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A Multicriteria Policy Analysis: Policy Framework for Sustainable Groundwater Management in Kupang City, East Nusa Tenggara, Indonesia

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ABSTRACT

This study aimed to provide a policy framework for groundwater management in Kupang City, East Nusa Tenggara. The method used in this research was a multicriteria policy analysis method with a qualitative approach. Data were collected using a focus group discussion method. The study participants were 14 stakeholders, including the Director of Planning and Supervision of Watershed Management Nusa Tenggara II River Basin Management Center, Head of the Watershed and Protected Forest Management Center Benain Noelmina, Development Planning Agency, Regional Research and Development of East Nusa Tenggara, Southeast Province, Chair of the River Basin Forum of East Nusa Tenggara Province, Kupang City Development Acceleration Team, Commission III Regional Legislative Council of Kupang City, Non-governmental Organizations, Environmental Practitioners, Provincial Level Environmental Observer Groups, Kupang City and Regency, Legal Practitioners, and Academics. In the focus group discussion, the respondents were free to express their opinions on sustainable groundwater management policies in Kupang City, East Nusa Tenggara. The results show that the groundwater information system is the best in an integrated scenario with a superior program for establishing special zones to identify watershed conservation areas.

Introduction

Groundwater is found in layers of soil or rocks below the land surface [1–4]. Water availability contains salt water 94% and fresh water 6% consisting of 95% groundwater, surface water 3.5%, and soil moisture 1.5%. The groundwater potential in Indonesia is 712 billion m^3/year, and is available in 421 Groundwater Basins (*Cekungan Air Tanah*) [5]. The increasing community demand for water has encouraged the government to use groundwater to provide clean water [6–8]. Groundwater management is based on various policies and strategies. Currently, the Kupang City government has established regulations regarding groundwater management based on East Nusa Tenggara Regulation Number 11/2018 concerning Groundwater Management. This policy is a direction for implementing the conservation, utilization, and control of destructive forces and groundwater information systems. Efforts to conserve groundwater in urban areas include creating infiltration wells and implementing water conservation techniques [9–11]. Groundwater use in this region is extensive, as indicated by groundwater production drilling spread throughout the region [12–17]. Groundwater management requires actions to plan, monitor, and evaluate the implementation of

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groundwater conservation, utilization, and control the destructive power of water. Therefore, when performed optimally, it impacts and minimizes its use [18–26].

The higher the demand for groundwater utilization permits, the greater the need for a system that can provide information on the exact area for groundwater extraction, manage the results of field surveys, and display information regarding well location points [27]. MULTIPOL is a multi-criteria-based policy analysis tool that was developed [28]. In principle, this analysis uses scores and weights to determine the hierarchy or the best choice. First, the analysis was conducted by integrating a participatory approach through stakeholder involvement in multi-criteria assessments. Second, the analysis depends on the criteria used and the interaction between action, policy, and scenario components to determine action choices or program alternatives, which will evaluate the effectiveness of these options. These three components work together to generate two different forms of assessment: action-to-policy-based evaluation, which compares programs to policies to evaluate which program is best for each policy and how actions affect policies. Furthermore, policies to situations are used in the assessment to determine which policies are suitable for certain designs, creating a policy hierarchy and the effect of designs [29].

Materials and Methods

This study used a qualitative approach to map policy options, scenarios, and priority programs for sustainable groundwater management by collecting data through a participatory process/Focus Group Discussion (FGD). The process involved 14 participants and experts, including the Director of Planning and Supervision of Watershed Management (*Derah Aliran Sungai*) of the Nusa Tenggara II, River Basin Management Center (*Balai Wilayah Sungai*), Head of the Regional Management Center River Flows and Protected Forests Benain Noelmina, East Nusa Tenggara Regional Development Planning, Research and Development Agency, Southeast Province, Chair of the East Nusa Tenggara Province River Watershed Forum, Kupang City Development Acceleration Team, Commission III Regional Legislative Council (*Dewan Perwakilan Rakyat Daerah*) of Kupang City, Non-Governmental Organizations (NGOs), Environmental Practitioners, Environmental Observer Groups in Provincial, City and Regency Levels of Kupang, Legal Practitioners, and Academics. In the FGD, the respondents were free to express their opinions on sustainable groundwater management policies in Kupang City, East Nusa Tenggara.

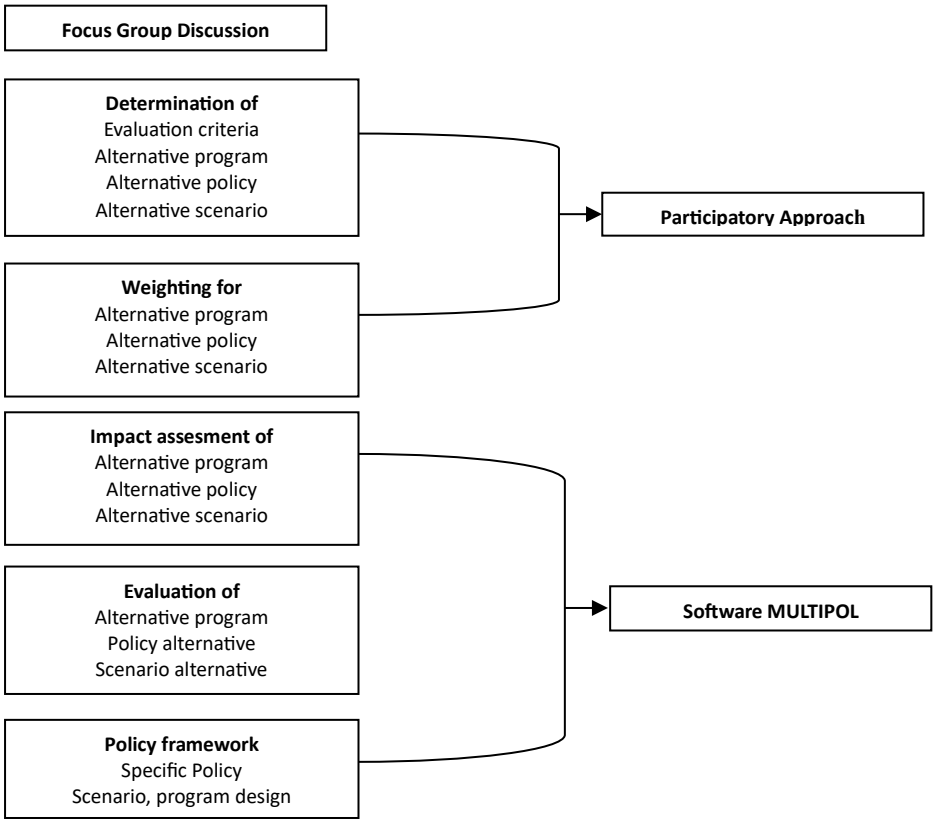

Figure 1. Determining the stage of the policy framework.

The obtained data will be analyzed using the policy analysis method with the MULTIPOL technique (multicriteria policy). This method was used to test the effectiveness of various policies and actions against scenarios, including determining the framework for choosing activities, policies, and the best scenario for the project [30,31]. Figure 1 illustrates the steps to implement the participative approach in practice and to use the MULTIPOL technique. The FGD results provide actions or programs to implement the following four policies: The first policy is groundwater conservation, groundwater use, control of the destructive power of groundwater, and groundwater information systems. The result of the participatory stage from the series input required MULTIPOL analysis. As shown in Table 1, the inputs consisted of the success criteria, other programs, strategies, and scenarios.

The evaluation criteria are quantifiable dimensions used to examine many possible choices that may be realized. Every assessment process evaluates how well those situations, rules, and initiatives are integrated with their functions. Instead, the procedures were designed for future development with achievable goals and objectives. Policy is a method for accomplishing planned goals and objectives that are directly tied to the political, social, economic, and physical environments in which the evaluation takes place. Program activities are connected to prospective interventions meant to implement policies [29,30]. Figure 1 illustrates the phases of implementing the participatory approach and the MULTIPOL method-based data analysis. The first and second blocks choose scenarios, actions, policies, criteria, and weights, which is a participatory approach. For designs, the weight values ranged from 1 to 6, whereas for policies and actions, both ranged from 0 to 100. The second block is a MULTIPOL device that determines the best hierarchy of activities based on policies and scenarios previously defined in the first block. The determination of this hierarchy is also based on the score of the action component based on predetermined criteria, with scores ranging from 0 to 20 [15].

Table 1. Criteria, alternative program action, policy, and scenario.

Criteria	Symbol	Program	Symbol	Policy	Symbol	Scenario	Symbol
Serious attention from the central government to watersheds	C1	Planting trees around the watershed	A1	Groundwater conservation	P1	Integrated management scenario	S1
Budget support	C2	Fiscal capacity concerns the budget.	A2	Utilization of groundwater	P2	Individual management scenario	S2
Technical planning	C3	Political policy	A3	Controlling the destructive power of groundwater	P3		
Regulations	C4	Support from the watershed forum and the Ministry for Watershed Management Planning	A4	Groundwater information system	P4		
Handling watershed problems its use and potential	C5	Special zone to identify watershed conservation areas	A5				
Legitimize conflicts of interest that occur in society	C6	Environmental services	A6				

Results and Discussion

The Evaluation Program Towards Policy

Table 2 displays the priority programs for groundwater management in Kupang City, based on the findings of the policy program assessment. The program was ordered according to each special zone policy program's average value and standard deviation to identify the watershed conservation areas (A5). Tree planting around the watershed (A1) was the most favored program. This result depends on the conditions under which groundwater management requires the regulation of conservation area zone policies and tree planting around the watershed.

Table 2. The excellence programs.

Action program /policy	Mean	Deviation standard	Ranking
A1	10.9	2	5
A2	10.8	2.6	3
A3	8.5	0.6	1
A4	10.3	1.4	2
A5	12.6	1.5	6
A6	10.9	1.5	4

Figure 2 shows that the superior programs of each groundwater utilization policy (P2) and groundwater damage control policy (P3) are excellent. In the conservation policy (P1), a special zone for identifying watershed conservation areas (A5) is an ideal program. The groundwater utilization policy (P2) and special zones for identifying watershed conservation areas (A5) are excellent programs. Superior programs are policies to control the destructive power of groundwater (P3) and the fiscal capacity of the budget (A2). Meanwhile, in the groundwater information system policy (P4), the special zone policy for identifying watershed conservation areas (A5) is an excellent program.

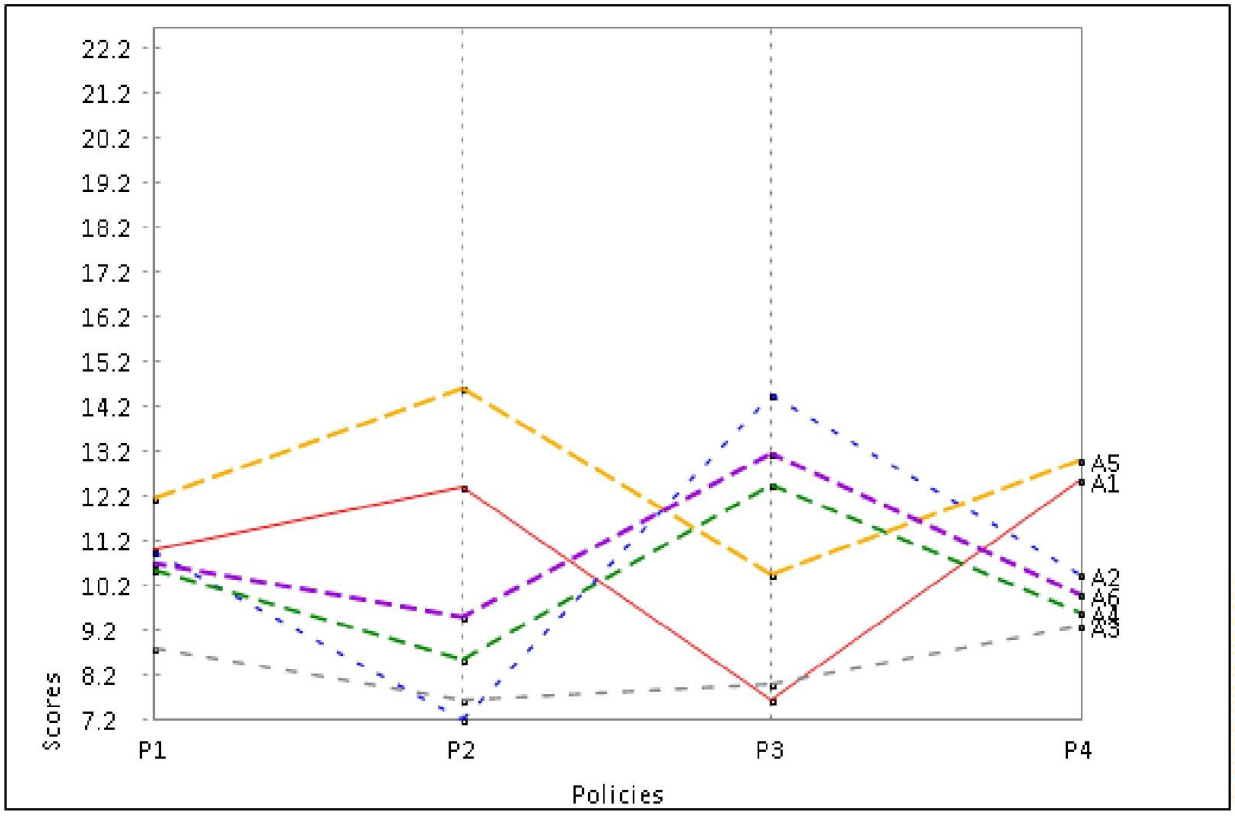

Figure 2. The profile map toward policy.

Figure 3 shows the closeness of action programs to policies. Groundwater conservation policies are closely related to fiscal capacity programs regarding the budget. Groundwater utilization policy is closely associated with a program for establishing special zones to identify watershed conservation areas. Furthermore, the procedure for controlling the destructive power of groundwater is closely related to programs in the form of support from watershed forums and ministries for planning watershed management and environmental services; groundwater information system policies are closely related to political policies and planting trees around the watershed. The closeness of policies to programs can be a means of implementing a policy, and should be supported by interrelated programs.

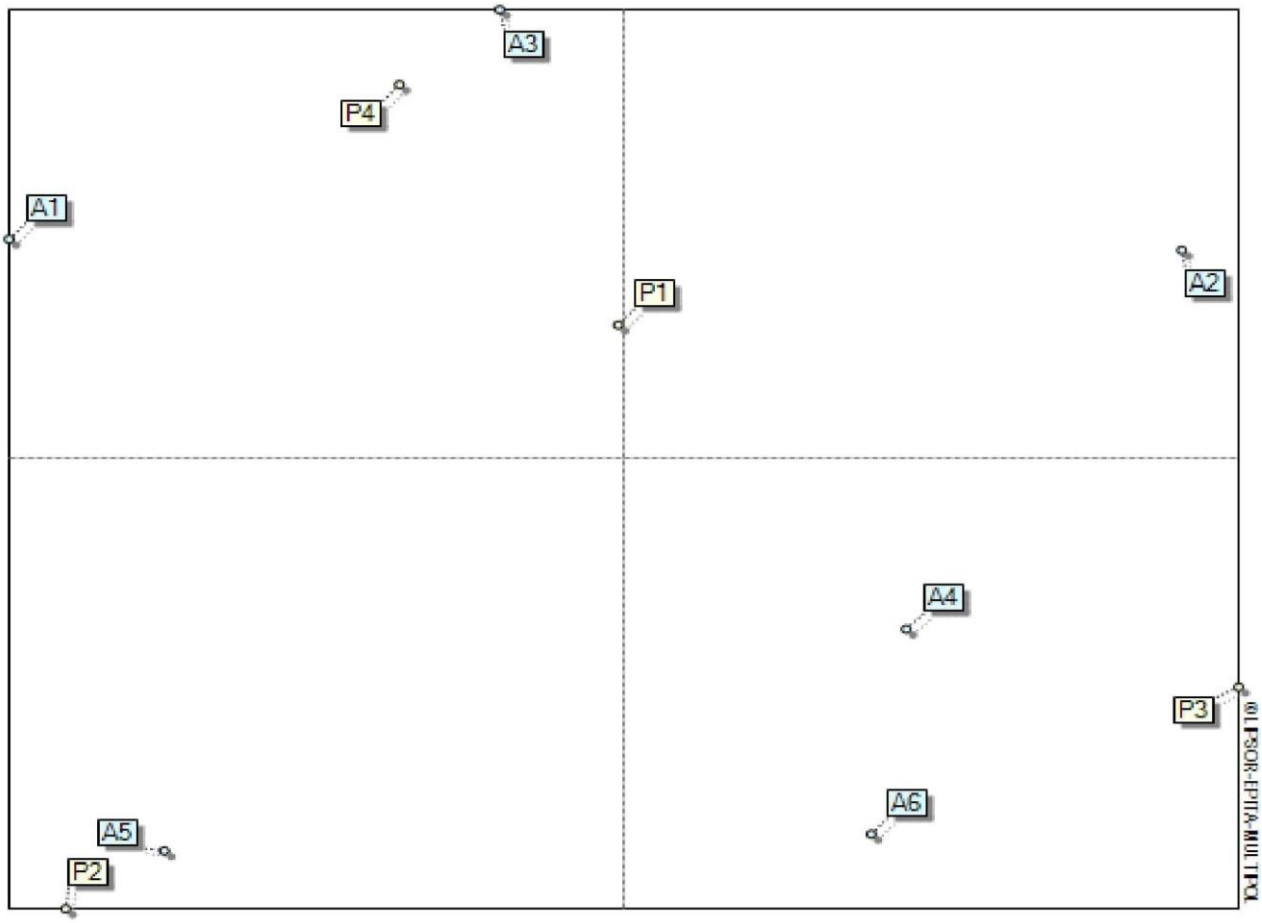

Figure 3. Closeness of program towards policy.

Evaluation of The Scenario Policy

Table 3 displays the order of the favored policies because of the scenarios' policy assessments. The groundwater destructive power control policy (P3) is superior, followed by the groundwater information system policy (P4) are the following excellent policies. Furthermore, the groundwater conservation policies (P1) and groundwater utilization policies (P2) were the most effective.

Tabel 3. The policy excellence.

Policy/scenario	Average	Deviation standard	Ranking
P1	14.3	0.3	2
P2	12.5	3.6	1
P3	16.4	3.3	4
P4	14.8	0.9	3

Figure 4 presents the order of the policy advantages in each scenario. It is known that the groundwater utilization policy (P2) is the most favored policy in the integrated management scenario (S1), whereas the groundwater destructive control policy (P3) is less preferred. In the individual management scenario (S2), the groundwater destructive control policy (P3) was the most favored, whereas the groundwater utilization policy (P2) was not a superior policy.

Figure 5 shows that the groundwater destructive power control policy (P3) determines groundwater management in Kupang City. This policy needs to be supported by the groundwater information system policy (P4) in the upper-left quadrant, while the groundwater conservation and utilization policies support policies. The policy alternatives for each scenario are shown in Figure 6. Although the procedure for controlling the destructive power of groundwater (P3) has become the leading policy in the individual management scenario (S2), the groundwater information system (P4), groundwater conservation (P1), and groundwater utilization (P2) are superior policies in the integrated management scenario (S1).

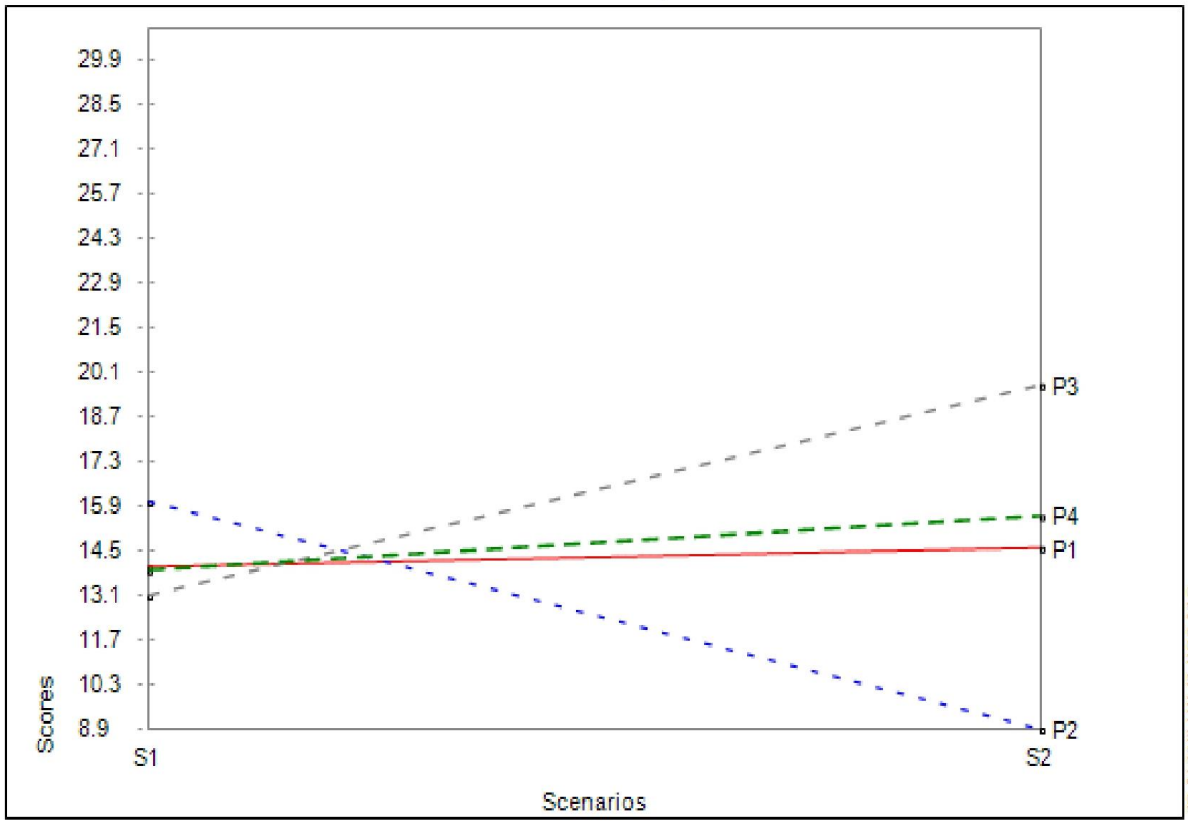

Figure 4. The map of priority policy towards the scenario.

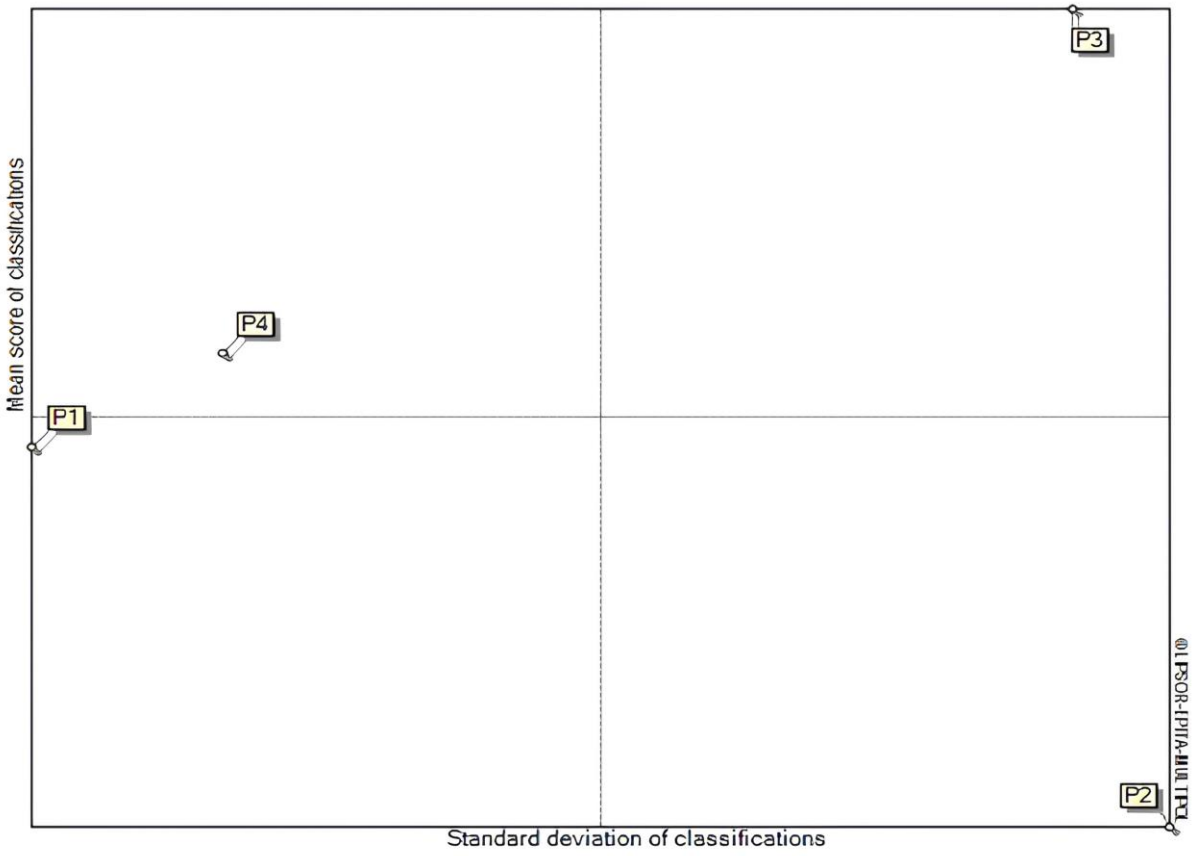

Figure 5. Map of clasification sensitivity.

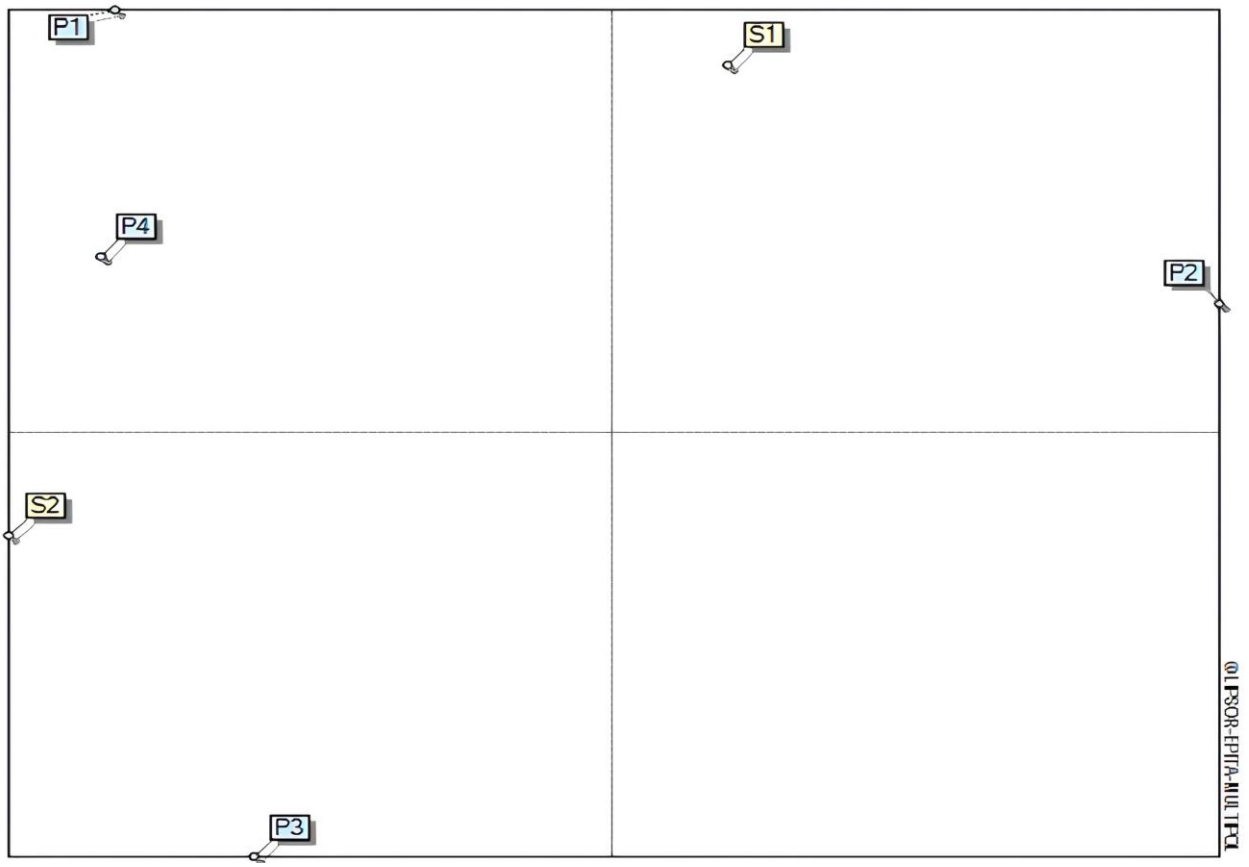

Figure 6. Policy / scenario closeness map towards scenario.

Framework for Sustainable Groundwater Management in Kupang City

The evaluation results of the programs, policies, and scenarios can be described (Figure 7) to determine alternative policy frameworks that are appropriate for groundwater management in Kupang City. The policy framework is presented in Figure 7, which shows the policy path for each scenario and the proposed program.

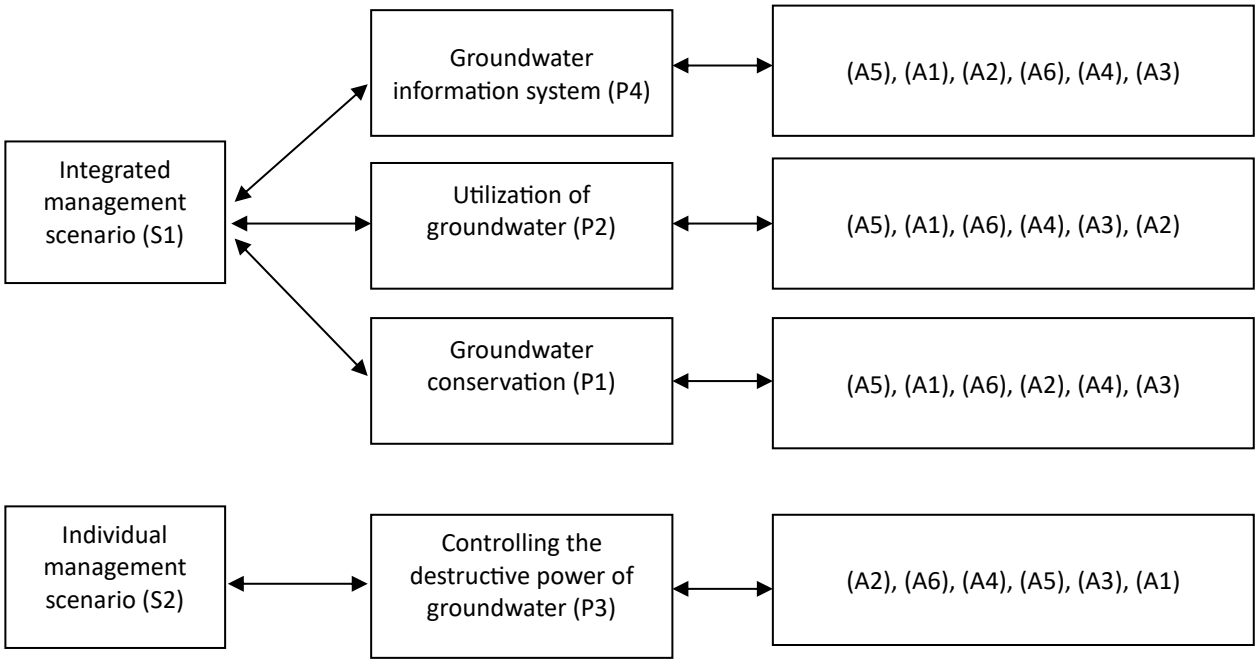

Figure 7. Potential policy pathways to achieve each groundwater management scenario in Kupang City.

The road map for groundwater management in Kupang City began with a selection of scenarios, policies, and superior programs. Figure 7 shows that two alternative management scenarios can be selected for groundwater management in Kupang City, an integrated scenario (S1) and an individual scenario (S2). Integrated management scenarios combine all stakeholder plans in an integrated system. The integrated scenario describes collaborative work to jointly manage groundwater in Kupang City. This scenario emphasizes management efforts to connect various stakeholders in the groundwater information system policy (P4) with a particular zoning program to identify watershed conservation areas (A5), tree planting around the watershed (A1), fiscal capacity regarding the budget (A2), environmental services (A6), support from watershed forums and ministries for watershed management planning (A4), and political policies (A3).

Utilization of groundwater (P2) with a particular zoning program to identify watershed conservation areas (A5), tree planting around the watershed (A1), environmental services (A6), support from the watershed forum and the Ministry for Watershed Management Planning (A4), political policy (A3), and fiscal capacity of the budget (A2). Groundwater conservation (P1) with a particular zone program to identify watershed conservation areas (A5), tree planting around the watershed (A1), environmental services (A6), fiscal capacity regarding the budget (A2), support from the watershed forum and Ministry for Watershed Management Planning (A4), and political policy (A3). Furthermore, it comes to the policy of controlling the destructive power of groundwater (P3) with a fiscal capacity program regarding budget (A2), environmental services (A6), support from watershed forums, the Ministry for Watershed Management Planning (A4), special zones to identify watershed conservation areas (A5), political policy (A3), and planting trees around the watershed (A1).

Conclusions

This study highlights a management policy design in Kupang City grounded in a participatory planning methodology. By offering different groundwater management scenarios, coupled with the policy guidelines needed for program execution and suggestions, this technique offers a solution that supports the interests of several stakeholders. According to the MULTIPOL assessment findings, the best policy in the integrated scenario is the groundwater information system policy (P4). A management scenario that is executed collaboratively and synchronized by all parties involved is known as an integrated scenario. The flagship program that supports this scenario is the establishment of special zones to identify the watershed conservation areas (A5). This policy regulates the involvement of stakeholders in their respective roles based on coordination; therefore, it can overcome the sectoral egos that have occurred so far.

In individual scenarios, each stakeholder can control the destructive power of groundwater (P3) with priority programs in this policy, namely fiscal capacity regarding budget (A2), environmental services (A6), support from watershed forums, and ministries for watershed management planning. (A4), a special zone to identify watershed conservation areas (A5), political policies (A3), and the planting of trees around the watershed (A1). The proposed policy framework provides flexibility to the decision-making process. Prioritizing policy decisions based on appropriate options for every future scenario is necessary to ensure sustainable implementation of groundwater management regulations in Kupang City. In addition, the study relates to the complicated process of public participation in groundwater management in Kupang City, which involves the interplay of policies, actions, and situations. This study considers activities or programs suited for groundwater management in many contexts rather than focusing on a single policy linked to a single program.

Author Contributions

AB: Conceptualization, Methodology, Software, Investigation, Writing & Editing; **SS**: Investigation, Review & Editing, Supervision; **SKS**: Review & Editing; and **RLK:** Review & Editing.

Conflicts of interest

There are no conflicts to declare.

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