

DEVELOPMENT OF IRRIGATION NETWORK INFRASTRUCTURE IN SIRAPIT DISTRICT FOR FOOD SECURITY IN LANGKAT REGENCY

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Abstract

This study aims to examine the influence of irrigation network infrastructure development on food security in Sirapit District, Langkat Regency. Through a qualitative approach, this study explores the role of irrigation in supporting agricultural productivity and the stability of local food supply. The results of the study indicate that the existence of a good irrigation network significantly increases cropping intensity and production efficiency, and reduces the risk of crop failure. However, the effectiveness of the irrigation system still faces various obstacles such as physical damage, weak community participation, and lack of water management technology. Therefore, collaboration between the government and the community and technological innovation are important strategies in realizing food security based on sustainable irrigation management.

Keywords: *Irrigation, Food Security, Agricultural Infrastructure, Sirapit District, Water Management, Community Participation*

INTRODUCTION

Food security is an important issue in regional development, especially in supporting the sustainability of sufficient and even food supply for the community.(Sugiarto, Yamin s, et al., 2024). Langkat Regency, located in North Sumatra Province, has great potential in the agricultural sector, especially in terms of food production such as rice, corn, and soybeans. However, food security in this area faces various challenges, one of which is limited access to efficient irrigation infrastructure. Sirapit District, as one of the districts with quite large agricultural potential, often experiences problems related to uneven water management and distribution, especially during the dry season. Dependence on inadequate irrigation systems hampers agricultural productivity and threatens the area's food security. This is exacerbated by natural factors such as increasingly unpredictable climate change, causing significant fluctuations in water availability for agricultural needs.

The development of efficient irrigation network infrastructure in Sirapit District is expected to be a strategic solution to increase the availability of water evenly for farmers. With a good irrigation network, water distribution to agricultural fields can be more controlled, improve planting patterns, and increase food production. Along with the increase in agricultural production, food security in Langkat Regency will also be increasingly guaranteed. However, despite the importance of developing irrigation infrastructure, various obstacles such as budget constraints, technical problems in the construction of irrigation networks, and challenges in coordination between the government and the community, are still obstacles that need to be considered. Therefore, it is important to examine in more depth how the development of irrigation network infrastructure in Sirapit District can affect food security in Langkat Regency, as well as what solutions can be implemented to overcome these obstacles.

In recent years, the community in Sirapit District, Langkat Regency, has faced quite complex dynamics in the agricultural sector, especially related to the productivity of agricultural land which tends to fluctuate. One of the main causes is the suboptimal irrigation network infrastructure available. Many farmers in this area still rely on traditional irrigation systems or even rain-fed irrigation, which makes planting patterns uncertain and harvest results less than optimal. In the dry season, most agricultural land experiences drought because it does not get an adequate water supply. Conversely, in the rainy season, the lack of a good drainage system often causes land to be flooded and damages crops. This irregularity in water supply causes uncertainty in agricultural production, which in turn has an

impact on food availability at the local level. In addition, some existing irrigation infrastructure is damaged and does not receive routine maintenance. Clogged irrigation channels, leaking small dams, and uneven water distribution are common complaints from farmers. As a result, the agricultural potential that is actually quite large in Sirapit District cannot be utilized optimally. This phenomenon is even more worrying when associated with the issue of regional food security. The decline in agricultural productivity due to limited irrigation risks reducing the level of local food availability, increasing dependence on supplies from outside the region, and ultimately can trigger price instability and a decline in farmer welfare. Therefore, this problematic phenomenon emphasizes the importance of systematic and sustainable efforts in developing irrigation network infrastructure as a key strategy to support food security in Langkat Regency, especially in Sirapit District. Research on the development of irrigation network infrastructure in Sirapit District is very urgent considering the strategic role of irrigation in supporting the agricultural sector which is the backbone of food security in Langkat Regency. In the context of an agrarian area like Sirapit, the availability of regular and even water is not only a technical need, but also a foundation for the economic sustainability of farming communities and social stability in the region. Inequality in water distribution, damage to irrigation networks, and minimal water management planning have had a direct impact on agricultural productivity. If this condition is left without a concrete solution, local food security has the potential to be significantly disrupted. This is certainly contrary to the agenda of sustainable development and national resilience which makes the agricultural sector one of the main pillars.

Another urgency of this research lies in the importance of data and empirical studies that can be the basis for making targeted policies. So far, many irrigation development programs have been top-down and have not considered the social, geographical conditions, and real needs of farmers in the field. With research that focuses on the local context of Sirapit District, it is hoped that specific problem patterns and alternative solutions that are applicable and sustainable can be found. Furthermore, this research can provide an important contribution in strengthening the synergy between local governments, technical agencies, and farming communities in an effort to realize a resilient and efficient irrigation system. Therefore, this research is not only academically relevant, but also very important in practice in responding to real challenges in the field, while supporting the achievement of equitable and just food security in Langkat Regency. (Hidayat *et al.*, 2023).

Various previous studies have discussed the importance of irrigation infrastructure in supporting the agricultural sector and food security. For example, research by Raharjo (2020) highlighted the effect of irrigation network rehabilitation on increasing rice crop productivity in Sleman Regency. The study showed that improving the irrigation system can increase yields by up to 20% in one planting season. Another study by Fitriani and Nugroho (2019) in West Java Province also emphasized that the development of irrigation infrastructure must be accompanied by the active participation of farmers so that water management is more effective and sustainable. However, most of the existing research still focuses on areas with relatively advanced agricultural infrastructure or in areas with strong central government program support. In addition, the approaches used are generally quantitative and emphasize the relationship between technical aspects of irrigation and increased yields, without exploring much of the social, geographical, and local dynamics that influence the effectiveness of the infrastructure.

In this context, the research gap that this study aims to fill is the lack of studies that specifically examine the development of irrigation network infrastructure in rural areas with geographical characteristics and social challenges such as in Sirapit District, Langkat Regency. This area has great agricultural potential, but until now it has not been widely used as a study location on the relationship between irrigation development and food security. In addition, this research approach prioritizes contextual analysis by considering the socio-economic conditions of farmers, the form of community participation in irrigation development, and local obstacles that are often ignored in technical policies. Thus, this study offers a new, more holistic and grounded perspective on the issue of food security through the development of irrigation infrastructure in peripheral areas.

Identification of problems

Based on the phenomena and urgency that have been explained previously, several main problems can be identified as follows:

1. The irrigation network infrastructure in Sirapit District is not yet adequate to support agricultural needs optimally.
2. There is an imbalance in the distribution of irrigation water between agricultural areas, especially during the dry season and extreme rainy season.
3. Maintenance and management of irrigation channels is less than optimal, which causes a decrease in the function and efficiency of the irrigation system.

4. Local food security in Langkat Regency has the potential to be disrupted due to unstable agricultural productivity.
5. Lack of community participation and synergy between stakeholders in the development and maintenance of irrigation networks.
6. There is a lack of local studies that examine the relationship between irrigation infrastructure and food security in rural areas such as Sirapit District.

Formulation of the problem

Based on the identification of the problem, the formulation of the problem in this study is as follows:

1. What is the current condition of the irrigation network infrastructure in Sirapit District?
2. What are the factors that hinder the optimization of irrigation network functions in supporting agricultural productivity?
3. How does the development of irrigation network infrastructure affect food security in Langkat Regency?
4. What is the role of the community and government in the management and development of irrigation networks in Sirapit District?
5. What strategies can be implemented to increase the effectiveness of irrigation development in supporting food security?

LITERATURE REVIEW

2.1 Development of Irrigation Network Infrastructure

The development of irrigation network infrastructure is an important component in supporting the productivity of the agricultural sector. According to Nurhadi and Rahman (2020), good irrigation will increase the efficiency of water use and ensure water availability throughout the planting season. This is very vital considering the uncertain fluctuations in rainfall due to global climate change. Irrigation not only affects the quantity of agricultural production, but also the quality of the harvest. Yuliana (2020) emphasized that investment in modern irrigation infrastructure such as drip irrigation systems, sprinkler irrigation, and rehabilitation of traditional irrigation channels can increase the cropping index and farmer income. Meanwhile, according to the Agricultural Research and Development Agency (2020), the success of developing irrigation networks is highly dependent on participatory planning involving farmers and local stakeholders, as well as regular maintenance of the infrastructure.

2.2 Irrigation and Food Security

Food security is a condition where household food needs are met, as reflected in the availability of sufficient, safe, nutritious, and affordable food (BKP, 2020). Irrigation plays a direct role in maintaining food availability because it supports a sustainable agricultural production system. According to Prasetyo and Lestari (2020), areas with good irrigation systems have higher and more stable land productivity compared to rainfed areas. In areas such as Sirapit District, which are largely dependent on the agricultural sector, adequate irrigation networks can be key to creating food security at the local and district levels. Faisal et al. (2020) added that improving irrigation not only has an impact on food security, but also on the social and economic aspects of rural communities, such as reducing urbanization and increasing farmer welfare.

2.3 Challenges and Strategies for Irrigation Development in the Regions

The development of irrigation networks in rural areas faces challenges such as budget constraints, channel damage, and minimal coordination between institutions. Rahayu and Subekti (2020) suggest implementing a collaborative approach between local governments, farming communities, and the private sector in the development and maintenance of irrigation networks. In addition, the use of digital technology for monitoring and managing irrigation has also begun to be implemented. According to Surya and Arifin (2020), the use of the Internet of Things (IoT) in irrigation systems has been shown to increase the efficiency of water use and reduce water loss during distribution.

2.4 Framework of Thought

Agriculture is an important sector in supporting food security in a region. In areas such as Sirapit District, where the majority of the population depends on the agricultural sector, water availability is a major factor in the success of food production. One strategic effort to ensure water availability is through the development of irrigation network infrastructure. Well-planned and managed irrigation network infrastructure can increase the efficiency of agricultural irrigation, extend the planting season, and increase harvest yields. Thus, irrigation development has a

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direct impact on productivity and stability of food supply, which will ultimately strengthen food security in Langkat Regency. However, this development is also faced with various challenges such as infrastructure damage, budget constraints, and lack of community participation. Therefore, collaborative and innovative strategies are needed in irrigation management so that food security goals can be achieved sustainably. In other words, there is a close relationship between irrigation infrastructure development and food security through increasing land productivity, water distribution efficiency, and the sustainability of local agricultural systems.(Rahmadhani et al., 2023).

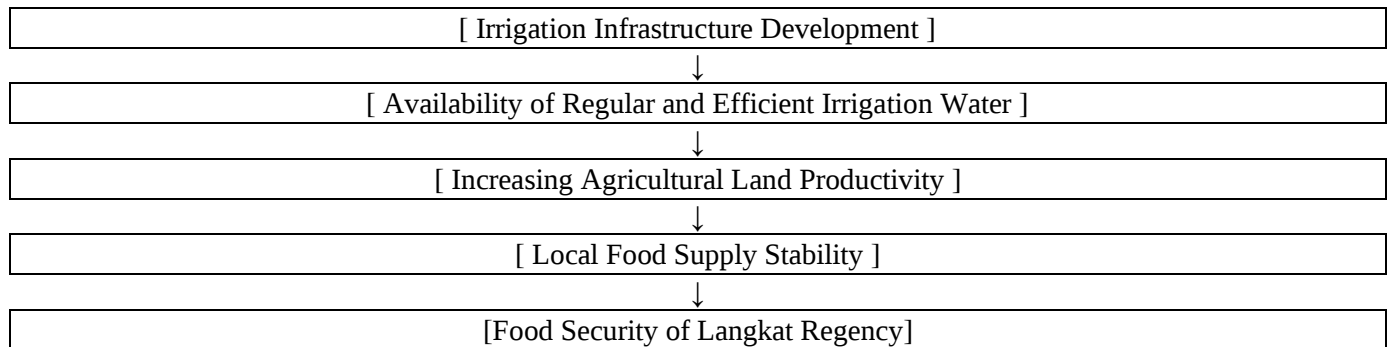


Figure 2.1 Framework of Thought

Supporting Factors:

- 1) Modern irrigation technology
- 2) Participation of farmers and communities
- 3) Government policies and support

Inhibiting Factors:

- 1) Damage to irrigation channels
- 2) Lack of budget and maintenance
- 3) Lack of coordination between agencies

RESEARCH METHODS

3.1 Research Approaches and Types

This study uses a descriptive qualitative approach, which aims to describe in depth the phenomena that occur in the field regarding the development of irrigation networks and their impact on food security. According to Moleong (2020), a qualitative approach is used to understand the meaning behind human actions and interactions in their natural social context. This type of research is a case study. Yin (2020) explains that case studies allow researchers to explore problems in depth in a real-world context, which is very appropriate for the topic of irrigation development in certain areas such as Sirapit District.

3.2 Research Location and Subjects

The research location was determined in Sirapit District, Langkat Regency, because this area is an agricultural area that depends on the irrigation system in its agricultural activities. The research subjects included farmers, village officials, irrigation managers, and officials from related agencies such as the Agriculture Service and PUTR Service.

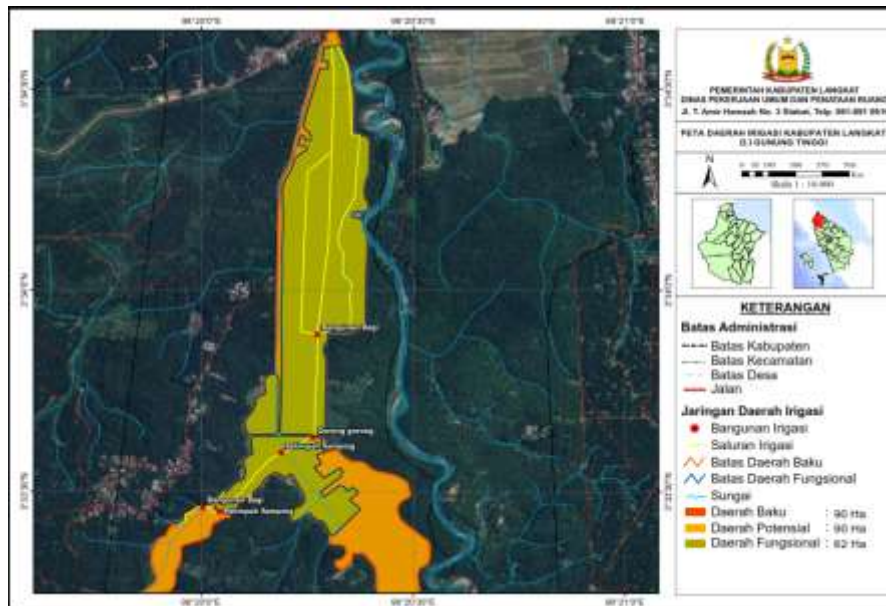


Figure 3.1. Geospatial Map of Irrigation Areas

3.3 Data Collection Techniques

Data collection techniques are carried out through:

1. In-depth interviews – According to Creswell (2020), interviews in qualitative research allow researchers to gain direct understanding of the subjects' experiences and perceptions of the issues being studied.
2. Participatory observation – Researchers are directly involved in the field to observe the condition of irrigation infrastructure and farmer activities, as suggested by Sugiyono (2020) in a qualitative observation approach.
3. Documentation – Used to complete data from planning documents, irrigation development reports, and food security policies from local governments.

3.4 Data Analysis Techniques

The data was analyzed using thematic analysis techniques, which is the process of identifying important patterns or themes from the data that has been collected. (Akus Harmoko et al., 2024). Braun and Clarke (2020) explain that thematic analysis is very suitable for understanding the deep meanings of respondents' narratives and experiences. The data analysis process is carried out through several stages, namely: (1) transcription of interview data, (2) data coding, (3) categorization of themes, (4) interpretation of meaning, and (5) preparation of a narrative of the findings. (Sugiarto, Kamakaula, et al., 2024).

3.5 Validity of Data

To ensure the validity of the data, source and method triangulation techniques are used. According to Patton (2020), triangulation is a way to confirm and validate findings by comparing data from various sources and techniques. Validity is also strengthened by confirming the results with informants (member checking).

RESULTS AND DISCUSSION

4.1 What is the current condition of the irrigation network infrastructure in Sirapit District?

The current condition of the irrigation network infrastructure in Sirapit District can be said to be far from optimal. Although this area is known as one of the areas with quite large agricultural potential in Langkat Regency, the main supporting system in the form of an irrigation network has not been fully able to meet the water needs evenly and sustainably for existing agricultural lands. Many irrigation channels in Sirapit District are simple, non-permanent, and have not been systematically integrated. Some channels are even still in the form of earth ditches that are easily damaged by erosion or covered by mud deposits and wild vegetation. In addition, permanent irrigation networks often experience structural damage, such as channel leaks, collapsed irrigation walls, and blocked water distribution lines due to lack of regular maintenance.



Figure 4.1. Structural Damage to Channels

Dependence on rainwater is also still high, especially in areas that are not reached by main irrigation channels. This causes agricultural productivity to be very vulnerable to weather changes, especially in the dry season when the water discharge from irrigation sources is greatly reduced. On the other hand, in the rainy season, irregular irrigation systems cause some land to experience excess water to the point of being flooded, which has an impact on plant damage. In terms of management, irrigation infrastructure in Sirapit is not yet supported by an effective management system. The involvement of farmer groups in regulating water distribution is still limited, and coordination between farmers and local governments or technical services has not been optimal. This results in the absence of structured supervision and maintenance, thus worsening the existing irrigation conditions. The irrigation network infrastructure in Sirapit District, Langkat Regency, has a primary focus on developing irrigation for rice fields. Currently, Langkat Regency has 6,000 hectares of rain-fed rice fields, while irrigation is only available for 4,000 hectares. The Wampu Dam, which has the potential to irrigate 10,000 hectares, does not yet have primary, secondary, and tertiary irrigation networks. Overall, the condition of irrigation infrastructure in Sirapit District currently requires serious attention, both in terms of technical planning, physical development, and aspects of management and community participation. Without comprehensive improvements, the agricultural potential in this area will continue to be hampered, and food security in Langkat Regency is at risk of being disrupted.

4.2 What are the factors that hinder the optimization of irrigation network functions in supporting agricultural productivity?

Irrigation is one of the crucial elements in the agricultural system, especially in areas that are highly dependent on artificial water to support plant growth. However, in practice, many obstacles cause irrigation networks to not function optimally. These obstacles are technical, managerial, and socio-economic.

1. Physical Damage to Infrastructure

One of the main obstacles is the damage to irrigation channels, both primary and secondary, caused by old construction age, natural disasters, and lack of regular maintenance. Damaged irrigation channels cause uneven distribution of water, even not reaching the agricultural land that needs it. This has a direct impact on decreasing productivity because plants lack water at critical growth phases.



Figure 4.2. Damage to the Primary Channel Causing Reduced Water Distribution

2. Lack of maintenance budget

According to various studies, such as those presented by Rahayu and Subekti (2020), many irrigation networks are built without being accompanied by a long-term maintenance budget. Local governments often focus on initial physical development, but do not allocate sufficient funds for regular operations and maintenance. As a result, irrigation infrastructure quickly deteriorates and loses its function.

3. Lack of Farmer Participation

Optimizing irrigation also depends heavily on the involvement of farming communities. In many places, irrigation systems have not been managed in a participatory manner. Farmers are not involved in planning, monitoring, or maintaining irrigation networks. This has led to an attitude of indifference, so that minor damage is often ignored until it becomes major damage.



Figure 4.3. Lack of Farmer Participation in Maintaining Canals

4. Conflicts Between Water Users

Uneven water distribution often causes conflicts between farmers, especially in the dry season. Farmers in the downstream part of the canal often do not receive the water supply they should because farmers in the upstream part use water excessively. Without a fair regulatory system and strong supervision, these conflicts will continue to occur and hinder irrigation efficiency.

5. Land Conversion and Sedimentation

The conversion of agricultural land into residential or industrial areas also disrupts existing irrigation channels. In addition, mud and garbage deposits that are not cleaned routinely cause sedimentation, so that the capacity of the water channel decreases and irrigation becomes ineffective.

6. Lack of Technology and Monitoring System

In the digital era, there are still many irrigation networks that have not implemented modern technology for water flow regulation and monitoring. Without an automatic control system or sensor-based monitoring, efficient water use is difficult to achieve. As a result, a lot of water is wasted or not optimally utilized.

4.3 How does the development of irrigation network infrastructure affect food security in Langkat Regency?

Food security is a strategic issue that is not only related to the availability of food, but also concerns the social and economic stability of a region. In Langkat Regency, which is an agricultural area with a significant area of agricultural land, the development of irrigation network infrastructure is a key factor in supporting a resilient and sustainable food system.

1. Ensure Water Availability Throughout the Planting Season

The development of irrigation infrastructure directly ensures the continuity of water supply to agricultural land. In Langkat Regency, many lands that previously depended on rainfall can now be planted more than once a year due to the development of technical and semi-technical irrigation. The availability of water not only increases the frequency of planting, but also minimizes the risk of crop failure due to drought, which is very important in maintaining the stability of food supply.

2. Increase Productivity and Quality of Agricultural Products

Good irrigation infrastructure allows farmers to organize planting patterns in a more planned manner, organize planting and harvesting times more consistently, and increase the efficiency of agricultural input use such as fertilizers and pesticides. This has an impact on increasing land productivity and the quality of agricultural products. The higher the productivity, the greater the contribution to local food availability and the reduced dependence on supplies from outside the region.

3. Reducing Inequality of Access and Water User Conflict

The development of an even and integrated irrigation system across all sub-districts, including Sirapit, can reduce the inequality of water access between regions, especially between upstream and downstream farmers. With fair and orderly water management, the potential for conflict between farmers can be reduced, so that the agricultural environment becomes more conducive to supporting sustainable food production.

4. Encourage Price Stability and Regional Food Independence

Increased food production due to effective irrigation will help control food price fluctuations, especially in critical seasons. If local production is stable, Langkat Regency will not need to rely too much on food distribution from other regions. Thus, the development of irrigation networks indirectly also supports regional food independence.

5. Strengthening the Socio-Economic Resilience of Farmers

With increased yields and reduced risk of crop failure, farmers' incomes tend to increase. This strengthens the economic resilience of farming households and encourages them to remain in the agricultural sector, reduces urbanization, and creates new jobs in supporting sectors such as agricultural processing and logistics. (Rahmadhani et al., 2023).

4.4 What is the role of the community and government in the management and development of irrigation networks in Sirapit District?

Sustainable management and development of irrigation networks require active collaboration between the government and the community. In Sirapit District, where most of the area relies on the agricultural sector, the success of the irrigation system is not only determined by the physical development of infrastructure, but also by social involvement, local institutions, and participatory governance.

1. Role of Government

The government, both at the district and provincial levels, plays an important role as policy maker and resource provider in the development of irrigation networks. (Ramadhani & Nuraini, 2024). These roles include:

- a) Policy formulation and technical planning: The government has the authority to determine irrigation development and rehabilitation plans that are tailored to local needs. Through the PUTR Service and the Agriculture Service, the government determines priority locations, budgets, and technical specifications for irrigation network development.
- b) Budget and infrastructure provision: The local government allocates APBD funds and sometimes accesses central funds (APBN or village funds) to build or repair irrigation networks in Sirapit. These activities include the construction of main channels, secondary channels, water gates, and reservoirs.
- c) Mentoring and training: The government is also tasked with providing counseling and training to farmers through the Agricultural Extension Center (BPP) program so that the community is able to understand the function and methods of maintaining irrigation.
- d) Regulation and supervision: In addition to construction, the government also establishes water utilization regulations and distribution schedules, and monitors the effectiveness of irrigation management.

2. Role of Society

The community, especially groups of water-using farmers, have a central role in maintaining the sustainability of the irrigation network that has been built. (Hidayat et al., 2023). The roles include:

- a) Participation in planning and supervision: Farmers who are members of the Water Users Farmers Association (P3A) can be involved from the start of the irrigation development planning process, so that the solutions taken are more in line with field needs.

- b) Routine maintenance of irrigation channels: Communities are responsible for light maintenance such as cleaning channels of blockages, sediment and rubbish, and reporting damage to the authorities.
- c) Equitable water distribution management: In a social context, communities have a moral responsibility to share water fairly and avoid conflict between users. This is realized through a system of mutual cooperation, deliberation, and local agreements.
- d) Local innovation and adaptation: Communities can also play a role in implementing local practices that are adaptive to climate change, such as water availability-based planting scheduling or implementing water-efficient irrigation systems.

4.5 What strategies can be implemented to increase the effectiveness of irrigation development in supporting food security?

Food security is a main pillar in sustainable regional development, especially in agricultural areas such as Langkat Regency. To ensure the availability of sufficient, safe, and nutritious food, one of the vital components that must be strengthened is the irrigation system. However, irrigation development is not enough just limited to physical development, but also requires a comprehensive and participatory strategy. Here are some strategies that can be applied:

1. Irrigation Planning Based on Local Needs

The first strategy is to implement a bottom-up planning approach, namely irrigation planning that involves farmers and farmer groups from the start. This approach ensures that irrigation development is truly in accordance with field conditions, crop needs, and community planting patterns. With the active participation of farmers in the planning stage, the irrigation system that is built tends to be more efficient and sustainable.

2. Strengthening Farmer Institutions (P3A and GP3A)

The effectiveness of irrigation is highly dependent on the institutional system that manages it. Therefore, it is necessary to strengthen the capacity of the Water User Farmers Association (P3A) and the P3A Association (GP3A) through training, organizational facilitation, and technical support. Strong farmer institutions will be able to regulate water distribution schedules, resolve conflicts, and carry out light maintenance independently.

3. Utilization of Modern Irrigation Technology

Technology plays an important role in increasing the efficiency of water use. The use of drip irrigation systems, sprinklers, or irrigation based on soil moisture and weather sensors can save water while increasing crop yields. In addition, digital systems based on GIS and drone mapping can also be used to design more effective and targeted irrigation networks.

4. Rehabilitation and Modernization of Old Infrastructure

Many irrigation networks built decades ago are now damaged or not functioning optimally. Therefore, an important strategy that must be carried out is the rehabilitation and modernization of old irrigation systems, by renewing irrigation channels using durable materials and adding automatic water flow control features.

5. Implementation of Integrated Irrigation System

Irrigation development should be integrated with other agricultural programs, such as the provision of superior seeds, fertilizer subsidies, and pest control. This system will create a more complete and efficient agricultural ecosystem, where irrigation becomes part of a sustainable food production chain.

6. Increased Budget and Multi-Sector Partnerships

To achieve optimal effectiveness, the government needs to increase the irrigation budget in the APBD or collaborate with the private sector and non-governmental organizations in the form of public-private partnerships (PPP). Through this cooperation, irrigation development and management are not only the burden of the government, but also a shared responsibility that is managed professionally.

7. Continuous Monitoring and Evaluation

Every irrigation development program must be accompanied by a systematic monitoring and evaluation system, so that its impact on agricultural productivity and food security can be measured objectively. This evaluation is also useful for improving policies and decision-making in the future.

5. CLOSING

Conclusion

Based on the results of the study and analysis, it can be concluded that the development of irrigation network infrastructure in Sirapit District has a significant influence on increasing food security in Langkat Regency. The availability of adequate irrigation water encourages increased planting intensity, agricultural productivity, and reduces the risk of crop failure. The role of government and society, especially farmer groups, is a key factor in the management and maintenance of irrigation networks. However, there are still several obstacles that reduce the effectiveness of the irrigation system, such as infrastructure damage, lack of farmer participation, and limited technology used.

Suggestion

1. Regional governments are advised to increase budget allocations for the development and maintenance of irrigation networks, as well as expand the reach of technical and modern irrigation systems.
2. Communities, especially farmers, need to be actively involved in decision-making, water management, and irrigation channel maintenance through strengthening institutions such as P3A.
3. The application of modern irrigation technology and data-based monitoring systems must be expanded to make water distribution more efficient and adaptive to climate change.
4. Cross-sector collaboration, both from the government, private sector, and educational institutions, needs to be improved in building a sustainable irrigation system based on local needs.

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