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Agricultural development: Policies for sustainable irrigation management

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ABSTRACT

The rate of environmental degradation in Indonesia, which is increasing from time to time, is one of the phenomena. One of the implications of forest destruction is the decreasing availability of water to meet the community's needs in the dry season, including irrigation water for agricultural purposes. The purpose of this research is to formulate the determinants of policy strategies in sustainable irrigation management; create and synthesize various basic assumptions that support policy strategies in sustainable irrigation management; develop the structure of policy strategies in sustainable irrigation management through the synthesis of environmental, economic, technical and institutional aspects. This research uses a system modeling approach through the Soft System Methodology (SSM) method, which is oriented towards preparing guidelines for action (action-oriented). Sustainable Irrigation Management has three sub-models: water resources conservation, irrigation network management/rehabilitation, and irrigated agriculture development. Developing sustainable irrigation management policies requires awareness, commitment, and alignment of local governments with active community participation. Prioritization of activities to realize sustainable irrigation management is compiled through FGDs using the Exponential Comparison Method, which provides a focus of action on the operation, maintenance, and rehabilitation of irrigation networks and immediately issued regional regulations related to the empowerment of irrigation institutions and Irrigation Commissions.

Keywords:
Irrigation, Management, Policy, Sinjai Regency, Sustainable

1. Introduction

The management of the environment [1–4] and natural resources [5,6] in the economic development of developing countries is still not given much attention in maintaining its sustainability [7–10]. Economic indicators have been more dominant in the implementation of development activities than environmental indicators [3,4,11–13]. The logical consequence is that there are many unexpected impacts in the form of environmental damage and the increasingly limited natural resources utilized [14].

Uncontrolled utilization of natural resources can cause various environmental problems [15,16]. Without proper regulation of the utilization of natural resources [17], it will have an impact on the welfare of the people, which will not be guaranteed and is even vulnerable to environmental damage [14]. The rate of environmental damage in Indonesia, which has increased over time, is one phenomenon. One of the implications of forest destruction is the decreasing availability of water to meet community needs during the dry season, including irrigation water for agricultural purposes [18–21].

The development and management of water resources will become a problem due to the increasingly limited availability of water and the increasing demands for meeting water needs [22,23]. The imbalance between the increasingly limited water availability and various users' increasing demand for water can lead to economic, social, and cultural conflicts. In addition, the problem will become more complex when water quality is neglected in development activities, causing environmental problems [24].

At the utilization level, water resources have organized and harmonized social, environmental, and economic functions [22,25]. In general, the utilization of water resources is intended to meet basic needs, environmental sanitation, agriculture, power, industry, mining, transportation, forestry and biodiversity, sports, recreation and tourism, ecosystems, aesthetics, and other needs determined by laws and regulations [26].

Based on this, the allocation of water supply for crop needs or smallholder agriculture through an irrigation system is a top priority in the framework of water resources development. Given the strategic importance, striving for proper and sustainable irrigation management is necessary. This is based on the fact that the main priority of irrigation development in Indonesia is still aimed at irrigation management to support the activities of the agricultural sector. Recognizing the vital role of irrigation in maintaining and improving food security, sustainable irrigation management is one of the essential priorities in the framework of irrigation development both nationally and regionally [27–29].

The implication of strengthening the role of local governments in irrigation management, especially at the district/city level which is the authority and responsibility is the development of primary and secondary irrigation systems that are intact in one district/city is the authority and responsibility of the district/city government concerned. The complete arrangement and division of irrigation management authority based on the strata of the irrigated agricultural land area is as follows: (1) Irrigation Areas of less than 1000 ha and located within one district/city are the responsibility of the District/City Government; (2) Irrigation Areas with an area of more than 1000 to 3000 or small DIs that cross-district/city are the responsibility of the Provincial Government and (3) Irrigation Areas with an area of more than 3000 ha or cross-provincial, national strategic, and cross-country are the responsibility of the Central Government.

In essence, irrigation functions in supporting farm productivity and increasing agricultural production in the context of food security and community welfare [21,30,31], which is realized through the sustainability of irrigation systems [18]. Therefore, a policy strategy is needed to support sustainable irrigation management [32,33]. Factors supporting sustainable irrigation management have shown pretty critical indications. This can be seen, among others, from the factors of water availability, the physical condition of irrigation networks irrigated agricultural land, and the ability of irrigation management institutions [34,35].

The development of irrigation management institutions [17,21,34,36,37] has now received much attention from various circles of observers and practitioners related to irrigation management. Formal institutions that have been developed so far through the organization of the Water User Farmers Association (P3A) tend to show powerlessness in three dimensions, namely: (1) initiative, (2) socio-economic, and (3) technology. As a result, not many Waters User Farmer Association (P3A) organizations can help their members improve their welfare. In addition, the working pattern of government agencies, still characterized by sectoral egoism, causes cooperation between them to be not optimal in assisting the development of farmer organizations [37].

Several previous studies show that the limited institutional capacity of irrigation management, both at the level of farmer organizations and government, causes the implementation of operation and maintenance activities not to run well. This resulted in physical damage to irrigation and higher mud sedimentation in almost all irrigation networks. The tendency for limited institutional capacity in irrigation management is also seen from the indication of the implementation of regional autonomy. On the other hand, institutional coordination that regulates irrigation management is still less than optimal, both irrigation committees and irrigation commissions. Such conditions will make sustainable irrigation management activities increasingly unclear [22].

Various problems related to the carrying capacity of sustainable irrigation management certainly require reorganization in the form of government policy. Based on this, this research aims to formulate a regional policy strategy for sustainable irrigation management, especially in the development of aspects of water availability, physical condition of irrigation networks, irrigated agricultural land, and institutional capacity for sustainable irrigation management.

2. Methods

The research location of the policy strategy in sustainable irrigation management was carried out in Sinjai Regency. The selection of the area was determined purposively with several considerations: the existence of environmental problems related to sustainable irrigation management both directly (water management is not yet optimal, there is no guarantee of irrigation water, conversion of irrigated land, and damage to irrigation networks) and indirectly (the absence of Irrigation Regulations, the Irrigation Commission is not yet optimal, and the empowerment of water user farmer communities is still limited). As well as having the potential for further development and management of irrigation for the achievement of community welfare [38,39].

Table 1. Data and types of research data

Numb.	Data	Data Type
1	Water sources and water availability	Primer
2	Irrigation network infrastructure	Primer
3	Irrigated agricultural land.	Primer
4	Irrigation management institution	Primer
5	Farmer household income	Primer
6	Farm income	Primer
7	Irrigation management fee	Primer
8	Operation and maintenance of irrigation networks	Primer
9	Regional Autonomy Policy	Seconds
10	Reform of Water Resources and Irrigation Management Policy	Seconds
11	Agriculture Policy	Seconds

Numb.	Data	Data Type
12	Overview of Research Location	Seconds
13	Local policies and regulations related to irrigation management.	Seconds
14	Strategic Plan for Sustainable Irrigation Management	Seconds
15	Profile of the irrigation system	Seconds
16	Institutional profile of P3A organization	Seconds
17	Physical environmental conditions, water resource economics, agricultural data, land area, agricultural productivity, and regional food security.	Seconds
18	Village economic structure	Seconds
19	Identification of social institutions and Economic institutions	Seconds

Based on the research objectives achieved, the research method used is a system approach using the Soft System Methodology (SSM) method, which is oriented towards preparing guidelines for action (action-oriented). The method is used to pay attention to efforts to prepare relevant information on a policy that must be determined (policy research) [40–42].

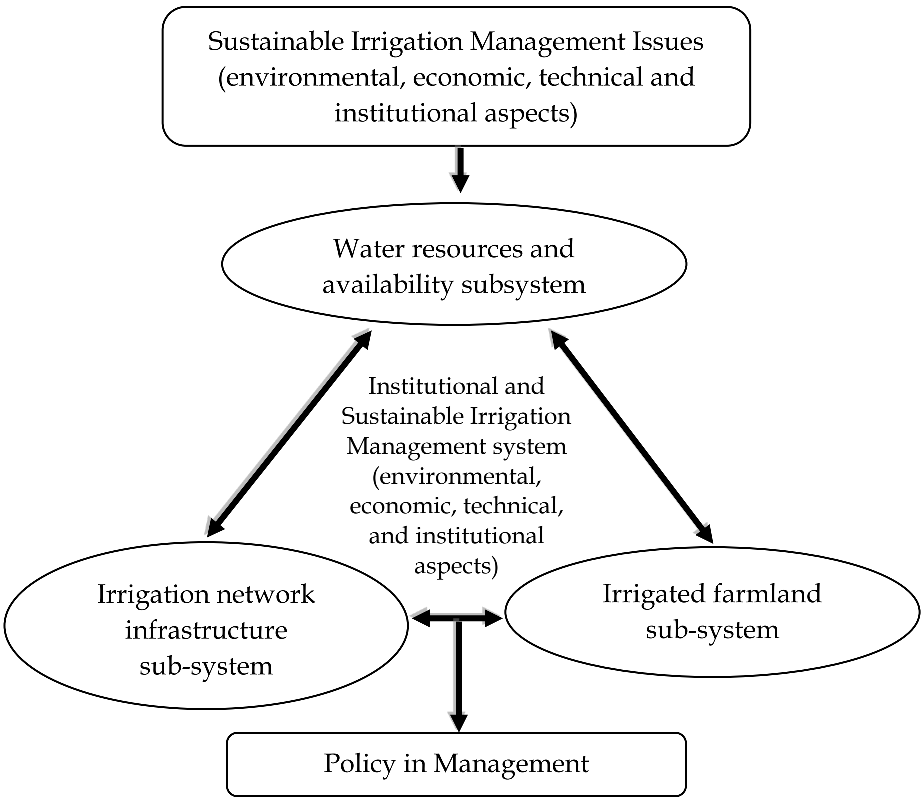

Figure 1. Research framework

Parameters of irrigation management sustainability are measured based on the synthesis of social, economic, and environmental indicators of various elements or supporting elements of sustainable irrigation management, namely water resources, irrigation network infrastructure, land resources, and irrigation management institutions. This study's primary data collection techniques were pre- and direct observation through a survey approach. Expert surveys conducted through interview guidance and Focus Group Discussions (FGD) supported the study [43,44].

Regional policy strategies in sustainable irrigation management at the Sinjai district level can be formulated through interrelated parts within the framework of the irrigation system. Irrigation as a system consists of several supporting elements, namely: (1) water sources, including water availability; (2) infrastructure in the form of irrigation networks, both channels and irrigation buildings; (3) irrigated agricultural land; and (4) irrigation management institutions both at the government level and water user farmer communities. Based on this, the research framework is organized based on these supporting elements as the basis for developing a policy, as shown in Figure 1.

3. Results and Discussion

3.1. Sustainable Irrigation Framework

The paradigm approach to sustainable irrigation management is based on various physical and socio-economic changes that have increased pressure on water resources, including irrigation, including (1) Increasing population in the context of increasing demand; (2) The development of industrialization which has an impact on irrigation water pollution; (3) Damage to the watershed caused by economic activities resulting in increasingly limited water availability; (4) Increasing water users which has implications for competition for water utilization for various development sector allocations; (5) Increasing the rate of conversion of irrigated agricultural land; and (6) The decline in the physical condition and function of irrigation networks from year to year as a result of the lack of funding for the operation and maintenance of irrigation networks [45–48].

These changes can reduce water availability (dependable flow) with quality and quantity that does not meet essential human life needs. Therefore, policy adjustments are needed in future irrigation management efforts [19,23]. More specifically, it requires a change in water development and management orientation from a supply-side strategy to a demand-side strategy.

The demand-side strategy of water management emphasizes influencing users' behavior in using water by developing organizations and institutions to handle both aspects (demand and supply). The role of these institutions is essential in controlling the demand for water by various interests. The principles of water management through demand-side strategy [49] are: (1) Taking into account the value of water about the cost of providing it [28,50]; (2) Taking measures that require users to relate the level of water use to the cost to be paid; and (3) Treating water as an economic good (commodity) and not just a form of public service provided by the government and not required to be paid for.

One of the efforts to anticipate future irrigation management changes is through a paradigm approach to sustainable irrigation management, namely by integrating environmental, economic, technical, and institutional aspects. A needs analysis is required to produce an effective regional policy model in sustainable irrigation management. Needs analysis is the initial part of all Soft System Methodology (SSM) stages. Needs analysis concerns the interaction between the responses from a decision maker to the system's operation. Its identification can include a survey's results, an expert's opinion, a Focus Group Discussion (FGD), or field observations. The system is a group of elements interconnected and organized to achieve a goal or a group of goals. In the needs analysis process, an interaction relationship can always be realized positively or negatively in a decision-making system. The decision-making process in the needs analysis is primarily determined by the degree of importance and benefits that will be obtained for all parties or elements involved.

In the research context, the needs analysis can be mapped through various carrying capacities for sustainable irrigation management. The carrying capacity includes water resources, irrigation policy reforms, and the internal (irrigation water resources) and external environment (irrigation water resources institutions, technology, legal umbrella, and irrigated agricultural land). Table 2 outlines the needs analysis of various stakeholders related to sustainable irrigation management [2,18].

Table 2. Needs analysis of sustainable irrigation management model

Numb.	Stakeholders	Needs
1	Government	a. Adjustment of regulations and arrangements for water supply and water utilization for various user sectors. b. Synchronization of policies and laws and regulations. c. Development of appropriate technology in supporting irrigation systems. d. Adjustment of the economic value of water and irrigation resources. e. Sustainable irrigation management
2.	Irrigation Commission	a. Coordination of participatory irrigation management planning in supporting regional development performance. b. Coordination of inter-sectoral programs related to water resources and irrigation. c. Coordination of irrigation water supply and utilization allocation plans. d. Coordination of control over the conversion of irrigated agricultural land. e. Coordination of irrigation management funding and control of the implementation of sustainable irrigation management activities. f. Coordination of water resources conservation programs.
3.	Institutionalization of Irrigation Management	a. Capacity building for sustainable irrigation management through education and training. b. Development of a legal entity organization. c. Guarantee of irrigation water management rights.

Numb.	Stakeholders	Needs
		d. Utilization of irrigation water through a water-saving approach. e. Increased ability to finance irrigation management. f. Management of irrigation water utilization conflicts g. Conservation of water resources.
4.	Water Using Farmer Communities	a. Guarantee of irrigation water use rights for irrigated agricultural needs. b. Maintain and defend irrigated agricultural land from conversion efforts for various sectors on "green" land. c. Community participation in irrigation management. d. Optimizing the contribution of irrigation to farm productivity. e. Development and application of irrigation water saving technology. f. Conservation of water resources.
5.	Private	a. Clarity and firmness of regulations on the provision and utilization of water resources and irrigation. b. Economic value of water resources and irrigation (including cost recovery). c. Conservation of water resources.

Regional policy models in sustainable irrigation management are based on at least three fundamental interests to be achieved and have intersecting goals that cannot be separated from each other, as stated by Glória et al. [18], "Inherent tensions exist between the three spheres of overlapping sustainable development objectives:

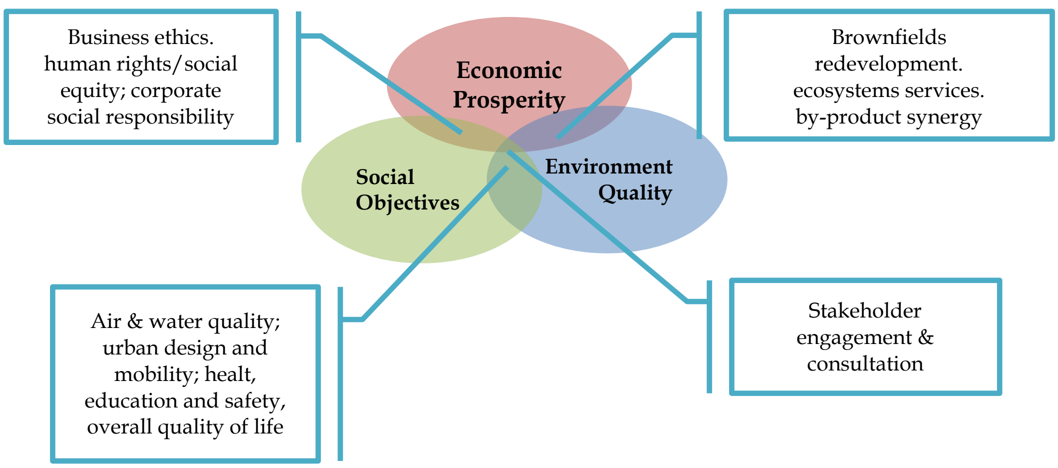

Figure 2. Linkages between sustainable development goals

(1) economic development and the alleviation of poverty, (2) protection of the natural environment, and (3) social objectives such as health, education, and peace". The intersection of these three objectives can be seen in Figure 2.

The sustainable development model is developed based on 3 (three) principles of sustainability as stated, namely: (1) appropriate decision-making, (2) fulfillment of community needs through efficient use of resources, and (3) Equitable development. The sustainability of the irrigation system is formulated through a pattern of development and management of irrigation using a system approach and utilizing various factors/components that affect the irrigation system.

It is also stated by Wang et al. [51], that sustainable environmental problems are also related to social issues. Sustainable irrigation management is needed to optimize the potential of water resources and reduce the issues that arise. Problems related to irrigation include the following: "Many problems in irrigation O&M have emerged recently. The major issues are associated with scarcity of water sources, low adaptability of irrigation structures to the local environment, low irrigation efficiency, and low farmers' participation. The problems arise partly due to changes in environmental factors such as (1) change in agricultural practices and orientation, (2) scarcity in land and water as the two principal resources in agriculture on one side, while on the other side, the demand is increasing, (3) recent vital requirement of more sustainability development and better environment quality, and (4) change in socio-economic attitudes of villagers as an impact of the development process in the country".

3.2. Basic Assumptions of Integrated Irrigation Management Policy

The basic assumptions for the development of integrated irrigation management policies were obtained from the results of focus group discussions, better known as the FGD (Focus Group Discussion) method, held at the Sinjai district level involving various stakeholders from both the Regional and Central Government, the water user farmer community of Sinjai District, irrigation institutions (P3A, GP3A and IP3A), Non-Governmental Organizations and related agencies [17].

The results of identifying integrated irrigation management policy development factors from the FGD activities are then used as material for expert discussion activities to develop alternative assumptions to prepare regional policy strategy models in sustainable irrigation management. The assumptions are grouped into 4 (four) aspects, namely: (1) technical aspects, (2) economic aspects, (3) institutional aspects, and (4) environmental aspects. The results of the preparation of alternative assumptions are then discussed to give importance and certainty values that refer to questions that include: (1) how significant is the influence of the assumption on success or failure, and how far is the confidence that the assumption can be justified and ensured success.

The results of each participant's assessment were combined to obtain the position of each basic assumption in the importance and certainty quadrant map, as shown in Table 3.

Table 3. Regional policy assumptions in integrated irrigation control

Numb.	Assumption	Level of Importance	Level of Certainty
1	Technical Aspects		
	a. Public awareness and participation to maintain and preserve the irrigation network	√	
	b. Activities of changing the function of irrigation network buildings by the community and other parties can be well controlled by irrigation officers.	√	
2	Economic Aspects		
	a. Sufficient and adequate irrigation networks and institutions from the local and central government through the APBD and APBN.	√	
	b. Government action program agenda for funding forest conservation in upstream areas.	√	
	c. Funding for operations, maintenance the irrigation fee payment system at the P3A, GP3A and IP3A levels can run well.	√	
3	Institutional Aspects		
	a. Management that is not concurrent in irrigation institutions (P3A, GP3A and IP3A)	√	
	b. The administration of irrigation institutions runs in an orderly manner.	√	
	c. Good cooperation between irrigation institutions and farmer groups.		√
	d. Adequate funding from the government in the implementation of irrigation institutional activities.	√	
	e. Local government fostering the management of irrigation institutions is done continuously and effectively.	√	√
	f. Order in the arrangement of good irrigation water distribution along the river (upstream, middle and downstream).	√	√
	g. Synergistic cooperation between Perum Perhutani, Forest Service, Ministry of Public Works and Ministry of Agriculture in the maintenance and provision of water discharge and water availability from upstream to downstream.	√	
	h. Good cooperation between Micro Enterprises (farmers) and Micro Finance Institutions (MFIs) in order to improve the welfare of farmers.		√

Numb.	Assumption	Level of Importance	Level of Certainty
4	Environmental Aspects		
	a. Forest conservation and reforestation are carried out with the support of the government and surrounding communities.	√	
	b. Forest conservation activities in upstream areas can maintain the stability of irrigation water discharge in upstream, middle and downstream areas.	√	

Source: Primary data after processing

Noting the interrelated position of several assumptions that have high importance and certainty [17], further synthesis was carried out to identify the following most strategic assumptions: (a) Forest conservation and reforestation are carried out with the support of the government and communities around the forest. Suitable irrigation water distribution arrangements along the river flow (upstream, middle, and downstream) to keep the irrigation flow stable and evenly distributed along the irrigation flow; (b) Management that is not concurrent in irrigation institutions (P3A, GP3A, and IP3A) improves the performance of irrigation institutions; (c) There is sufficient funding for operations maintenance of irrigation networks and institutions from the local and central government through the APBD and APBN; (d) Forest conservation activities in upstream areas are supported by synergistic cooperation between Perum Perhutani, the Forestry Service, the Ministry of Public Works and the Ministry of Agriculture to maintain the stability of water discharge provision and water availability from upstream to downstream; (e) Adequate funding for implementing irrigation institutional activities and continuous and practical guidance of irrigation institutional administrators by the local government; (f) Cooperation between KPI and Poktan with the support of Microfinance Institutions to improve the welfare of farmers.

3.3. Policy Strategy for Sustainable Irrigation Management

The policy model framework is built by identifying actors and their functions and coordinating and cooperating between institutions and activity programs. Sustainable irrigation management has several essential actors in the region, which include (1) Regent and DPRD; (2) Irrigation Commission; (3) Bappeda; (4) Department of Public Works and Housing (Water Resources Management Division); (5) Department of Food Crops, Horticulture and Plantations; (6) the community, including farming communities, conservation communities, community leaders, P3A/GP3A/IP3A organizations; and (8) Funding support institutions such as BPD, Banks, and other financial institutions.

Model Policy Strategy Sustainable irrigation management provides direction in the function of policy and guidance carried out through various activity programs, among others, are (1) forest conservation in the catchment area; (2) preservation of water resources (rivers) through normalization and labor-intensive activities; (3) good irrigation management at the central network level (primary, secondary and management in tertiary networks; (4) Optimization of production land through farming activities; and (5) farming market policies that support access to marketing of local community farming products.

The design of this Sustainable Irrigation management strategy also requires a set of supporting policies and regulations, including funding assistance from the Province and the Center. District, provincial, and central governments need synchronization of rules, policies, programs, and funding. The final results or outputs expected from the draft strategy include (1) the availability of sufficient water throughout the year; (2) the provision of plant water needs that meet the optimal limits of growth; (3) the increased productivity of agricultural products; and (4) the farm income supported by other income to achieve community welfare.

The function mechanism of the entire Sustainable Irrigation Management Strategy (SPIB) is described more simply through 3 (three) sub-models, namely: (1) the water resources conservation program sub-model, (2) the irrigation network management/rehabilitation program sub-model, and (3) the farm income improvement program sub-model.

Table 4. Order of priority in sustainable irrigation management

Numb.	Alternative Activities	Priority
1	Network Operation, Maintenance, and Rehabilitation Irrigation	I
2	Establishment of regional policies (local regulations and Irrigation Commission)	II
3	Coordination between institutions and all stakeholders	III
4	Relevant stakeholders (BAPPEDA, PSDA Agency, TPHP Agency, PT/NGOs, MFIs, and P3A/GP3A/IP3A). TPHP, PT/NGO, LKM, and P3A/GP3A/IP3A)	IV
5	River Normalization (O&P and labor-intensive programs)	V
6	Conservation of water resources	VI
7	Prevention of conversion of irrigated agricultural land	VII
8	Food Security and Energy Credit (KKP-E)	VIII

Source: Primary data after processing

Based on the Exponential Comparison method analysis, operational activities, maintenance, and rehabilitation of irrigation networks have the most significant value of weighted agreements in prioritizing activities. Operational activities, maintenance, and rehabilitation of irrigation networks are some of the most essential activities to be done immediately to improve integrated irrigation control compared to other alternative activities. Given that until now, the operational activities, maintenance, and rehabilitation of irrigation networks in the research area, namely Sinjai Regency, have been very deficient. This can be seen from the high damage to irrigation networks, around 74%. The priority order of activities is presented in Table 4.

4. Conclusion

The determinants of policy strategies in sustainable irrigation management based on case studies in Sinjai Regency are environmental, economic, technical, and institutional conditions. Environmental factors damage the upstream area, with indications of increasing settlements and low reforestation, so critical land is getting wider. Economic factors show limited income in the agricultural sector and low funding for irrigation management. Technical factors show network damage and limited irrigation water discharge. Sustainable Irrigation Management is formulated in three sub-models: water resources conservation, management/rehabilitation of irrigation networks, and development of irrigated agriculture. Developing sustainable irrigation management policies requires awareness, commitment, and alignment of local governments with active community participation. Prioritization of activities to realize sustainable irrigation management is compiled through FGDs using the Exponential Comparison Method, which focuses on the operation, maintenance, and rehabilitation of irrigation networks and immediately issues regional regulations related to the empowerment of irrigation institutions and Irrigation Commissions.

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