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The effect of land cover forest on fluctuations in availability of water in the Batutegi Dam, Lampung, Indonesia

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Abstract: The Sekampung Hulu watershed has an important role in Lampung Province, as a catchment area for the Batutegi Dam with the main function as a supplier of irrigation water therefore it is very dependent on the availability of water (inflow). The inflow fluctuation is one of the indicators to determine the hydrological condition. The relationship between forest cover and inflow fluctuations was obtained from forest cover analysis on Landsat images using the object-oriented classification (OOC) method and inflow fluctuation analysis, followed by regression analysis between them. The results showed that the total inflow value in 2005 - 2020 is fluctuated with the lowest total inflow value of 6862.243 m³/S in 2015 and the highest value of 9296.141m³/S in 2020. Inflow fluctuation from 2005-2020 was included in the low and moderate category. The condition of forest cover in the Sekampung Hulu watershed in 2005-2020 has increased and decreased in each period. Analysis of the relationship between forest cover and inflow fluctuations is a significant with a p-value of 0.092 with a 90% confidence level. The results showed that the condition of forest cover greatly affects the stability of the water availability of the Batutegi Dam.

1. Introduction

The Sekampung Hulu watershed is a water catchment area for the Batutegi dam which has the main function as a provider of irrigation water in Lampung Province. Currently, based on data from the Lampung XX forest area consolidation center, land cover conditions in the catchment area of the Batutegi Dam, is the Sekampung Hulu watershed, experienced a 5.6% decrease in forest land area for the period 2005-2018. Conditions of land cover and use in an area reflect the natural and socio-economic conditions of the region and their use in terms of time and space [1]. The dynamics of land cover and use is a process that is widespread, rapid and significant by human activities related to space and time. Based on research, deforestation is the main factor causing land cover change in Indonesia [2]. Human activities drive the dynamics of land cover and use, which is a comprehensive, rapid and

significant process. LULC change analysis is one of the most appropriate techniques to understand how land was used in the past, what kinds of changes are expected in the future [3]. Conditions and characteristics of land cover and use in the watershed have a direct influence on downstream conditions and the availability of dam water resource potential [4].

Forests have an important role in maintaining the balance of the watershed ecosystem, because it will affect the hydrological processes that occur in a watershed. Forests have the ability to act as sponges, which absorb rainwater in the rainy season and release it slowly during the dry season. Land use conditions in the Sekampung Hulu watershed will affect the hydrological conditions of the Batutegi dam, one of which can be known by looking at the value of inflow fluctuations. Forests play a role in preventing flooding during the rainy season so that if there is forest conversion, it will increase the value of inflow fluctuations. The purpose of this study is to see how forest cover affects inflow fluctuations in the Batutegi watershed from 2005 to 2020. In the context of making decisions on the rehabilitation and management of the Sekampung Hulu watershed, this research is expected to provide input and advice for policymakers and other stakeholders.

2. Materials and Methods

2.1. Area Stud

This research was conducted in February 2021. The location of this research is in the Sekampung Hulu watershed and the Batutegi Dam in the Tanggamus Regency area. Geographically, the Sekampung Hulu watershed is located at 05°05'50"S and 104°30'34"E to 05°16'33"S and 104°49'14"E with an altitude between 175 m to 1,775 m above sea level, with an area of 42,400 ha. (Figure 1).

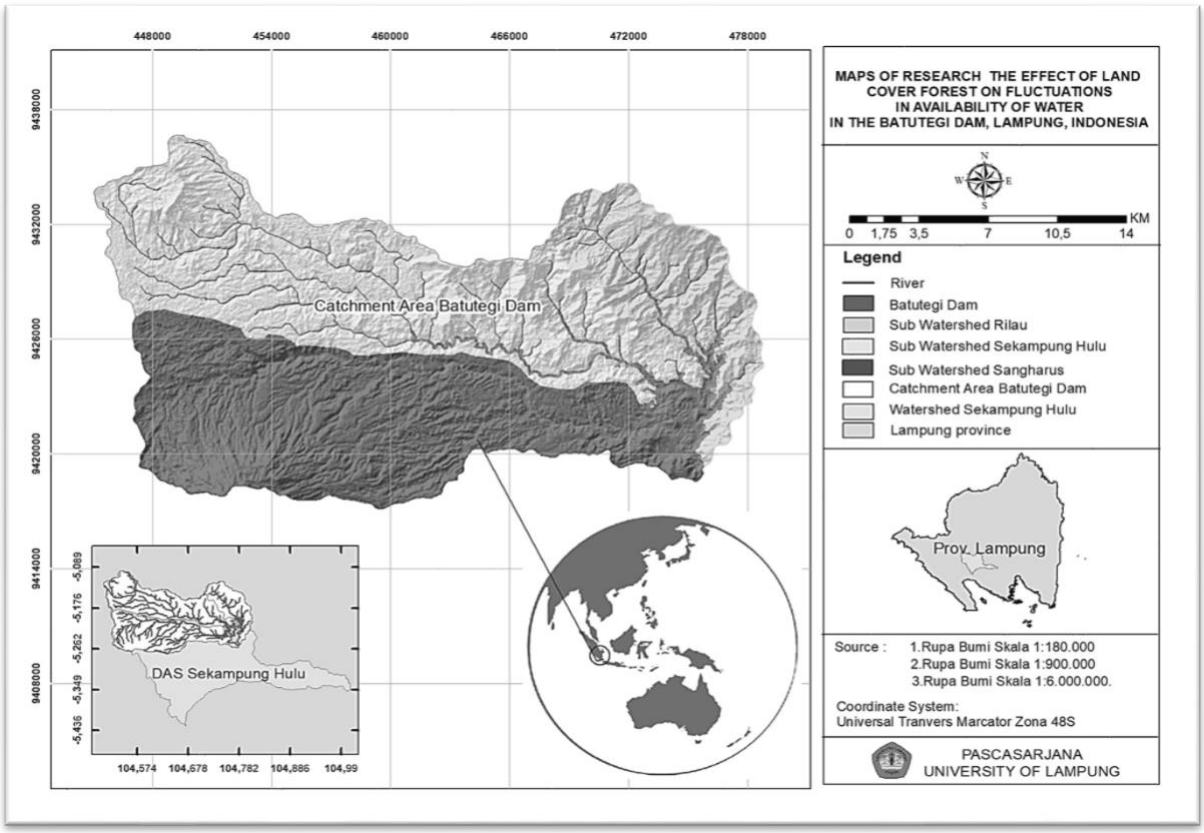

Figure 1. The Map of Research.

2.2. Research Tools and Materials

The study uses tools such as the Global Positioning System (GPS), cameras and supporting software including ArcGIS 10.4 and Microsoft Excel. The research materials used are rainfall data, inflow data and land use maps in the Sekampung Hulu watershed in 2005 and 2020 from the classification of Landsat ETM +5, ETM +7 and Lansat ETM +8 satellite imagery images 124 64

2.3. Forest cover and use analysis

Forest land cover analysis using eCognation Developer software and Arc GIS 10.4. land cover and land use classification on Landsat ETM +5, ETM +7 and Lansat ETM +8 path row 124 64 satellite images using the Object Oriented Classification (OOC) method to produce data on forest land cover in the Batutegi dam water catchment area for the period 2005 to 2020 i.e. 2005,2010,2015 and 2020.

2.4. Inflow Fluctuation Analysis

Analysis of inflow fluctuations in 2005-2020 by comparing the maximum inflow value with the minimum inflow for one year. The formula for calculating inflow fluctuations and categorizing inflow fluctuations is based on Permenhut P.61/Menhut-II/2014 [5].

$$\text{Inflow Fluctuation (KRA)} = \frac{Inflow\ Maximum}{Inflow\ Minimum}$$

Tabel 1. Categorization of Inflow Fluctuation Value (KRA)

Grade	Category	Score
KRA≤ 20	Very low	0,5
20 < KRA ≤ 50	Low	0,75
50 < KRA ≤ 80	Medium	1
80 < KRA ≤ 110	High	1,25
KRA > 110	Very high	1,5

2.5. Analysis of the Relationship between Forest Cover and Inflow Fluctuations (KRA)

Simple linear regression analysis was used in the study to see the relationship between forest cover and inflow fluctuations so that the relationship between the two was obtained. Simple statistical analysis between forest land cover area and fluctuations in water availability of the Batutegi dam (inflow) in 2005-2020 using Microsoft Excel software.Y= a+bx

3. Results and Discussion

3.1. Forest Cover Analysis

Based on the interpretation of Landsat ETM +5, ETM +7 and Lansat ETM +8 satellite images, the catchment area of the Batutegi dam is 42,400 ha consisting of 3 sub-watersheds, namely the rilau sub-watershed, the sangharus sub-watershed, and the sekampung Hulu sub-watershed. The condition of forest land in the catchment area of Batutegi Dam based on BPDASHL WSS data (2020) the forest area in that area always tends to decrease due to land conversion. The results of the classification of forest cover in the Batutegi dam catchment area from 2005 to 2020 obtained through land cover analysis using Landsat imagery can be seen in table 2.

Table 2. Forest Coverage Area of Batutegi Dam Catchment Area 2005-2020

Year	Forest Area	
	Hectares (Ha)	Percent (%)
2005	17777,22	41,93
2010	12647,12	29,83
2015	14014,51	33,05
2020	11034,61	26,03

The forest cover area in the catchent area of the Batutegi Dam experienced a significant change from 2005 to 2020, which decreased by 15.9%. Based on previous research in the Sekampung Hulu watershed, there was a change in forest land into agricultural land, and settlements [6]. The condition of forest cover in the Batutegi Dam water catchment area for the period 2005 - 2020 by classifying Landsat imagery in 2005, 2010, 2015 and 2020 experienced a decrease and increase in forest area from 2005 to 2010 the forest area decreased by 12.1%, in 2010 -2015 the forest area has increased by 3.22% and in 2015-2020 it has decreased again by 7%. Changes in land cover from natural cover to agrosystems are related to increasing human and livestock pressure, in this case deforestation due to the expansion of agricultural land which needs attention to maintain ecosystem stability and sustainability [7].Visually, a map of forest cover in the catchment area of the Batutegi dam can be seen in (Figure 2)

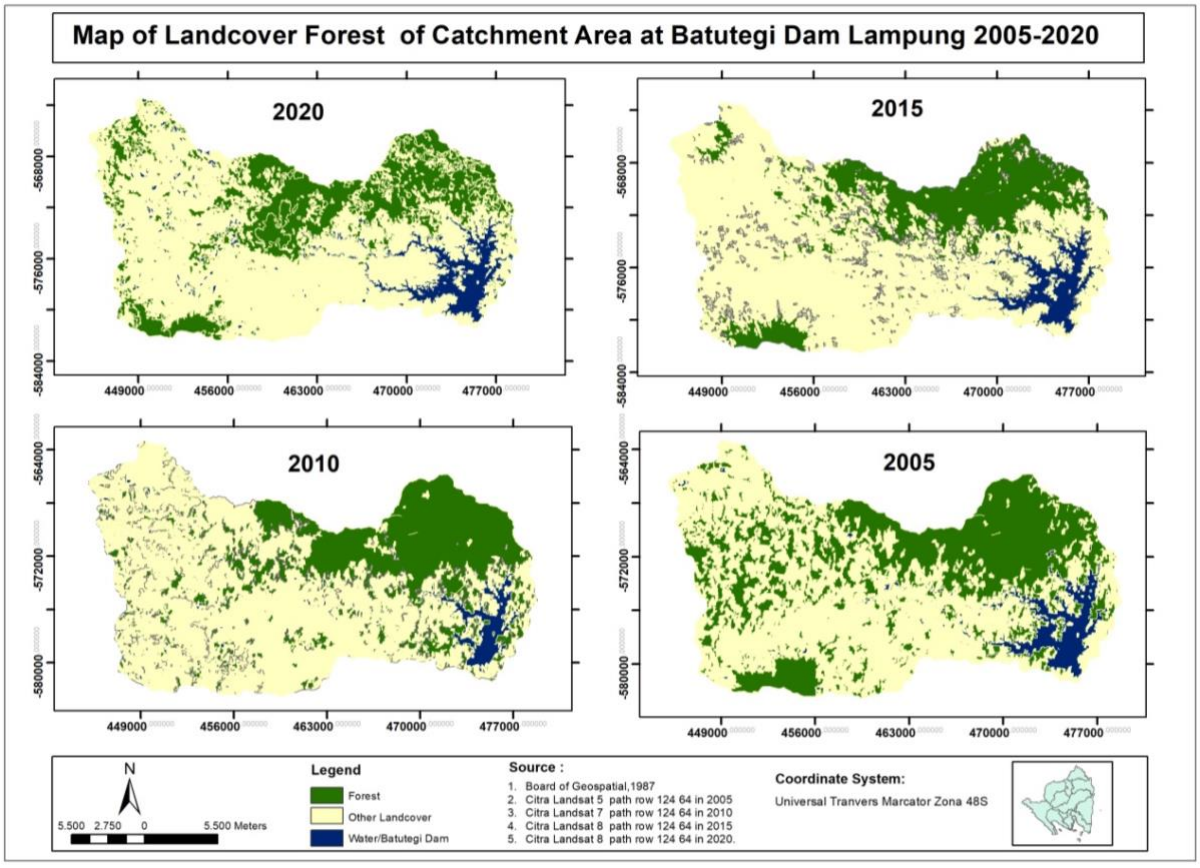

Figure 2. Map of Landcover Forest of Catchment Area Batutegi Dam.

3.2. Inflow Analysis

Inflow is the amount of water entering/availability of water from river water, rainwater, and springs [8]. The level of water availability (inflow) in a dam or dam is a very decisive factor in providing irrigation water for plant needs, especially in the dry season and as a guarantor of the availability of raw water [9]. The inflow data obtained from the Mesuji-Sekampung River Basin Center (BBWS-SM) can be seen in Table 3.

Table 3. Batutegi Dam Inflow 2005, 2010, 2015 and 2020.

Total Montly Inflow (m^3/S)				
Year	2005	2010	2015	2020
January	1179.730	631.190	1023.875	851.220
February	967.123	1073.179	1154.620	771.797
March	981.322	1134.909	1061.861	1170.594
April	742.284	725.762	878.675	1242.630
May	554.004	547.854	637.695	1421.398
June	679.309	473.206	526.196	948.150
July	465.026	492.122	313.060	659.470
August	326.336	586.725	248.166	489.514
September	417.808	692.752	217.101	385.178
October	263.466	702.137	143.590	333.366
November	394.282	312.618	201.575	493.042
December	259.231	824.226	455.829	529.783
Amount	7229.920	8196.681	6862.243	9296.141
Average	602.493	683.057	571.854	774.678

Based on the inflow data in table 3, the highest inflow occurred in May 2020, namely 1421.398 m3/S while the lowest inflow value occurred in October 2015 which was 143.590 m^3/S. Average monthly inflow in one year, the highest inflow occurred in 2020 at 774.678 m3/S and the lowest average monthly inflow in 2015 was 571.854 m^3/S.

3.3. Inflow Fluctuation

The calculation of the value of fluctuations in water availability (inflow) of the Batutegi Dam in 2005-2020 with a 5-year counting period, namely in 2005, 2010, 2015 and 2020, which is known by calculating the ratio of the maximum inflow and minimum inflow that occurs every year. The value of the Batutegi Dam inflow fluctuation can be seen in Table 4.

Table 4. Inflow Fluctuation Batutegi Dam in 2005, 2010, 2015 and 2020.

Year	Inflow (m^3/S)			Inflow Fluctuation (KRA)	
	Total	Maximum	Minimum	Value	Class Category
2005	7229.92	60.56	1.96	30.94	Low
2010	9380.72	101.07	2.07	48.87	Low
2015	6862.24	71.04	1.25	56.75	Medium
2020	8196.68	83.56	1.12	74.54	Medium

3.4. Regression analysis was carried out between forest land cover and fluctuations in debit

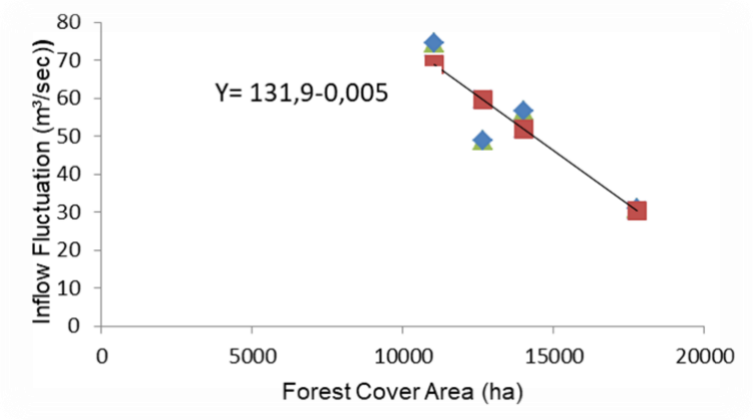

Figure 3. Relationship between Forest and Inflow fluctuation

Based on figure 3, it shows that if the forest area increases, it will decrease the value of fluctuations in the inflow that enters the dam. The condition of forest cover affects the watershed balance in maintaining the availability of water products which regulates fluctuations in discharge or in this case inflow, controls runoff, increases baseflow and reduces erosion and sedimentation. Forest conditions will affect inflow fluctuations in the rainy and dry seasons [10]. One of the indicators of watershed monitoring and evaluation is the value of fluctuations/KRA. The value of inflow fluctuation is obtained from the ratio between the maximum inflows to the minimum inflow, the ability to store water from an area is categorized as good if the inflow fluctuation value in the rainy and dry seasons is small. Discharge fluctuation as a key indicator of watershed system stability [11]. Land cover conditions from changes in land use will affect the ability of the land to accommodate rainwater that falls on the soil surface (infiltration) and surface runoff (runoff), so this will affect the inflow (inflow) as the volume of dam water availability.

Changes in land use, especially forest land, will greatly affect the runoff and infiltration conditions that occur. The amount of runoff and infiltration that occurs will affect inflow in the rainy season and dry season so that it will affect the Inflow Ratio in the rainy season and dry season. According to research, changes in forest land cover that turn into non-vegetative land cover will increase the maximum discharge in a watershed [12]. Deforestation leads to disruption of the hydrological cycle, resulting in a reduction in river flow once during the dry season, in the rainy season, the water discharge increases [13]. Changes in the use or cover of forest land will affect the environment so that it will have an impact on the contribution of the watershed for irrigation and power generation needs based on research changes in land cover patterns affect water quality [14].

4. Conclusions

Forest cover changes in the Catchment area of Batutegi Dam for the period 2005–2020 decreased from 41.93% to 26.03% and the value of inflow fluctuations increased from 30.94 in the low category to 74.54 in the medium category so that with a decrease in area the forest will increase the value of inflow fluctuations, which means that the hydrological conditions have disturbed the balance between maximum and minimum inflows. Based on the regression analysis, forest cover area has a significant effect on the value of inflow fluctuations with a p-value of 0.092.

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