were the main drivers of acceptance. The results of this study are also in line with Prabayanti (2010), who emphasized that trialability encourages farmers to adopt biopesticide innovations. However, unlike these findings, the Mina Taruna group did not conduct formal trials, but rather observational learning. This indicates that in the context of farmer groups, social mechanisms and trust among members play a greater role than individual technical trials.

Considerations of Members of the Mina Taruna Fish Farming Group Regarding Paddle Wheel Technology.

Based on an assessment of the five characteristics of innovation according to Rogers (2003), each member of the Mina Taruna Fish Farming Group formed personal considerations that ultimately determined their choice to adopt paddle wheel technology. Qualitative analysis of in-depth interview data, participatory observation, and field documentation shows that members' considerations can be grouped into four categories: (1) permanent acceptance, (2) temporary acceptance, (3) temporary rejection, and (4) permanent rejection (Table 2).

Based on Table 2, members of the Mina Taruna Group are considering permanent adoption because paddle wheel technology increases productivity linearly, from an average production of 6 kg/m²/year to an average production of 15 kg/m²/year, with faster harvests and healthier fish, resulting in high survival rates and improved fish meat quality. Members of the group who accept permanently have an adoption perspective based on empirical experience as the basis for their belief in benefits that can be seen and calculated economically. This decision to accept permanently arises when technical evidence (observability) is able to overcome cost concerns.

Members of the Mina Taruna Group are considering temporarily adopting paddle wheel technology due to sluggish market conditions and rising cultivation costs. The group recognizes the technical benefits, but implementation is conditional on external variables such as market prices and operational costs. Their decision is pragmatic: the technology is applied when profit margins are adequate and discontinued when economic risks increase. Qualitative interpretation shows that short-term cash flow calculations and aversion to financial risk are the main determinants of temporary adoption patterns.

Table 2. Considerations of Members of the Mina Taruna Fish Farmers Group Regarding Paddle wheel Technology.

No.	Category of consideration	Main Reason	Adoption Pattern
1	Permanent adoption	Increase in stocking density from 5–10 fish/m² to 40–50 fish/m², increase in production yield from 1–2 kg per meter to 8–10 kg, faster harvest, healthier fish resulting in high survival rates and improved fish meat quality. (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)	Members implement continuously
2	Temporary acceptance	Sluggish market conditions and increased aquaculture operational costs. (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)	Members have implemented it before but then stopped
3	Temporarily rejecting	Looking at the results of other farmers, concerns about operational costs, lack of technical understanding, and views on windmill technology must be balanced with certain criteria that are difficult for farmers to meet. (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)	Members initially rejected but later accepted Permanent rejection
4	Reject forever	Lack of interest, unsuitable pond conditions, limited capital, low focus on fish farming activities, and lack of motivation in fish farming. (Interview with the chairperson and members of the fish farmers' association that uses water wheels, KPI Mina Taruna (November 2024–June 2025)	Members who remained in rejection

Source: Data Processing Results, 2025

Table 3. Summary of Assessment, Considerations, and Adoption Patterns for Paddle Wheel Technology among the Mina Taruna Fish Farmers Group

No.	Aspect/Indicator	Research Results	Impact on the application of paddle wheel technology
1	Member assessment	Members assess the paddle wheel technology as useful, easy to use, suitable for cultivation practices, uncomplicated, easy to test, and with immediately observable results	Positive Influences the decision to adopt permanently
2	Considerations for Adoption	Reasons for acceptance: Linear increase in productivity from an average production of 6 kg/m²/year to an average production of 15 kg/m²/year, faster harvest, healthier fish resulting in high survival rates and improved fish meat quality. Reasons for accepting temporarily: Sluggish market conditions and increased operational costs of cultivation. Reasons for rejecting temporarily: Waiting to see the results of other cultivators, concerns about operational costs, lack of technical understanding, and the view that turbine technology must be used in ponds with certain criteria that are difficult for cultivators to meet. Reasons for rejection: Lack of interest, unsuitable pond conditions, limited capital, low focus on fish farming activities, and lack of motivation in fish farming.	Determining the adoption pattern category: accept permanently, accept temporarily, and/or reject temporarily and reject permanently
		The majority of members did not permanently adopt the technology; only some used paddle wheel technology (9 people).	Simplifying member classification for technology adoption analysis and success evaluation

Source: Data Processing Results, 2025

Members of the Mina Taruna Group are considering temporarily rejecting paddle wheel technology because they want to see the results of other farmers first, are concerned about operational costs, lack technical understanding, and believe that paddle wheel technology must be used in ponds that meet certain criteria that are difficult for farmers to fulfill. This temporary rejection stems from a cautious strategy. Members of the Mina Taruna Group are waiting for more extensive evidence from the experiences of other members and groups before adopting the technology. At this stage, members of the Mina Taruna Group are learning about paddle wheel technology by observing the success of other members, rather than through direct trials. Doubts about the costs involved and limited technical knowledge have led some members to choose to wait before adopting the technology.

Members of the Mina Taruna Group are considering permanently rejecting paddle wheel technology due to a lack of interest in fish farming, unsuitable pond conditions, limited capital, low focus on fish farming activities, and a lack of motivation in fish farming. Permanent rejection is related to structural and psychosocial

factors: physically unsupportive ponds, limited capital, low business motivation, or lack of interest in aquaculture. According to Soekartawi (2005), factors such as risk-taking, relationship patterns, attitudes toward change, and work motivation explain why some individuals do not include technology adoption in their economic agenda. According to Hapsari et al. (2015), technology adoption is influenced by education, cultivation experience, age, land area, interaction with field instructors, and utilization of information sources. Meanwhile, according to Yuliyanto et al. (2023), the factors that influence adoption patterns are farmer education, the presence of extension workers, and group dynamics. The assessment, considerations, and adoption patterns of paddle wheel technology among the Mina Taruna Fish Farmers Group are summarized in Table 3.

Table 3 shows that the assessment, consideration, and adoption patterns of paddle wheel technology among the Mina Taruna Fish Farmers Group indicate diversity in acceptance among members. In terms of assessment, members consider the paddle wheel technology to be useful, easy to use, suitable for farming practices, easy to test, and produce directly observable results. This positive assessment is in line with Rogers (2003) statement that an innovation tends to be more easily adopted if it has relative advantages, is suitable for the needs and experiences of users, can be tried on a small scale, and its results can be observed directly.

The findings show that although paddle wheel technology is perceived to have relative advantages in terms of increased fish production and quality, most members of KPI Mina Taruna have not permanently adopted it. This condition is in line with Rogers' Diffusion of Innovations theory (2003), which states that adoption decisions are not only determined by the relative advantages of innovation, but also by perceptions of complexity, risk, and the suitability of innovation to user conditions. In the context of KPI Mina Taruna, increased operational costs and market uncertainty reinforce the perception of risk, prompting some members to be cautious and opt for temporary adoption or even rejection. This shows that the innovation adoption process is dynamic and can change with experience and external conditions, as Rogers emphasises that innovation decisions are not always final. These findings are also in line with Soekartawi (1995), who emphasised that economic factors, attitudes towards risk, and business motivation are important determinants in innovation adoption decisions in the agriculture and fisheries sectors. Thus, the results of this study confirm that the sustainability of aquaculture technology adoption does not only depend on the technical superiority of the innovation, but is also influenced by economic stability, the technical capacity of farmers, and the social context of the group.

CONCLUSION

The results of the study show that: First, The Mina Taruna group assessed that paddle wheel technology provides tangible benefits in aquaculture activities. This technology has been proven to increase stocking density and production yields, produce more uniform fish sizes, accelerate growth, and enable two harvests, despite having an impact on increased operational costs. In addition, this technology is considered to be in line with the group's objectives and relatively easy to use and maintain. The positive effects of using water wheels can be observed directly, including better fish health, improved meat quality, and improved pond water circulation. Thus, paddle wheel technology is considered to have high potential for widespread adoption by group members. Second, the considerations of Mina Taruna Group members in adopting paddle wheel technology are influenced by production benefits, market conditions, technical capabilities, and resources. Members who see increased productivity and fish quality tend to accept the technology permanently, while concerns about costs, sluggish markets, technical limitations, and pond conditions trigger temporary acceptance or rejection. Permanent rejection is usually associated with disinterest, capital constraints, and low motivation in aquaculture. Overall, the adoption decision is influenced by a combination of the benefits of the technology, individual capabilities, and the socio-economic conditions of the members. Third, the pattern of paddle wheel technology adoption among members of the Mina Taruna Fish Farmers Group includes permanent adoption, temporary adoption, temporary rejection, and permanent rejection. The results of the

study suggest that There is a need to strengthen communication and interaction within the group so that the technology adoption process can proceed more evenly, Then Ongoing assistance from administrators and extension workers is needed to help members understand the benefits and how to use the technology, External support such as government policies, training, or assistance with facilities can be a driving factor in expanding technology adoption, Further research is needed to explore socio-economic aspects in greater depth, so that group dynamics can be linked to improvements in member welfare.

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