Decision support system in determining the priority of disaster mitigation infrastructure development in villages level using the Simple Additive Weight (SAW) method

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Abstract. Disasters are a global problem now. Particularly in Indonesia, disaster management has entered a new paradigm, from previously only focusing on emergency response activities and using mitigation and preparedness approaches. Mitigation and preparedness are carried out when a disaster does not occur. Disaster mitigation or mitigation needs to be integrated with disaster risk reduction efforts into development for the sake of sustainability and mainstreaming disaster risk reduction into village program and activity planning. In other words, a disaster risk analysis must be one of the bases in planning sustainable development. The construction of facilities and infrastructure for disaster management is also one of the priorities in village development. However, village infrastructure development planning that has been implemented has not yet considered the disaster management aspects. In this study, a decision support system model (simple additive weight, SAW) was designed, which considers aspects of disaster management that are integrated into the village development planning process.

1. Introduction

Most of the territory of the Republic of Indonesia is a disaster-prone area. There are at least 12 disaster threats in Indonesia. Those disasters are classified into geological disasters (earthquakes, tsunamis, volcanoes, land movement/landslides), hydrometeorological disasters (floods, flash floods, droughts, extreme weather, extreme waves, forest, and land fires), and anthropogenic disasters (epidemic outbreaks, disease, and technology-failure, industrial accidents). According to the Indonesian Disaster Risk Index, in 2013, there are 205 million people live in disaster-prone areas [1]. Disasters arise when a threat meets vulnerable people who have low or no capacity to respond to the threat. Combining the two causes of the disruption of people's lives, such as the destruction of houses, property damage, and
casualties [2]. For this reason, people who are vulnerable to disasters should be the main actors in disaster mitigation planning in their area.

Indonesian Law No. 24/2007 on Disaster Management states that people have the right to be actively involved in disaster management efforts in their communities. This is in line with Indonesian Law number 6/2014, better known as the Village Law, which prioritizes development planning in the village with the bottom-up process, no longer to the central government or regional government's top-down approach. Therefore, village authority mandated by the law can strengthen the Village community as development subjects [3], no longer as development objects like the previous era.

Disaster mitigation infrastructure can be budgeted for by the village government and included in the Village Government Work Plan (Rencana Kerja Pemerintah, abbreviated as RKP), which is prepared annually for development planning to be realized on the following year. The development planning cannot be decided and determined just like that but is determined through a consultation process known as the Village Development Planning Consultation (Musyawarah Perencanaan Pembangunan, abbreviated as Musrenbang) [4]. A village development plan that is according to the mandate of the Village Law is determined by the quality of the village consultation. Based on Tresiana & Duadji's research results [5], which shows that the village development planning meeting is only an annual routine agenda and is still a formality. Substantively, the Musrenbang village does not reflect the agenda, problems, and needs of the villagers. Also, the community has not been able to access their proposal for Musrenbang at the next level directly. The main obstacle in village development planning meetings is the lack of involvement of elements/stakeholders at the village level. The village Musrenbang is only arranged by a part of the elite in the village. The proposed program is also biased towards the interests of the village elite [5].

For this reason, the decision-making system is critical in determining the disaster-mitigation infrastructure development-plan in the village. So that it can produce development programs that are by community needs and village conditions. Development planning based on the results of determining priority options for activities will create effective rural development [6]. This decision-making system is expected to be one of the guides for the community and village government in ranking activities according to their priorities, without eliminating the concept of deliberation and consensus.

2. Decision-making system & simple additive weighting method

A decision support system (DSS) is a computer-based information system that combines models and data to support decision-makers in solving semi-structured problems or dependency problems that involve the user in-depth [7].

Multiple Criteria for Decision Making (MCDM) is a method or method used to determine the best alternative or choice from several options based on specific criteria used for limits or standards in making decisions. MCDM is divided into two based on its objectives: MADM (Multi-Attribute Decision Making) and MODM (Multi-Objective Decision Making). The main difference between the two is that MADM is used to determine decisions or choices from a limited/discrete number of alternatives. In contrast, in MODM, it is used for continuous/continuous problems, such as mathematical programming problems.

There are many types of decision-making systems that can be used according to the context of the case/problem at hand. For this research, the SAW method is used where this method is a method that
is widely used in decision making, which has many attributes [8]. Fishburn and MacCrimmon in [9] were suggesting that the Simple Additive Weight (SAW) method is often known as the weighted addition method. The SAW method's basic concept is to find the weighted sum of the performance ratings for each alternative on all attributes.

2.1. System model

The decision support system model is developed with integration with the village development planning process. In general, the flow of the infrastructure activity ranking process using the SAW method is shown in Figure 1 below, uses several forms in its application.
2.1.1. Village consultation

The initial stage in ranking using the SAW method began with the holding of village consultation for RKP. The Village Consultative Body (Badan Musyawarah, abbreviated in Bahasa as Bamus) holds village consultation to prepare the Village Government Work Plan (RKP). In West Sumatra Province, village consultation meetings are generally called Musyawarah Nagari (abbreviated in Bahasa as Musnag).

In this village consultation, representatives of village community elements are invited to gather aspirations and activity proposals from the community. This proposal from the community is the basis for the preparation of the village’s RKP document and becomes alternative data for ranking with the SAW method. Community proposals in village infrastructure development are recorded as alternative data for activities to be ranked. After collecting all community proposals, it is followed by the consultation meeting to agree on the criteria and weight of the criteria used in ranking the infrastructure activities in the village. The form used at this stage is a form, namely the Criteria and Weight Criteria Data form, as shown in the Table 1 below.

### Table 1. Data criteria and weights of criteria

| Code | Name Criteria                                             | Weight |
|------|-----------------------------------------------------------|--------|
| C1   | Earthquake Disaster Management                           |        |
| C2   | Flood Disaster Management                                |        |
| C3   | Landslide Disaster Management                             |        |
| C4   | Drought Disaster Management                               |        |
| C5   | Tornado Calamity Relief                                  |        |
| C6   | Fire Disaster Management                                  |        |
| C7   | Epidemic Disaster Management and Disease Outbreaks       |        |
| C8   | Priority Based on Benefits                                |        |
| C9   | Priority Based on community participation.               |        |
| C10  | Priority Based on Sustainability                          |        |
| C11  | Priority Based on the Assurance of Supervision           |        |
| C12  | Based on village typology                                |        |

There are 12 basic criteria for ranking village infrastructure activities. These criteria are coded C1 to C12 and can be continued to as many as criteria desired or agreed upon by the community. According to the Statistic Bureau, the criteria C1 to C7 are disaster management following the
potential for disasters in the area [10]. Meanwhile, the criteria C8 to C12 are priority aspects of development according to the Village Law. These twelve essential criteria are not binding, only as an initial guide for the village community in determining criteria. The community can add or subtract criteria according to mutual agreement.

In addition to agreeing on the criteria, the weighting of each criterion is also carried out. The weight of the criteria is given in a score range of 0 (zero) to 10 (ten). The rule that the greater the weight, the more important the criteria/priority. With the record, no criteria have exactly the same weight.

2.1.2. Field verification. The next stage is field verification carried out by a team called the RKP Team. The RKP team is a team that consists of 7 to 11 members formed by the Village Head or Wali Nagari. The RKP team is tasked with compiling and formulating the RKP, including ranking activities, which will later be presented at the Musrenbang forum.

Before compiling the RKP, the RKP Team verifies the location of the proposed development activities. In the field verification process, previously, the RKP Team only gave the value of 'appropriate' or 'unfit' for the proposal's location to be included in the RKP of the village. However, in the SAW method, the RKP Team was given a form, which is used to assess the construction location according to the conditions in the field and assess its relationship to the ranking criteria agreed upon in the previous village meeting (Musnag). On the form, there is a value column with five grade levels. The RKP team marks the value column based on the site conditions' suitability with the required criteria. The survey results are then entered into a matrix table.

2.1.3. Formulation of RKP After that, the alternative activity assessment matrix is multiplied by the weight of the criteria previously agreed upon at the RKP Village Consultation. The RKP design formulation can be done through the activity ranking matrix.

Furthermore, the alternative assessment matrix is multiplied by the weight of the criteria previously agreed upon at the RKP village consultation. The RKP design formulation can be done through the activity ranking matrix.

2.1.4. Village development planning consultation (Musrenbang). The final stage the RKP Team carried out is the compilation of ranking results that were sorted from the first rank to the last rank. The ranking results are compiled using a form.

At the village development planning stage, the RKP Team presents the rankings to the village community and then together with the community to agree on the ranking results that have been compiled by the RKP Team.

3. Research methodology

This research was conducted in three Nagari or villages in Pancung Soal Subdistrict in the South Coastal District, West Sumatra Province. The Nagari or villages are Nagari Inderapura Barat, Nagari Inderapura Selatan, and Nagari Inderapura Tengah. These three Nagari are villages with the largest area in the Pancung Soal sub-district. In this paper, only the results and discussion from Nagari Inderapura Selatan are presented. The SAW method in decision making described in section 2 is applied to this village, using the process shown in Figure 1.
4. Results and discussion

This system has been implemented in Nagari Inderapura Selatan, Pancung Soal District, Pesisir Selatan Regency, West Sumatra Province.

4.1. Alternative data.

Alternative data is data on infrastructure activities that are planned to be implemented in 2020. Alternative data are obtained from the village Government Work Plan (RKP) Document for the 2020 fiscal year.

| Alternative Code | Alternative Activity                                         | Type of Infrastructure |
|------------------|-------------------------------------------------------------|------------------------|
| A1               | Build drainage culvert in Parit Miring                      | Drainage               |
| A2               | Rehabilitation of village health center in Sungai Kuyung    | Building               |
| A3               | Build office for kindergarten Harapan Bangsa                 | Road                   |
| A4               | Build roof and floor for PAUD (Early Childhood Education and Development) Asah Bundo | Building               |
| A5               | Build koran school in Nurul mosque                          | Building               |
| A6               | Drainage in Tapan Kecil                                    | Road                   |

For 2020, the people of Nagari Inderapura Selatan are proposing six activities in infrastructure development (Table 2). The proposals varied from building buildings, roads, culverts, and other types of infrastructure. Proposed activities are dominated by building construction.

4.1.1. Data criteria and weighting criteria  
Criteria and weight criteria data were obtained through the implementation of FGD. From the implementation of the FGD, the criteria and weight criteria data were obtained, as shown in Table 3 below.

| Code | Criteria Name                  | Weight |
|------|--------------------------------|--------|
| C1   | Earthquake Disaster Management | 8.5    |
| C2   | Earthquake Disaster Management | 10.0   |
| C3   | Landslide Disaster Management  | 7.5    |
| C4   | Drought Disaster Management    | 9.5    |
| C5   | Tornado Calamity Relief        | 5.0    |
Table 3 above shows that the most crucial ranking criterion in *Nagari Inderapura Selatan* is flood disaster management, with the highest score, namely 10. While the criteria that are considered unimportant or have the lowest points are tornado disaster management with a score of 5.

4.1.2. *Alternative weight data*. Each alternative activity was then assessed by conducting a survey directly by the surveyor and the drafting team for the RKP Nagari Inderapura Selatan. The data on the results of the alternative assessment of the proposed activities are entered into a matrix, as shown in Table 4 below. C1 to C14 are the ranking criteria, while A1 to A6 are surveyed proposed activities.

| Code | Criteria Name                                                                 | Weight |
|------|-------------------------------------------------------------------------------|--------|
| C6   | Fire Disaster Management                                                      | 7.8    |
| C7   | Epidemic Disaster Management and Disease Outbreaks                             | 9.0    |
| C8   | Priority Based on Benefits                                                    | 8.0    |
| C9   | Priority Based on community participation                                     | 8.6    |
| C10  | Priority Based on Sustainability                                              | 8.9    |
| C11  | Priority Based on the Assurance of Supervision                                | 9.6    |
| C12  | Based on village typology                                                     | 8.2    |
| C13  | Priorities Based on Improving the Quality of Education                        | 9.7    |
| C14  | Priority-based on the number of beneficiaries from the elderly group          | 8.8    |

**Table 4.** Alternative weight data for *Nagari Inderapura Selatan*

|   | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 |
|---|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|
| A1| 20 | 20 | 20 | 20 | 20 | 20 | 60 | 60 | 20 | 80  | 100 | 80  | 60  | 20  |
| A2| 20 | 20 | 20 | 20 | 20 | 40 | 100| 100| 80 | 100 | 60  | 100 | 80  | 100 |
| A3| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 80 | 40 | 80  | 60  | 100 | 100 | 20  |
| A4| 60 | 20 | 20 | 20 | 20 | 60 | 80 | 80 | 80 | 80  | 100 | 100 | 20  |     |
| A5| 20 | 20 | 20 | 20 | 20 | 40 | 40 | 100| 60 | 100 | 80  | 100 | 100 | 20  |
| A6| 20 | 100| 20 | 20 | 20 | 20 | 20 | 100| 80 | 60  | 100 | 100 | 20  | 40  |

4.1.3. *Ranking results with SAW* The activity alternative weight data matrix is then multiplied by each criterion's weight (Table 6) without being normalized first. This is to make it easier for the village/Nagari community to implement the ranking system using the SAW method. The multiplication of alternative weights and the criteria weights are then added up, and then the sums will be ranked. Activities that have the greatest value are the activities with the most priority, as seen in Table 5 below.
Table 5. Results of SAW ranking in Nagari Inderapura Selatan

| Criteria | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | Total | Ranking |
|----------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|--------|---------|
| Weight   | 8.5| 10 | 7.5| 9.5| 5  | 7.8| 8  | 8.6| 8.9| 9.6 | 8.2 | 9.7 | 8.8 |       |         |
| A1       | 170| 200| 150| 190| 100| 156| 540| 480| 172| 712 | 960 | 656 | 582 | 176   | 5244   | 6       |
| A2       | 170| 200| 150| 190| 100| 312| 900| 800| 688| 890 | 576 | 820 | 776 | 880   | 7452   | 1       |
| A3       | 170| 200| 150| 190| 100| 156| 180| 640| 344| 712 | 576 | 820 | 970 | 176   | 5384   | 5       |
| A4       | 510| 200| 150| 190| 100| 156| 540| 640| 688| 712 | 768 | 820 | 970 | 176   | 6620   | 3       |
| A5       | 170| 200| 150| 190| 100| 312| 360| 800| 516| 890 | 768 | 820 | 970 | 176   | 6422   | 4       |
| A6       | 170| 1000|150| 190| 100| 156| 900| 800| 688| 534 | 960 | 820 | 194 | 352   | 7014   | 2       |

The ranking of the Nagari Inderapura Selatan infrastructure development program for the 2020 fiscal year using the SAW method obtained results, as shown in Table 6 below:

Table 6. Nagari Inderapura Selatan Ranking Results

| Ranking | Alternative Code | Alternative Activity                                      | Type of Infrastructure |
|---------|------------------|---------------------------------------------------------|------------------------|
| 1       | A2               | Rehabilitation of village health center in Sungai Kyung  | Building               |
| 2       | A6               | Drainage in Tapan Kecil                                  | Road                   |
| 3       | A4               | Build roof and floor for PAUD (Early Childhood Education and Development) Asah Bundo | Building               |
| 4       | A5               | Build koran school in Nurul mosque                       | Building               |
| 5       | A3               | Build office for kindergarten Harapan Bangsa              | Road                   |
| 6       | A1               | Build drainage culvert in Parit Miring                    | Drainage               |

Table 6 shows that the priority for infrastructure development in Nagari Inderapura Selatan is the Rehabilitation of village health, drainage, and education facilities. This is because these infrastructure development activities meet the ranking criteria with the greatest weight, namely the criteria for Flood Disaster Management (weight 10), Epidemic Management and disease outbreaks (weight 9), and Improving the Quality of Education (weight 9.7).

After the alternative ranking process of activities was completed, in this study, questionnaires were distributed to find out people's opinions about the process and results of the SAW ranking method. The results of the questionnaire showed that previously the community was in doubt whether the results of the ranking so far have been based on the needs of the community or not; with the SAW method, the respondents were sure that the resulting ranking was based on the needs of the majority of
the village / Nagari community. In addition, the results of the questionnaire show that respondents are satisfied with the results of the ranking using the SAW method compared to the method used in the previous year.

5. Conclusion

In this study, the Simple Additive Weight (SAW) method was used in making decisions to determine decisions about activities to be carried out at the village level. The use of this method in Nagari Inderapura Selatan shows that this method is easy to use and can determine priorities well concerning community needs. In determining priority activities, the community has also paid attention to disaster aspects in their village.

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Acknowledgment

This paper is a part of a research funded by Kemenristekdikti and Universitas Andalas through Penelitian Tesis Magister (PTM)/ Magister Thesis Research scheme grant (contract number T/34/UN/16/17/PT.01.03/PKR-Kebencanaan/2019).