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Implementation of the Pump Irrigation Program in Improving Rice Crop Productivity at the Agricultural Extension Center of Barru District, Barru Regency

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ABSTRACT

This study aims to analyze the implementation of the pump irrigation program in improving rice crop productivity at the Agricultural Extension Center (Balai Penyuluhan Pertanian/BPP) of Barru District, Barru Regency. The pump irrigation program plays a strategic role in ensuring water availability for rice farming, particularly during dry seasons and periods of low rainfall. This research employs a qualitative descriptive approach, with data collected through in-depth interviews with key informants, including the Head of the Agricultural Extension Center, as well as field observations and document analysis. The data were systematically analyzed using NVivo software to identify key themes related to program implementation, institutional support, benefits, and challenges.The findings reveal that the Agricultural Extension Center of Barru District plays a crucial role not only in providing pump irrigation facilities but also in delivering technical assistance, training, and continuous supervision to farmers. The implementation of pump irrigation has significantly improved water accessibility, enabled more flexible planting schedules, increased cropping intensity, and enhanced rice productivity. However, several challenges persist, including unstable water discharge, limited technical skills among farmers, and unfavorable topographical conditions that hinder water distribution. To address these constraints, collaborative strategies such as water source assessment, technical training, and farmer group empowerment have been implemented. Overall, the study concludes that the pump irrigation program, supported by strong institutional involvement and farmer participation, contributes positively to local food security and farmer welfare. The findings highlight the importance of strengthening agricultural extension services as key agents of change in promoting sustainable and adaptive agricultural practices.

Keywords: pump irrigation, rice productivity, agricultural, qualitative analysis, NVivo

A. INTRODUCTION

Rice farming remains a fundamental pillar of food security and rural economic stability in Indonesia, as rice is the primary staple food for most of the population. The sustainability of rice production is therefore closely linked to national food resilience and farmer welfare. However, rice productivity is highly dependent on water availability and effective irrigation management, which are increasingly threatened by climate variability and environmental stress (Hussain & Hanjra, 2014). Prolonged dry seasons, irregular rainfall patterns, and declining water resources pose serious challenges to maintaining stable rice yields, particularly in rural areas (Rockström et al., 2017). These conditions require adaptive strategies that can ensure consistent water supply throughout the planting cycle. Efficient irrigation management is thus recognized as a key determinant of agricultural productivity and sustainability (Molden et al., 2010). Consequently, irrigation technology has become a strategic focus in agricultural development.

One technological solution widely promoted to address water scarcity in agriculture is pump irrigation. Pump irrigation enables farmers to access alternative water sources, such as rivers and groundwater, thereby reducing dependence on rainfall and conventional gravity-fed irrigation systems (Burney et al., 2013). This technology is particularly relevant in areas with uneven topography or limited irrigation infrastructure, where water distribution is often inefficient. Empirical studies indicate that pump irrigation can significantly increase cropping intensity and farm income when supported by appropriate management systems (Hussain & Hanjra, 2014). However, the effectiveness of pump irrigation is not solely determined by the availability of equipment. Institutional support, technical guidance, and farmer capacity are equally critical factors influencing successful implementation (Feder et al., 2010). Without these elements, irrigation technologies may fail to deliver sustainable productivity gains.

Agricultural extension institutions play a vital role in facilitating the adoption and effective use of irrigation technologies at the local level. Extension services function as intermediaries between government policies, technological innovations, and farmers' practical needs (Anderson

& Feder, 2007). Through training, technical assistance, and continuous supervision, extension institutions enhance farmers' capacity to adopt and manage new technologies (Swanson & Rajalahti, 2010). Effective extension systems have been shown to improve technology uptake, farm productivity, and rural livelihoods. In the context of pump irrigation, extension services are essential in ensuring that farmers understand both operational and maintenance aspects of the technology. Therefore, the performance of agricultural extension institutions significantly influences the sustainability of irrigation-based agricultural development.

In Indonesia, the Agricultural Extension Center (Balai Penyuluhan Pertanian/BPP) serves as a key institutional actor in rural agricultural development. The BPP is responsible for disseminating agricultural innovations, strengthening farmer capacity, and aligning national agricultural programs with local conditions. In Barru Regency, rice farming remains a dominant livelihood, yet farmers frequently face water shortages during the dry season due to limited irrigation infrastructure. These constraints have historically restricted planting schedules and rice productivity. The introduction of the pump irrigation program in this area aims to address such challenges by improving access to irrigation water. The Agricultural Extension Center of Barru District plays a central role in facilitating the implementation of this program and ensuring its alignment with farmers' needs.

Previous research emphasizes that irrigation technology alone is insufficient to guarantee productivity improvements without strong institutional arrangements. Uphoff (2015) argues that effective irrigation systems require farmer participation, local institutional capacity, and continuous learning processes. Similarly, Meinzen-Dick et al. (2014) highlight the importance of collective action and governance in managing shared water resources. In pump irrigation systems, farmers must possess not only technical skills but also organizational capacity to manage water distribution fairly and efficiently. Extension institutions are therefore expected to foster both technical competence and social coordination among farmers. This perspective underscores the importance of examining institutional roles in irrigation program implementation.

Climate change further intensifies the urgency of adopting adaptive irrigation strategies in rice farming systems. Increasing temperatures and unpredictable rainfall patterns have heightened water stress in many agricultural regions (Rockström et al., 2017). These climatic changes pose

serious risks to rice production, particularly in regions that rely heavily on rainfed agriculture. Pump irrigation offers a flexible adaptation mechanism by enabling farmers to secure water during critical growth stages. However, climate adaptation through irrigation technology requires coordinated efforts between institutions and farming communities (Molden et al., 2010). Agricultural extension services are therefore increasingly expected to function as agents of climate adaptation at the local level. Their role extends beyond technical assistance to include capacity building for climate-resilient farming practices.

Despite the growing importance of pump irrigation, many studies focus primarily on quantitative production outcomes and overlook the institutional and implementation dimensions. Feder et al. (2010) note that weak institutional support often undermines the long-term sustainability of agricultural technology adoption. Qualitative approaches are particularly useful for understanding how irrigation programs are implemented, managed, and experienced by local actors. By exploring institutional roles, farmer perceptions, and implementation challenges, qualitative research provides deeper insights into program effectiveness. Such approaches also allow researchers to capture contextual factors that influence technology adoption. Therefore, a qualitative analysis of pump irrigation implementation is necessary to complement existing quantitative studies.

Based on these considerations, this study aims to analyze the implementation of the pump irrigation program in improving rice crop productivity at the Agricultural Extension Center of Barru District, Barru Regency. The study focuses on the role of the extension institution, the benefits of pump irrigation for farmers, and the challenges encountered during implementation. By examining these aspects, the research contributes to the literature on agricultural extension, irrigation governance, and rural development (Anderson & Feder, 2007; Swanson & Rajalahti, 2010). The findings are expected to provide practical insights for policymakers and extension practitioners in designing more effective and sustainable irrigation programs. Ultimately, strengthening institutional support for pump irrigation can enhance food security and farmer resilience in the face of climate and water scarcity challenges.

B.RESEARCH METHODOLOGY

This study adopts a qualitative descriptive research design to examine the implementation of the pump irrigation program in improving rice crop productivity at the Agricultural Extension Center of Barru District, Barru Regency. A qualitative approach is appropriate because it allows for an in-depth exploration of institutional roles, implementation processes, and contextual challenges that cannot be adequately captured through quantitative methods. Qualitative research emphasizes understanding social phenomena from the perspectives of participants and the specific settings in which programs are implemented (Creswell & Poth, 2018). Through this approach, the study seeks to capture how pump irrigation technology is facilitated, managed, and adapted at the local level to support rice farming activities.

The research was conducted at the Agricultural Extension Center of Barru District, selected purposively due to its strategic role in coordinating and supporting the pump irrigation program in a major rice-producing area. Data were collected through in-depth interviews with key informants, including the Head of the Agricultural Extension Center and agricultural extension officers, supported by field observations and document analysis. Purposive sampling was used to ensure that informants possessed relevant knowledge and experience related to the program. The combination of multiple data sources enables a comprehensive understanding of the implementation process and strengthens data credibility through triangulation (Miles et al., 2014).

Qualitative data analysis was carried out using NVivo software to support systematic coding and thematic analysis. The analysis process involved data transcription, open coding, categorization, and theme development to identify patterns related to program implementation, benefits, and challenges. NVivo facilitated data organization and enhanced analytical transparency by allowing researchers to trace themes back to original data sources. This analytical approach improves rigor and consistency in qualitative research and supports the development of well-grounded interpretations (Miles et al., 2014).

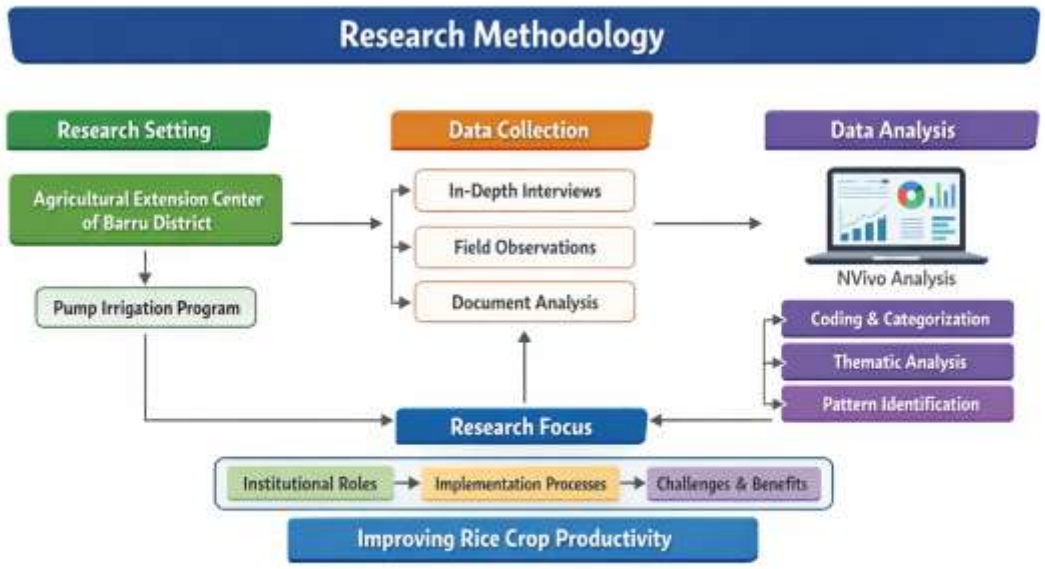

Figure 1 Framework diagram

C. RESEARCH RESULTS AND DISCUSSION

- Research Results

The research findings indicate that the implementation of the pump irrigation program in the working area of the Agricultural Extension Center (BPP) of Barru District is perceived as a strategic solution to overcome irrigation water limitations, particularly during the dry season. Based on data coding results using NVivo, the main themes that emerged were *water availability*, *productivity improvement*, and *institutional role*. Informants explained that prior to the implementation of pump irrigation, rice planting patterns were highly dependent on rainfall, which often resulted in delayed planting schedules. The introduction of water pumps has enabled farmers to obtain a more stable water supply. This condition has had a direct impact on the continuity of rice cultivation activities. Thus, pump irrigation serves as an important supporting factor in maintaining planting cycles.

The second dominant theme identified in the analysis is the role of the Agricultural Extension Center in supporting the success of the pump irrigation program. Agricultural extension officers actively provide technical assistance related to the operation, maintenance, and management of water pumps. NVivo analysis shows a high frequency of references to the nodes *extension assistance* and *technical guidance*. Farmers reported increased confidence in operating pump irrigation technology due to direct support from extension officers. In addition, extension agents function as intermediaries between farmers and local government institutions. This finding indicates that program success is determined not only by technological availability but also by the strength of supporting institutions.

The findings also reveal that the implementation of pump irrigation contributes to an increase in rice cropping intensity. Prior to the program, many farmers were only able to cultivate rice once per year. After the introduction of pump irrigation, farmers were able to increase cropping intensity to two or even three planting seasons annually. The theme *increased cropping intensity* consistently emerged in the NVivo coding results. Improved water availability allows farmers to adjust planting schedules without waiting for the rainy season. This development has led to an increase in total rice production in the study area. Consequently, pump irrigation plays a significant role in optimizing agricultural land use.

In addition to increased cropping intensity, the research findings indicate an improvement in rice productivity per hectare. Farmers reported that rice plants grew more optimally due to the adequate and evenly distributed water supply. NVivo grouped these statements under the themes *crop growth quality* and *production stability*. Sufficient water availability reduced the risk of crop failure caused by drought. Rice plants appeared healthier and more uniform in growth. These conditions resulted in improvements in both the quantity and quality of rice yields.

Nevertheless, the study also identified several challenges in the implementation of the pump irrigation program. One of the main constraints is operational costs, particularly related to fuel consumption and pump maintenance. The theme *operational constraints* appeared prominently in the NVivo analysis. Some farmers stated that without subsidies or collective management mechanisms, operational costs could become a financial burden. Furthermore, pump

damage that is not promptly addressed can disrupt water distribution. These challenges highlight the need for a more sustainable management system.

Another challenge identified relates to farmers' institutional capacity in managing pump irrigation collectively. NVivo categorized this issue under the themes *farmer group coordination* and *water distribution*. In some locations, differences in interests among farmers regarding pump usage schedules still occur. The absence of formal agreements increases the potential for conflict in water distribution. This finding suggests that strengthening farmer group institutions is essential for program sustainability. Without proper management, the effectiveness of pump irrigation may decline over time.

The findings further indicate that farmers' levels of understanding of pump irrigation technology vary considerably. Some farmers are already capable of operating and maintaining pumps independently, while others remain highly dependent on extension officers. The theme *farmer capacity* emerged as a significant finding in the NVivo analysis. Differences in education levels and farming experience influence the speed of technology adoption. Therefore, continuous training is a critical necessity. This reinforces the importance of agricultural extension services in facilitating technology transfer in the agricultural sector.

From a socio economic perspective, the results show that pump irrigation has contributed to increased farmer income. With higher cropping frequency and improved production levels, farmers' incomes have become more stable. NVivo identified the theme *farmer welfare* as a secondary impact of the program. Farmers reported that additional income could be used to meet household needs and to finance subsequent farming activities. This impact demonstrates that pump irrigation affects not only technical agricultural aspects but also farmers' socio-economic well being.

Overall, the findings indicate that the implementation of pump irrigation at the Agricultural Extension Center of Barru District has been relatively effective in improving rice crop productivity. Program success is influenced by the availability of technology, the active role of extension services, and institutional support among farmers. However, challenges related to operational costs, collective management, and farmer capacity remain significant concerns.

NVivo-based analysis provides a deeper understanding of the dynamics of program implementation. These findings serve as an important foundation for policy formulation and the strengthening of pump irrigation programs in the future.

- NVivo Data Analysis

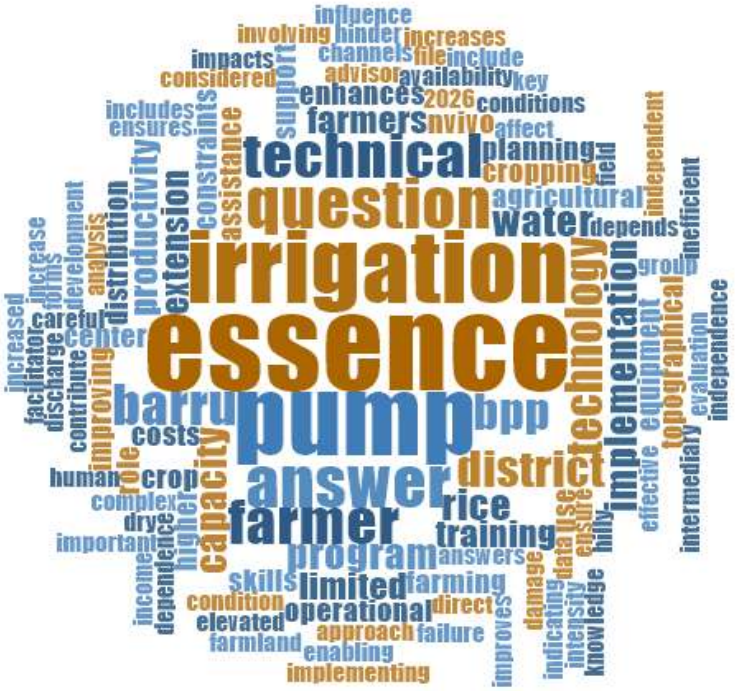

Figure 2 Word Cloud Visualization of Qualitative Data Using NVivo

The NVivo-based word cloud analysis of the image shows that keywords such as irrigation, pump, essence, technical, and implementation appear most frequently. This indicates that the primary focus of the qualitative data is on the implementation of pumping technology as a technical solution in rice irrigation systems. The dominance of these terms reflects a strong focus on the technical aspects of water supply, pump operational mechanisms, and the role of institutions in supporting irrigation sustainability at the local level, particularly in Barru District.

Furthermore, the emergence of terms such as farmer, productivity, training, capacity, and district demonstrates the close relationship between the implementation of pumping technology and increasing farmer capacity and agricultural productivity. This analysis confirms that the success of the program is determined not only by the availability of technology but also by the

support of mentoring, training, and human resource capabilities of farmers. Therefore, the results of this word cloud analysis reinforce the finding that pumping is a strategic intervention, both technical and social, in increasing the resilience and efficiency of rice farming systems.

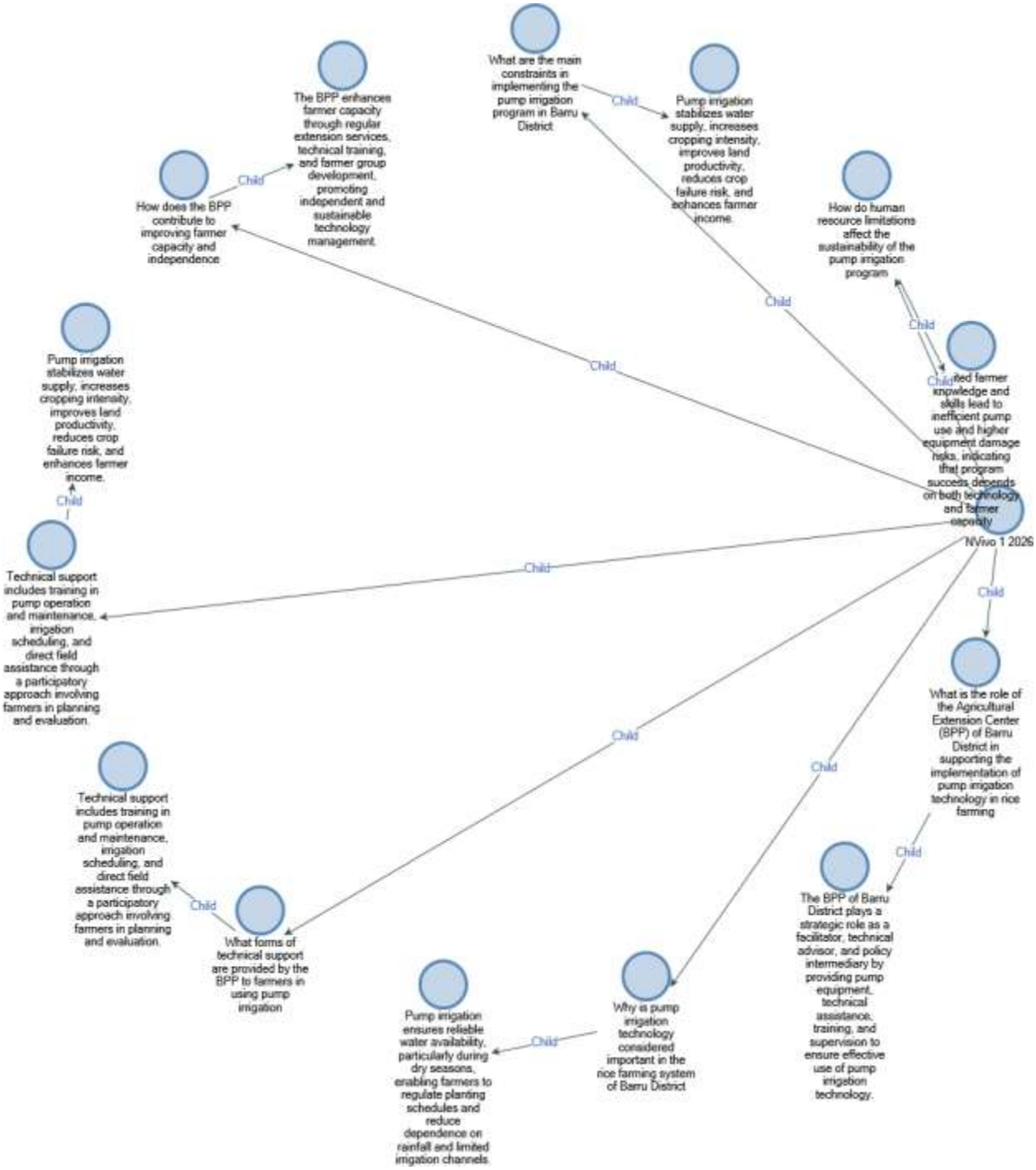

Figure 3 Thematic Relationship Map Analysis

This analysis was used to visualize the relationships between the main themes, subthemes (child nodes), and research questions based on the results of qualitative data coding. This systematically demonstrates the interrelationships between the role of the Agricultural Extension Agency (BPP), the implementation of pumping, the impact on productivity, and the constraints and capacities of farmers. The figure displays the results of an NVivo-based thematic model analysis that maps the relationships between the research questions, institutional roles, technical support, and the impact of pumping technology implementation in the rice farming system in Barru District. This model demonstrates that the Barru Agricultural Extension Agency (BPP) occupies a central position as a key actor connecting government policies with agricultural practices at the farmer level. Each node represents a main theme and subtheme emerging from the data coding process, while connecting lines indicate conceptual links between themes.

Furthermore, the figure illustrates that the implementation of pumping has a direct impact on the stability of water availability, increased cropping intensity, and agricultural land productivity. The subtheme related to the benefits of pumping indicates that this technology enables farmers to schedule planting more accurately, reduce dependence on rainfall, and reduce the risk of crop failure. The interrelationships between these themes also demonstrate that the success of pumping programs is determined not only by the availability of technology, but also by technical support in the form of training, field mentoring, and participatory irrigation management by the BPP.

In addition to the benefits aspect, this model also highlights various obstacles that impact the sustainability of the pumping program, such as limited human resources among farmers, uneven technical skills, and regional topographic challenges. The relationship between these obstacles and the role of the BPP demonstrates that increasing farmer capacity is a crucial factor in maintaining the effectiveness of irrigation pump use. Thus, this figure emphasizes that the success of the pumping program is the result of the interaction between technology, farmer capacity, and the institutional role of the BPP in supporting sustainable rice farming.

- Discussion

The discussion of the research findings indicates that the Agricultural Extension Center (Balai Penyuluhan Pertanian/BPP) of Barru District plays a highly strategic role in supporting the implementation of pump irrigation technology in rice farming. The BPP functions not only as an executor of government programs but also as a facilitator and intermediary that bridges public policy with farmers' practical needs at the field level. Through the provision of pump equipment, continuous technical assistance, and regular extension activities, the BPP encourages farmers to adopt irrigation technology more effectively. This finding is consistent with Anderson and Feder (2007), who emphasize that agricultural extension institutions are crucial in promoting technology adoption through knowledge transfer and capacity building among farmers.

The implementation of pump irrigation has been shown to contribute significantly to increased productivity and greater stability in rice farming activities in Barru District. Improved water availability enables farmers to cultivate rice more than once a year and reduces their dependence on rainfall. This condition leads to higher cropping intensity, more efficient land use, and a lower risk of crop failure. These findings support the work of Hussain and Hanjra (2014), who argue that pump-based irrigation systems can enhance agricultural output and farmer income when supported by effective management and strong institutional frameworks.

Nevertheless, the findings also reveal that the success of pump irrigation is not determined solely by the availability of technology. Limitations in farmers' human resources, particularly in terms of operational and maintenance skills, remain a major challenge. Insufficient technical knowledge can result in inefficient pump usage and increase the risk of equipment damage. This result reinforces the argument of Feder et al. (2010) that agricultural technology adoption is often constrained by low user capacity, highlighting the need for continuous training and capacity development alongside technological interventions.

In addition to human resource constraints, local topographical conditions also influence the effectiveness of pump irrigation implementation. Agricultural land located at higher elevations than water sources requires higher-capacity pumps and more complex distribution systems, which increases operational costs for farmers. These challenges demand more careful technical planning

and the selection of irrigation technology that is appropriate to local conditions. In this context, the role of the BPP becomes increasingly important in providing technical recommendations and assisting farmers in adapting technology to their specific environmental settings to ensure long-term sustainability.

Overall, the discussion confirms that the success of the pump irrigation program in Barru District is the result of a synergy between irrigation technology, farmer capacity, and institutional support from the BPP. A participatory approach that involves farmers from the planning stage through to implementation and evaluation has proven effective in fostering ownership and program sustainability. Therefore, strengthening agricultural extension institutions, enhancing farmers' technical competencies, and aligning irrigation technology with local environmental conditions are key strategies for achieving productive and sustainable rice farming systems.

D.CONCLUSION AND RECOMMENDATIONS

- Conclusion

This study concludes that the Agricultural Extension Center (Balai Penyuluhan Pertanian/BPP) of Barru District plays a crucial and strategic role in supporting the successful implementation of pump irrigation technology in rice farming. The BPP functions as a facilitator, technical advisor, and intermediary between government policies and farmers' practical needs by providing irrigation equipment, technical assistance, training, and continuous supervision. The implementation of pump irrigation has contributed positively to improving water availability, increasing cropping intensity, enhancing land productivity, and reducing the risk of crop failure, particularly during the dry season. However, the effectiveness and sustainability of the program are not determined solely by the availability of technology, but also by farmers' technical capacity and local environmental conditions, including topography and water source availability. The findings highlight that strong institutional support, farmer capacity building, and context-appropriate technology are key factors in achieving sustainable and productive rice farming

- Recommendations

Based on the findings of this study, several recommendations are proposed. First, the BPP should strengthen continuous and practical training programs to improve farmers' skills in operating, maintaining, and managing pump irrigation systems independently. Second, future pump irrigation programs should be preceded by comprehensive technical assessments, including water source capacity and topographical mapping, to ensure the suitability of pump types and irrigation systems. Third, local governments are encouraged to support the development of complementary irrigation infrastructure and explore alternative technologies, such as solar-powered pumps, to reduce operational costs and enhance sustainability. Finally, a participatory and collaborative approach involving farmers, extension officers, and local authorities should be maintained and expanded to ensure long-term program effectiveness, farmer empowerment, and regional food security.

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