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High conservation value approach in controlling water catchment area as a provider of environmental services

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Abstract. Catchment area is very important known for the protection of water resources as a provider of environmental services. Increasing population will increase water demand and the extent of land utilization. The purpose of this research is to determine the areas of high conservation value in the control of water catchment area at Peusangan Watershed as a provider of environmental services. One of the High Conservation Value (HCV) approaches is focused on water providers and flood control for downstream communities; and control of erosion and sedimentation. HCV is a spatial analysis, hence the use of multi-temporal satellite imagery and data processing using GIS plays an important role in the HCV assessment process. The results obtained, water catchment area in both natural and normal conditions 57.92%, getting critical 25.08% and rather critical, critical and very critical categories 17.0%. Sub-watershed in Peusangan Watershed area which has the largest critical area is Krueng Ceilala Sub-watershed (75, 56%) and Lut Tawar Sub-watershed (77.35%). Moderate Krueng Simpo Sub-watershed (35.44%) and Krueng Mane Sub-watershed (42, 17%). Krueng Ceulala Sub-watershed and Lut Tawar Sub-watershed is the upstream area of Peusangan Watershed which serves as a conservation area that needs to be kept in order to provide water availability in the transition and downstream Krueng Peusangan areas are to be maintained, as well as providing an impact in providing natural environment services and area that serves as water provider and flood controllers for downstream communities. The existence of water springs and rivers whose water has been utilized by the community is evidence that the area of watershed is high conservation value, due to the conversion of the land function that removes vegetation cover on the upstream causing functionality of the catchment area decreases.

1. Introduction

Catchment area is very important to be known for the protection of water resources as a provider of environmental services, especially in areas that have the function of catchment area. As the population increases, it will increase water needs and expand land use. This condition can be seen from the land use in Peusangan Watershed which currently leads to areas that are hydrogeologically a catchment area.

Based on the principle of sustainable development in terms of ecology, where in sustainable development is applied through the mixed land with the utmost, noting the existence of green open space, transportation systems and interconnected development and limiting the expansion of the city excessively [1], it takes effort to keep the catchment area so that future water needs can always be fulfilled [2]. Floods, erosion and sedimentation can lead to changes in vegetation cover, river morphometry and natural landscape.

Currently, the negative impact has been disrupting Peusangan Watershed in providing natural environmental services. Changes in land use patterns with vegetation cover (forest, agriculture and plantation) to land with non-vegetation cover (settlements, industrial estates and road facilities) in large amounts in a fast time can lead to most of rainwater flowing as surface runoff and only a small portion of the water volume that enters the ground (water recharging) as ground water reserves during the dry season [3]. One of the problems in increasing the rate of erosion in Peusangan Watershed is caused by reduced forest area and decreased forest quality. [4] research results stated that changes in various patterns of land use in Peusangan Watershed, directly or indirectly, have caused land degradation in the area of Peusangan Watershed.

By considering aspects of groundwater conservation it is necessary to conduct research on the catchment areas in Peusangan Watershed. This research was conducted to determine areas with high conservation value in controlling the catchment area in Peusangan Watershed as a provider of environmental services. Thus the extent of damage in water catchment areas that can affect the function of water catchment areas on Peusangan Watershed as a provider of environmental services can be discovered. From the results of this research are expected that the management system of Peusangan Watershed in the future can be developed so that its function as a provider of environmental services is maintained.

2. Materials and methods

The method used in this study is a survey method.The purpose of the survey method is to perform observations, measurements and recordings based on the phenomenon and facts on the field factually. The survey method is used in determining soil texture data in Peusangan Watershed, while rainfall data, soil type data, slope data, rock type data and land use data are obtained from secondary data.

2.1. Location

Administratively the location of Peusangan Watershed is spread across Kabupaten Aceh Tengah, Kabupaten Bener Meriah, Kabupaten Bireuen, Kabupaten Aceh Utara and Kota Lhoksumawe, Aceh Province [5][6][7]. Covering respective sub-district areas are located in Kabupaten Aceh Tengah, Bener Meriah, Bireuen, Aceh Utara dan Kota Lhoksumawe, with an area based on interpretation of topographic maps of 2,558.78 Km^2. Peusangan Watershed is divided into 12 sub-watersheds, with the largest sub-watershed is Laut Tawar sub-watershed, which is 15.27%, followed by Timang Gajah sub-watershed, which is 14.04%. For more details can be seen in Table 1 below.

Table 1. Area of Sub-watershed in Peusangan Watershed

No	Sub-watershed	Area (Ha)	Percentage
1	Bawang Gajah	11,526.40	4.50%
2	Krueng Ceulala	23,944.15	9.36%
3	Krueng Meueh	12,214.37	4.77%
4	Krueng Peusangan Hilir	29,142.38	11.39%
5	Krueng Simpo	18,004.34	7.04%
6	Laut Tawar	39,060.91	15.27%
7	Teupin Mane	18,309.10	7.16%

No	Sub-watershed	Area (Ha)	Percentage
8	Timang Gajah	35,925.49	14.04%
9	Ulee Gle	8,973.98	3.51%
10	Wih Balek	13,373.21	5.23%
11	Wih Bruksah	32,648.19	12.76%
12	Wih Genengang	12,755.39	4.98%
	TOTAL	**255,877.91**	**100.00%**

Peusangan Watershed is a fairly extensive watershed intended for the provision of water resources. Peusangan Watershed plays an important role in people's lives, especially in socio-economic field. This region has strategic geographical potential to be developed. Therefore, all potential water availability in this region must be maximally utilized.

2.2. High Conservation Value (HCV)

Seeing the increasing level of environmental damage and the impact of unsustainable forest management within a watershed area, indicates the need for an action to address the issue. Some actions that can be performed such as mapping, identifying and assessing conservation areas with restrictions that cause an area to be considered important outside the protected area [8]. Therefore, Toolkit comes as a reference for establishing High Conservation Value areas (HCVs). HCV identification is very useful in the preparation spatial plan of district/provincial forest area spatial plan so that spatial planning will provide a balance between ecological, economic and cultural benefits [9].

One of the basic principles of the HCV concept is that when there are areas that have high conservation value attributes, it does not always have to be an area where development is not permitted. The HCV concept precisely requires that development can be implemented by ensuring maintenance and increasing the value of the HCV. Therefore, this concept is expected to be obtained a rational balance between environmental and social sustainability with long-term economic development [10].

Making HCV as the basis on preparing regional spatial plan will create ecologically friendly regional planning, environmental and social services. However, the implementation of the HCV concept, especially related to environmental service aspects on controlling water catchment area that does not in accordance with field conditions. Thus, to make HCV as a basis for the preparation of regional spatial area of a watershed, first of all it is necessary to conducted identification activities that refer to the Government Regulation and evaluate the ability of land so that its application in the field is in accordance with the functions and carrying capacity of the environmental.

2.3. Population

The population in this study is Peusangan Watershed soil type with the research object is soil texture with the biophysical parameters studied, i.e. rainfall, soil type, rock type, slope while the comparison parameter is land use.

2.4. Metode pengumpulan data

The method of data collection/sample is done by using direct observation in the field. In the data collection it is necessary to conduct observation activities around the location of the sample, such as that is to note that the sample is not a land of decay. Some secondary data is required before conducting research. Secondary data were obtained from government agencies, journal publications, the internet, or from previous research. Secondary data along with the functions and sources of data are presented in Table 2.

Tabel 2. Matrix of Type, Source and Use of Data

No	Type of Data	Source of Data	Use of Data
1	Map of Rupa Bumi Indonesia (RBI) Peusangan Watershed area, scale 1:100,000	Balai Pengelola DAS dan Hutan Lindung Krueng Aceh	The area and boundaries of Peusangan Watershed
2	Administration map of Kabupaten Aceh Tengah, Kabupaten Bener Meriah, Kabupaten Bireuen, Kabupaten Aceh Utara and Kota Lhoksumawe	Bappeda Aceh	Administrative boundaries
3	Map of Spatial Plan and Region of Aceh 2013-2033	Dinas Pekerjaan Umum dan Penataan Ruang Aceh	Land use
4	Soil Type Map	Balai Pengelola DAS dan Hutan Lindung Krueng Aceh	Soil sampling point
5	Slope Map	Balai Pengelola DAS dan Hutan Lindung Krueng Aceh	Rate of erosion
6	Land use Map 2009-2018	Balai Pemantapan Kawasan Hutan Wilayah XVIII Banda Aceh	Crop Index Determination
7	Population data of Kabupaten Aceh Tengah, Kabupaten Bener Meriah, Kabupaten Bireuen, Kabupaten Aceh Utara and Kota Lhoksumawe	BPS Aceh	Demographics and population growth rate
8	Rainfall data 2009-2018	Sta. Met. Kelas III Malikussaleh - Aceh Utara BBMKG Wilayah I Medan	Precipitation erosivity
9	Physical characteristics of soil	Soil sampling and laboratory analysis	Prediction of soil erosion
10	Rock graduation	Soil sampling and laboratory analysis	Prediction of soil erosion

2.5. Data Analysis Methods
GIS analysis with a tiered quantitative method with the result of data levels represented by water catchment conditions.

3. Results and discussion
3.1. Land Use
Dengan menggunakan citra satelit Landsat 7 ETM+ dan Landsat 8 yang didapat dari website USGS (United State Geological Survey), penggunaan lahan pada DAS Peusangan dapat dilihat pada Tabel 3 berikut. Using Landsat 7 ETM+ and Landsat 8 satellite imagery obtained from the USGS (United State Geological Survey) website, the land use at Peusangan watershed can be seen in Table 3 below.

Table 3. Land Use based on Sub-watershed on Peusangan Watershed

No	Sub-watershed	Forest	Protected Forest	Production Forest	Limited Production Forest	Mix Plantation	Open Space	Plantation	Settlement	Wetland Agriculture	Dryland Agriculture	Livestock	Swamb	Shrub	Hunting Area	Pond	Waterbody	TOTAL
1	Bawang Gajah		2,965.98					4,513.71	16.73	1,072.80	2,957.18							11,526.40
2	Krueng Ceulala		12,985.19					8,529.58	21.27	900.66	1,507.45							23,944.15
3	Krueng Meueh	5,682.74		30.02		1,006.39					1,145.40			4,349.82				12,214.37
4	Krueng Peusangan Hilir						482.27		839.33	5,317.40	19,518.89		69.60	473.71		2,425.95	15.23	29,142.38
5	Krueng Simpo	2,719.68		901.95		339.57	178.38				7,018.31			6,846.45				18,004.34
6	Laut Tawar		11,838.05					11,022.64	1,252.13	3,763.40	1,476.84	37.30		307.84	3,401.12		5,961.59	39,060.91
7	Teupin Mane	3,671.22		77.34			29.88	103.65		36.07	12,911.10			1,479.84				18,309.10
8	Timang Gajah		8,936.65	1,322.77				357.66	224.12	519.14	12,022.98			12,542.18				35,925.49
9	Ulee Gle								94.40	693.08	6,958.58			716.38		511.53		8,973.98
10	Wih Balek		1,087.87	247.44				2,534.00	335.00	2,581.65	2,535.74			4,051.50				13,373.21
11	Wih Bruksah	1,103.23	14,743.04	9,198.04	1,802.41			1,384.70			4,416.78							32,648.19
12	Wih Genengang	3,214.15	89.93	3,834.99	5,011.54			11.54			83.80			509.44				12,755.39
	TOTAL	**16,391.02**	**52,646.71**	**15,612.54**	**6,813.95**	**1,345.96**	**690.53**	**28,457.46**	**2,782.97**	**14,884.21**	**72,553.07**	**37.30**	**69.60**	**31,277.18**	**3,401.12**	**2,937.48**	**5,976.83**	**255,877.91**

From the table above, it is known that the Peusangan Watershed is dominated by *Dryland Agriculture* at 28.35%, followed by *Forest* and *Protected Forest* at 26.98%. The settlement only uses 1.09% of the total 255,877.91 Ha area of the Peusangan watershed and concentrated in Bawang Gajah, Krueng Ceulala, Krueng Peusangan Hilir, Laut Tawar, Timang Gajah, Ulee Gle and Wih Balek Sub-watershed.

3.2. Water Catchment Conditions and HCV Suitability

Lithology data, soil type data, slope slope data and precipitation average data to produce natural infiltration data. Land use data is a non-natural infiltration data. This two infiltration are overlaid so that the water catchment data is obtained. Natural infiltration data and processed land use data then compiled into one data. The results based on infiltration suitability can be observed in the following Table 4.

Table 4. Results of Infiltration Data Compilation at Peusangan Watershed (Ha)

Sub-watershed	Very Critical	Critical	Rather Critical	Critical Start	Natural Normal	Good	TOTAL
Bawang Gajah	6.35	73.66	534.09	3,352.45	3,665.82	3,894.02	11,526.40
Krueng Ceulala	278.73	1,759.78	5,809.93	10,244.08	3,555.84	2,295.79	23,944.15
Krueng Meueh			610.01	588.18	2,927.48	8,088.70	12,214.37
Krueng Peusangan Hilir			1,946.15	7,445.04	17,571.14	2,180.04	29,142.38
Krueng Simpo		2,070.19	2,238.10	2,071.33	5,413.56	6,211.16	18,004.34
Laut Tawar	1,352.10	8,252.01	7,669.90	12,941.82	3,060.36	5,784.71	39,060.91
Teupin Mane		1,699.94	2,619.15	3,402.40	6,878.50	3,709.12	18,309.10
Timang Gajah		215.20	590.82	4,686.74	18,040.06	12,392.68	35,925.49
Ulee Gle			347.24	4,194.86	3,035.42	1,396.46	8,973.98
Wih Balek	11.95	139.59	74.52	310.74	3,873.56	8,962.84	13,373.21
Wih Bruksah		594.51	3,191.35	11,064.01	8,334.57	9,463.75	32,648.19
Wih Genengang		9.88	1,278.28	3,833.22	3,545.34	4,088.67	12,755.39
TOTAL	**1,649.14**	**14,814.75**	**26,909.54**	**64,134.87**	**79,901.67**	**68,467.94**	**255,877.91**

From the table above, the results of the water catchment area in good and natural good conditions are 57.92%, the critical start category is 25.08% and rather critical, critical and very critical categories are 17.0%. Sub-watersheds in Peusangan watershed which have the largest critical area are Krueng Ceulala Sub-watershed (75.56%) and Laut Tawar Watershed (77.35%), while Krueng Simpo Sub-watershed (35.44%) and Krueng Mane Sub-watershed (42.17%) are moderate. Land capability classification is systematic assessment of land components and grouping into various categories based on the characteristics that constitute potential and obstacles in land use. Krueng Ceulala sub-watershed and

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Laut Tawar sub-watershed are the upstream areas of Peusangan watershed, which serves as a conservation area that need to be kept in order to provide water availability in the transitional and downstream areas of Peusangan watershed, as well as providing an impact in providing natural environmental services and areas that serve as water and flood controllers for downstream communities. The existence of springs and rivers whose waters have been utilized by the community is proof that the Peusangan watershed is a HCV area.

4. Conclusions

The results of the research analysis can be concluded that the water catchment condition on Peusangan watershed, there are six conditions of water catchment, *Good* condition 26.67% dominated by Timang Gajah Sub-watershed 4.84%, *Natural Normal* 31.23% dominated by Timang Gajah Sub-watershed 7.05%, *Critical Start* 25.06% dominated by Laut Tawar Sub-watershed 5.06%, *Rather Critical* 10.52% dominated by Laut Tawar Sub-watershed 3.00%, *Critical* 5.79%, dominated by Laut Tawar Sub-watershed 3.22%, and *Very Critical* 0.64% is dominated by Laut Tawar Sub-watershed 0.53%. The ability of natural infiltration in Peusangan watershed is "Medium" with a percentage of 57.98% in normal natural and good conditions.

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