SUSTAINABLE RAINWATER RESOURCES MANAGEMENT POLICY TO SUPPORT WATER, FOOD AND ENERGY SECURITY

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ABSTRACT

Rainwater is the potential water resource that must be managed wisely, to meet the needs of water. The needs of water can be distinguished as: 1) clean water for household, 2) irrigation water for agriculture, to fulfil the food security, and 3) development of renewable energy. These needs have impacts on water availability, food security and renewable energy. This has been encouraging the study the sustainable rainwater resource management policies, which support water, food and energy security. The regional climatology studies are needed to determine the potential of rainwater that can be used to meet the need of clean water, agricultural and environmental water. These studies include: rainfall characteristics, to predict the potential and trends of the existing daily rainfall distribution; rainfall analysis to determine the potential available water from the rainwater management system. Secondly, it is necessary to study the suitability of land to ensure food security for the study-area. These studies include: land suitability studies by FAO’s agro-ecological zoning (AEZ) method, and the length of growing period (LGP) analysis to find the right planting period that provide optimal crop certainty and efficient water management. Thirdly, the study of renewable energy potential is carried out together with an analysis of rainwater resource management. Finally, a policy study is conducted to support the mass movement of rainwater resource management so that it can be sustainable. From the sustainable rainwater resources management policy supported by existing local wisdom, water is available to meet household needs, agricultural needs that produce food security, and the availability of renewable energy. This has an impact on the economic development of the study area, in making it an independent and prosperous area.

Keywords: Rainwater resources management, sustainable, water security, food security, energy security

1. INTRODUCTION

Rainwater is a potential water resource that can be developed to meet the need of water. Therefore, rainwater must be managed wisely, to fulfill different water needs, including:-

1) clean water to meet water needs in the household, such as drinking water, water for cooking, bathing and washing

2) irrigation water to meet water needs in agricultural businesses, namely food crops, which are the basis for fulfilling food, and water for the development of renewable energy. It can be said that water is a basic need that has an impact on food and energy security. This encourages a study to find the

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sustainable rainwater resources management policy that can support water, food and energy security.

It has been taken the Rukuramba Village, Ende Sub-District, Ende Regency, NTT Province, Indonesia, as an area of study (Figure 1). The river close to this village is the Lowo Nangaba River with its headwaters on Mount MbotuTendabonggi. The Rukuramba Village is a rural village that has an area of 8.74 km², consisting of 3 Hamlets, 5 RWs and 7 RTs. This village has a population of 954 people consisting of 449 men and 505 women, that has 228 households, with PLN electricity connections of 260 household connections. The village also has 1 of Kindergarten (20 students) and 1 private Elementary School (161 students), 1 Polindes, 1 Mosque, 1 Market, 24 Kiosks and 3 Food Stalls. In this village there are 89 motor-cycle and 9 cars owned by 81 residents (BPS Ende, 2018).

Figure 1. Rukuramba village (Google Earth, 2019)

The business of most people in the village is agriculture and livestock. The community plant a lot of cocoa, candlenut, coconut, banana, corn in the rainy season and vegetables in the home garden. While the livestock includes cows, pigs, goats and chickens.

2. METHODS

The study to find a sustainable rainwater management policy that supports food and energy security is carried out in a process step that consist of: regional climatology studies; agro-ecological zoning (AEZ) and length of growing periods (LGP); rainwater management and renewable energy potential analysis; as well as the sustainable rainwater management policy. This is shown in more detail in the figure 2.

Firstly, the regional climatology studies are needed to determine the potential of rainwater that can be used as clean water, agricultural and environmental water. These studies include: rainfall characteristics, to predict the potential and trends of the existing daily rainfall distribution; rainfall analysis to determine the potential available water from the rainwater management system.
Secondly, it is necessary to study the land suitability for agriculture of this study area, to ensure the food security of the area. These studies include: land suitability studies by FAO's agro-ecological zoning (AEZ) method, and length of growing period (LGP) analysis, to find the right planting period that provide optimal crop certainty and efficient water requirements. Thirdly, the study of renewable energy potential is carried out together with an analysis of rainwater resource management. Finally, a policy study is conducted to support the mass movement for rainwater resource management to make it sustainable.

2.1 Regional Climatology Studies

Regional climatology studies are intended to determine the potential of rainwater that can be used as clean water, agricultural water and environmental water. These studies include: climate data screens; rainfall analysis; and potential available water analysis.

The climate data screen is used to determine the feasibility of existing daily rainfall data. This test uses a data screening program (Dahmen et.al., 1981), which includes:

- a. Visual inspection of serial data plots
- b. Check for trends
- c. Variance stability check and mean (stationary)
- d. Examination of independence

The Spearman Rank Relationship method was used to find out for trends. This method is based on the Spearman’s Rank Correlation Coefficient ($R_{sp}$). The variance and mean (stationary) stability checks are carried out to determine data appropriateness, by using the t test (Student’s t distribution). For the independence check, a calculation is done by using the serial-correlation coefficient with lag 1, which is the correlation between adjacent observation data in the data series.

Further analysis of rainfall data is carried out to determine the amount of potential water availability that can be utilised. The analysis of rainfall data by position plotting method is done to determine the possibility of the magnitude of wet rainy years, dry
rainy years and normal rainy years, the potential water availability. An estimate of existing rainfall data can be found by plotting data on a probability graph. Data tabulation follows the formula:

\[ F_a = 100 \frac{m}{N+1} \]

\( N = \text{jumlah data} \)
\( m = \text{nomor urut} \)
\( F_a = \text{"plotting position"} \)

\[ P_{\text{av}} = \text{monthly average rainfall in the month } i \]
\[ P_{\text{dry}} = \text{monthly rainfall in dry years in month } i \]
\[ P_{\text{av}} = \text{annual average rainfall} \]
\[ P_{\text{dry}} = \text{annual rainfall at 80% is likely to be exceeded} \]

From the results of the analysis of wet, dry and normal rainy years, then potential water availability can be determined through topographic analysis of the study area.

2.2 Agro-Ecological Zoning (AEZ) And Length of Growing Period (LGP)

The land suitability analysis of the study area was carried out to ensure the food security. These studies consist of: land suitability analysis with FAO’s agro-ecological method, and an analysis of the length of the growth period (LGP) from FAO as well (FAO,1996) to find out the appropriate planting period that provides optimal crop certainty and water requirements efficient. Furthermore, alternative cropping patterns can be determined in the study area, so that the calculation of agricultural water requirements can be simulated using the CropWat 8 (FAO, 2009) program. In addition to agricultural water needs, household water requirements are also calculated based on the development of villagers, offices and industries such as tourism village.

2.3 Rainwater Management and Renewable Energy Potential Analysis

After knowing the potential of water availability and water needs, a water balance analysis is carried out to determine the necessary water infrastructure buildings. This infrastructure can be in the form of: rainwater storage ponds, runoff catching channels and rainwater conservation ponds or wells. These ponds are used to accommodate excess runoff during rainfall, and reuse it when there is no rain. If rainwater overflows above the required ponds, it is channeled into the conservation ponds to increase the recharge and reserves water into the soil.

For hilly topography, this water infrastructure building can also be used as a driving force for turbines, so as to produce renewable energy. For non-hilly topography, the use of these infrastructure buildings to drive turbines can also be done by utilizing the flow of water in existing channels.

2.4 Sustainable Rainwater Resources Management Policy

Finally, a policy study was carried out to support the mass movement of rainwater resource management, to make it sustainable. This study begins with exploring the potential of local wisdom in the study area, including: 1) the community's response to witnessing abundant rainfall, even potentially damaging the environment due to erosion and landslides, 2) efforts to get water during droughts, 3) agriculture developed so far, and so on. Furthermore, the dissemination of rainwater management options was carried out, and a dialogue to find regional policies to encourage the movement of rainwater management in the study area was initiated.
3. RESULTS AND DISCUSSION

3.1 The Rainfall Characteristic and Analysis

The rainfall characteristics of the study area, are shown as in the following figure.

![Figure 3. Paupanda rainfall station in the year of 1988-2016 (BMKG Lasiana, 2017)](image)

It is shown from the picture above, that the rainfall presented several changes in the rainfall intensity. The dynamics of rainfall intensity that occurred in the year of 2007-2016 were not as high as those that occurred in the year of 1998-2006. Furthermore, the dynamics that occurred in 1992-1997 were also lower than those that occurred in 1988-1991.

Analysis of rainfall to determine potential water availability is shown in the following figure and table.

![Figure 4. Plotting position analysis](image)
Table 1. The wet, dry and normal rainy years analysis

<table>
<thead>
<tr>
<th></th>
<th>Pdry</th>
<th>Pwet</th>
<th>Pnor</th>
<th>Pav</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>760</td>
<td>1200</td>
<td>960</td>
<td>982</td>
</tr>
</tbody>
</table>

Formula for determination of wet rainy-year, dry rainy-year and normal rainy-year:

\[
\text{P}_{\text{dry}} = \frac{\text{P}_{\text{av}}}{\text{P}_{\text{av}}} \\
\text{P}_{\text{wet}} = \frac{\text{P}_{\text{av}}}{\text{P}_{\text{av}}} \\
\text{P}_{\text{nor}} = \frac{\text{P}_{\text{av}}}{\text{P}_{\text{av}}}
\]


3.2 Agro-Ecological Zoning (AEZ) And Length of Growing Period (LGP)

Land suitability of the study area was analysed from Ende sheet geological maps (Suwarna, et al 1989), as shown in figure 3. This area is fertile, and is suitable for various types of plants. The community has developed a lot of cocoa which is the hope of the village economy. In addition, there are many candlenut plants, which do not require much attention to the need for water. More water is needed for food crops such as: corn, green beans, peanuts, bananas, pineapple, papaya and vegetables, which are planted in the area of the household gardens.

- Tmn : Nangapanda Formation – sandstone, limestone, in some places marl lenses and intercalations, locally breccia and siltstone intercalations.
- Tmk : Kiro Formation – breccias, lava, sandy tuff and tuffaceous sandstone
- QTv : Older volcanic products – lava, breccia, agglomerate and sandy tuff, interbedded with pumiceous tuff or breccia

The analysis of length growth period is shown in figure 6-9.
From the LGP analysis for the year of 1988-2016, it can be determined that the first planting should begin in December. Furthermore, the analysis of agricultural water requirements and domestic water needs can also be done. The cropping pattern is shown in figure 10 and the irrigation water requirement is shown in figure 11.
The Rainwater Resources Management

As a sample for rainwater management on a household scale, a total area of 200 m² is taken. The analysis results are shown in Table 3. The simulation was done for a family (5 people) with a land area of 200 m², with a house building of 100 m² and a garden of 100 m², cultivating agriculture with cropping patterns and irrigation water needs such as in the Crop Wat simulation. From the water balance analysis, a capacity of 42 m³ is needed for the ponds. The ponds dimensions can be taken as:

\[ 3.5 \times 4.0 \times 3.0 \text{ m}^3. \]
3.4 The Impact of Rainwater Resources Management Policy

From the socialisation to the people of the Rukuramba village, it was realised by the community how valuable and important the runoff flow of rainwater was abundantly wasted. Therefore, the community agreed to implement a rainwater management system on their land so that their needs for water could be guaranteed.

The rainwater management systems in household-scale, will be built by the community themselves with stimulant funds will have an abundant impact. In this system for the operation and maintenance costs are personal responsibility.

4. CONCLUSIONS

From the sustainable rainwater resources management policy and supported by existing local wisdom, water is available to meet household needs, agricultural needs that produce food security, and the availability of renewable energy. This has an impact on the economic development of the study area, and making the study area an independent and prosperous area.

5. REFERENCES

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