Determination of Micro Watershed Model Based on Ecohydrology for the Management at Krueng Peusangan Watershed

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Abstract

The integration of sectors and regions between the management of natural resources and the watershed environment depends on two factors: the self–important and the ethnocentrism. This case becomes very complex for watershed management between district and province. Studying about soil and water management comprehensively in watershed needs the right approach. The Krueng Peusangan is categorized as degraded area with first priority by Indonesia government and need two decades to improve its situation. This study aims to identify the biophysical environment, water resources, social and institutional conditions of the people in Krueng Peusangan watersheds. Determining the micro watershed models based on the concept ecohydrology according to the site conditions of the watershed. Micro watershed location selected by the variable physical, economic and social in Krueng Peusangan based on the highest score. Data obtained from the primary data based on questionnaires given to communities and key informants from the relevant agencies. The results obtained a watershed model of integrated and sustainable watershed management of the Krueng Peusangan watershed through the development of micro watershed model based ecohydrology by considering aspects of social, economic, cultural and institutional capacities in and around the sub watershed. Further, the critical of natural resource in Krueng Peusangan can be minimized and corrected for maintaining a sustainable watershed conditions. Micro watershed location selected by the variable physical, economic and social in Krueng Peusangan based on the highest score is the subzone Lut Tawar, Krueng Ceulala, Krueng Simpo, and Teupin Mane. Elected district that is the District Bintang, District Ceulala, District Lut Tawar, District Pinto Rime Gayo, District Timang Gajah and District Peudada.

Keywords: Micro watershed models, social, economic, cultural, and eco–hydrology.

Introduction

One indicator that the dominant cause disruption of the hydrological functions of watersheds is the formation of critical lands. The stability of water production at several observation points in the watershed Krueng Peusangan slope downward and only on the upstream side of the observation that tends Landscape (Ichwana, et al., 2013) The trend shows that there are some sub–watersheds in Krueng Peusangan degraded. Micro Watershed (small catchment) is part of a sub–watersheds that respond directly to rain in case the system changes the function of production area of less than 5,000 ha which is used as a place to demonstrate the process participative natural resource management, forest and land rehabilitation, engineering conservation of soil and water, farming systems in accordance with land capability, social, economic, cultural and community institutions (Directorate General of land Rehabilitation and social Forestry, 2009).

Change of one physical parameter. Watershed will respond to changes in the watershed system. Physically, the micro watershed is part of the watershed that is belong to the order 1–3 where 1 is the order of the most upstream river flow (Strahler, 1979). Through eco–hydrology concept that focuses on the ecological processes that occur in the hydrological cycle and trying to take advantage of the process to improve the environmental sustainability (Zalewski and Wagner, 2005). Then the micro watershed can restore the degradation of water resources and the environment to the improvement of ecosystem services for the
community. So that eco-hydrology is the use of ecological to control hydrological processes and the otherwise, using hydrology to regulate ecological (Zalewski, 2010).

The complexity of the problem is the fragmentation pattern of use of natural resources in the watershed based on approach pattern watershed management and regional development. Problems on the major watershed associated with the quantity and quality of water. A small scale watershed is easily controlled and identified for its management. Therefore the aim of this paper is to determine the location of micro watershed at watershed Krueng Peusangan so it can be a consideration and also income for local governments, businesses and communities to be used in formulating policies and appropriate activities that provide a double benefit such as preservation of natural resources and the improvement of people's income.

Material and Methods

Research has been conducted in Krueng Peusangan watershed. Watershed Krueng Peusangan disgorge in Lake Laut Tawar located in Central Aceh district and flows approximately 88 km across the Bener Meriah district before it finally empties in Bireuen district. Has extensive 2,557.8 Km$^2$. Geographically, Krueng Peusangan watershed is at the position of East Longitude (EL) 96°21'12”– 97°02'40” and North Latitude (NL) 4°30'38”–5°16'34” (Figure 1).

![Figure 1. Krueng Peusangan watershed.](image)

For social data, economic and institutional created to shapefile (shp) to provide an overview in the form of a map in Krueng Peusangan watershed. Identification of site selection is done in accordance with standard guidelines directorate general. The scoring can be seen in Table 1.

On the Table 1 (code x1), the value for an area has condition such as: erosion, landslides, floods, degraded land, deforestation, land conflicts, low land productivity, high level of urbanization and poverty. If the issue appears only 2 issue means low risk, if 3–5 (moderate risk) and > 5 (high risk). Code of x2 is accessibility to the area of the capital city (Kabupaten). Code of x3 is quality of human resources to see people’s reliance on agricultural income. Code of x4 and x5 are adjusted to the observation area that is bad (not declined but less support), good enough (to accept and support), very good (ready to participate in both human and financial). Data obtained from the primary data based on questionnaires given to communities and key informants from the relevant agencies. While secondary data are maps and the physical condition of the watershed obtained from the Department of Forestry and watershed management of Aceh.

Results and Discussion

The vulnerability of flooding in the watershed Krueng Peusangan will be combined with the results of the questionnaire from the public to observe the environmental issues of the community. A value of 1 defines the danger of lower region flooding, a value of 2 defines the region flooding moderately and the value 3 is a region with high floods. Identification of the flood area is one of the indicators of the variable to set a model.
of micro watershed in Krueng Peusangan watershed. Flood–prone areas in sub watersheds Krueng Tawar and Lut Tawar at the upstream followed by the lower and middle reaches. In the upstream, especially in Ceulala, essentially a flood–prone areas. This is consistent with community reports that the area often floods in rainy season and some of the events that have been reported in the newspapers about the floods and landslides in the area. Krueng Peusangan watershed area is the widest part of the largest sub–watershed consists of three districts, Bireuen, Bener Meriah and Takengon. To determine the location of a model micro watershed which is one of the variables is the level of public revenue dependence on agricultural commodities. The public has a livelihood in agriculture.

<p>| Table 1. Determining Criteria of Micro watershed area model (MDM) Location And Measurement |
|---------------------------------------------|----------------------------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Code</th>
<th>Criteria Description</th>
<th>Attributes measured</th>
<th>Score</th>
<th>Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x1</td>
<td>The existence issues problems</td>
<td>a. two issues</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. 3–5 issues</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. &gt;5 issues</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. Distance from the town center &gt;40 km</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Distance from the town center 20–40 km</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Distance from the town center &lt;20 km</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>x2</td>
<td>Accessibility</td>
<td>a. &lt;30% RT income from agriculture</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>x3</td>
<td>The level of Community dependence on agricultural income</td>
<td>a. 30–70% RT income from agriculture</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. &gt;70% RT income from agriculture</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>x4</td>
<td>Potential support community, private and NGO against MDM</td>
<td>a. bad</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. good enough</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. very good</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>x5</td>
<td>Goverment support potential against watersheds</td>
<td>a. bad</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. good enough</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. very good</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

City center is center for district city. Krueng Peusangan watershed includes three district (Kabupaten), Bireuen, Bener Meriah and Takengon, so it has three main centers in the area to be viewed accessibility area of micro watershed models. To determine the location of the Micro watershed model of one variable is the level of public revenue dependence on agricultural commodities. The public has a livelihood in agriculture. The dependence of high society for agricultural land led to an area of land and water management needs.

Community potential support is needed for the success of watershed management in micro scale. Survey and results of questionnaires in all districts in the watershed Krueng Peusangan, The potential of the community in supporting model of micro–watersheds are divided into three categories: poor (1), moderate (2) and good (3). Issue presence obtained from the questionnaire and also data from Bappeda office to determine the issue of sub districts problem in Krueng Peusangan watershed. Issues cover issues such as the problems of flooding, landslides, degraded land, erosion etc. Micro watershed area model (MDM) is a development model of integrated watershed management in micro scale involving various stakeholders in a participatory and realization model of natural resource management (sustainable) is based on biophysical, social, economic, and institutional measured to be developed on a large scale.

Through this research produced the criteria and standard guidelines for management of natural resources in accordance with the conditions of the local watershed. To compile this micro watershed model, guided by the directives of RLPS director general rule no. 15/V–SET/2009. Selection criteria Physical from the Overlay map geology, land use, degraded land, to determine the critical lands overlay maps. Identification of the landslide area is one of the indicators of the variable to set a model of micro watershed in Krueng Peusangan watershed. slope, rock type, land cover, a map of erosion, a map of productivity, map management, to determine erosion hazard overlay soil type, slope and cover land.

Social Criteria culture technology of farming, Indigenous culture, Institutions, NGOs/NG, Norma of community, Criteria Economics Infrastructure (market, transport, roads), demographics (livelihood), farming (the type of commodity, farm livestock, fisheries, agro–forestry), income of Farmers and farm income, plant seed, Community preferences, market and marketing system, production, revenue, income per capita, economic institutions and information systems.
Of the provisions set out in accordance with the conditions in the watershed Krueng Peusangan, this research determined the five variables to determine the location of the micro watershed models based on the concept ecohydrology. The results obtained from scoring which has been settled. The highest scoring value is the location chosen for the location of the micro watershed. The location obtained from 12 sub–watersheds Krueng Peusangan which are only four that got the highest score, namely sub watersheds Lut Tawar, sub Krueng Ceulala watersheds, sub–watersheds Krueng Simpo, sub watersheds Teupin Mane. Selected for the District can be seen in Table 1 which certainly are in sub watersheds were selected for micro watersheds (Figure 2).

![Figure 2. The sub watersheds were selected for micro watersheds](image)

Though much research focuses on the interaction between ecology and hydrology has been applied in some time (Bonell, 2002), but the true integration (especially between related and coupled hydrological and ecological processes) remains incomplete. It is caused by what, how, where and the relationship of research to be, and what has been practiced still debated. That is why, the logic to adopt a persuade approach hydro–ecological has been done but the integration of the integration of hydrology and ecology still require further careful evaluation. Currently, ecologists and biologists seem to look at the question from the perspective of research and hydrologists from another perspective. Scientists are attempting to address and solve the same problem without looking at the science that is superior because of the absence of a clear theoretical understanding of the elements of these disciplines as the key to its success.

Eco–hydrology future prospects of the concept should be based on three principles, namely the framework, targets and methodology (UNESCO, 2004). Continuous management efforts become a major focus in the concept eco–hydrology. So through eco–hydrology approach can reduce environmental degradation, ensuring the sustainability of water, ecosystems, and society. For the success in applying the concept eco–hydrology the expert must have data as complete as possible about the object to be handled. Although it takes a long time in the recovery of nature such as the hydrological cycle so that the completeness of the data is very important. According to Zalewski (1997), instability of hydrological processes affecting the increasing of the global temperature as it is now. This is evident from the return stream that is straightened into a meandering natural, reopening again water retention areas such as swamps to absorb water at the conservation area, and planting mangroves in coastal areas (Maryono, 2005). A holistic approach is essential because of the availability of water depends on environmental conditions such as forests, rivers, land cover, and other natural components so that interventions should be cross–sectoral cross. Through micro watershed models, it can be determined in accordance with the conservation model watershed conditions.

Complexity is characterized by a variety of behaviors, which emerge from the system. Changes in land use is an important component of the concept eco–hydrology, but to predict the changing is difficult because of the scale and complexity of the interaction between eco–hydrological non–linear and the process of socio–economic, spatial and temporal scales are different. A framework of the Ecosystem Approach
system, has been developed for the purpose of providing information for sustainable development policy. Ecosystem Approach highlights the problem of managing change in complex systems when the change may involve unexpected changes.

One effort that can be done to address the threat on water resources and climate change issues is to regulate the use of land (Nasution et al., 2013). The main focus is on the management of water hydrology while the ecological protection of the ecosystem so that their integration will be achieved sustainable development. To cope with recent advances in the understanding of the interactions between climate, water, and soil biogeochemical management practices, such as reforestation and ecological restoration indispensable further studies of ecohydrology (Wang et al., 2012). If there is a paradigm shift, the research ecohydrology desperately need an interdisciplinary team to bridge the gap between the boundaries of the subject of applied science research in basic ecological or hydrological. Therefore, it is clearly indispensable original interdisciplinary approach that takes the first step to generate new insights into ecosystem hydrology and their interactions. So that in the future we can identify, provide integrated solutions with new issues in the management of water resources.

Conclusion

Forms of watershed management in an integrated Krueng Peusangan in this research through the development of model–based Micro watersheds ecohydrology to consider aspects of the social, economic, cultural and institutional capacities in and around the watershed. Based on these aspects locations watershed micro–elected based on physical variables, economic and social watershed areas Krueng Peusangan based on the highest scores were sub watersheds Lut Tawar, sub watersheds Krueng Ceulala, sub watersheds Krueng Simpo, sub watersheds Teupin Mane. Elected district that is the District Bintang, District Ceulala, District Lut Tawar, District Pinto Rime Gayo, District Timang Gajah and District Peudada.

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