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Study on the Impact of Land and Forest Rehabilitation towards Increasing of Land Cover Density and other of its Spillover Effects in Central Sulawesi

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Abstract

The study was aimed at assessing the impact of land and forest rehabilitation (LFR) on the increase of land cover and other spillover effect in Central Sulawesi. The method used was ground check-based survey. Firstly, land cover status recorded in 2000, 2003, 2006, 2009, and 2012 was overlaid and analyzed statistically using linear regression to observe the change and trend of each land cover class and their density. Secondly, LFR and critical maps was overlaid with the increase of cover crop density map which then figuring the description of critical land change on land where cover crop increases. Finally, analyses on the impact of LFR on the increase of land cover crop density and other spillover effect was conducted accordingly. The results of the research showed that (1) LFR programme has significantly increased cover crop density which consequently decreased the amount of critical land, specifically, on three types of land, i.e., bush, secondary forest and mixed agricultural land .

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These types of land have LFR development covering about 5,046 ha and the increase in cover crop/decrease in critical land of 41,171.3867 ha, or eight time as much as before. (2) In addition it noted that at the same time decreasing flood potentials and run-off water. The relation between the increase in land cover density particularly in three land cover classes which is significantly experiencing decrease in the area of critical land (mixed dry land farming, bush land, secondary dry land forest) brought about implication of decreasing surface water run-off. This can also be explained that the LFR programme implemented on the three aforementioned land classes has increased land cover density by changing land cover into bush land, cash crop land, seconder mangrove forest, secondary marsh land and secondary dry land forest. Consequently, the increase in land cover density was followed by the decrease in C Coefficient indicating the decrease in surface water run-off.

Keywords: LFR; land cover density; critical land; potential of flooding; surface water run-off.

1. Introduction

The increase in human population and consequently the need of land has become the main cause of many critical land problem in Central Sulawesi [1]. Illegal activities such as encroachment, conversion to cash crops farming, logging and shifting cultivation have brought about significant overland flow causing floods and land slide. It was noted that during the period of 2006–2011 degraded land has reached about 55,405 ha and deforestation of about 57,406 ha [2].

During the period of 2007 – 2012 land and forest rehabilitation has been implemented in Central Sulawesi covering an area of about 31,515 ha [3], though the area of critical increased from 216,488 to 317,769. The fact, however, was that there was a decrease in the amount of severe critical land from 103,308 ha to 293,131 ha although the total critical land increased from 113,179 ha to 293,638 ha as an additional category of critical [4]. Therefore the real problem was the increase from category of "mild critical" to "severe critical". This indicated that more effort needed to improve LFR mechanism particularly on critical land categorized as severe. This also indicated that the rate of degradation and deforestation exceeds the LFR efforts.

Various methods were used during the LFR such as vegetative, civil, and chemical techniques although the first two were the most popular technique. Vegetative technique, from instance, was carried out through planting stand, reboitation mangrove rehabilitation, coastal green belt establishment, urban forest, and village forest. The success of the program can then be assessed through their land cover performance as it is reflecting on what is going on over the landscape [5]. Geographical Information System (GIS) was used throughout the research as the basis to undertake management, storage, processing and manipulation, and geographical data display [6]. Forestland land mapping were conducted using multi-temporal satellite imagery to gain data forest area and the change in land cover. GIS itself is able to analyze spatial aspects that significantly influence land and forest change dynamics associated with their corresponding implication on the environment [7]. Temporal analysis approach can be used to endeavor the magnificent of land and forest change within a certain period of time in Central Sulawesi. Temporal analyses was the combination of spatial and multi-time analysis.

Previously, various research using GIS to analyze land and forest change have been conducted in many place [8]. Similarly, research related to the impact of land use change on hydrologic aspect including erosion have also been conducted [9]. However, research related to LFR program on the increase on land cover density and its spillover effect seems to never as yet been conducted so farr.

1.1 Problem Statement

LFR was one of the various ways to develop forest in Central Sulawesi. It was aimed at rehabilitating, maintaining, and increasing land and forest ecological function so that their capability, productivity, and role to support living can be maintained. It was expected that the LFR can directly improve land cover. Land cover data were collected from"Badan Planologi Kementerian Kehutanan" and field ground check. Change in density and area of land cover were analyzed using multy-temporal data (in this research it was limited from 2000 to 2012) Temporal analysis has three yearly interval because with this time interval change in land cover is somehow significant. Also, secondary multi-temporal data were quite available with this three yearly interval.

1.2 Research Objectives

This research objectives were identify the impact of land and forest rehabilitation on the increase in land cover density as well as its potential spillover effects. The research were focused on land cover density.

1.3 Research Location

The research was conducted in Central Sulawesi which geographical location between 2022' NL and 3048' SL and 119022 EL and 124022' WL. Central Sulawesi Province is the largest province in Sulawesi Island of Indonesia with covering an area 68,033 km2 terrestrial and 189,480 km2 marine. The boundaries of the region are Sulawesi Sea and Gorontalo Province in the north, Maluku Province in the east, South Sulawesi, West Sulawesi and South East Sulawesi Province in the south, and Makassar Strait in the south.

I terms of are, the amount of critical land in the province is 999,832.53 ha (16.57%) consists of severe critical of 24,138.69 ha, critical of 264,805.05 ha, tend to critical of 710,888.79 ha. Meanwhile, non-critical land was about 5,032,354.36 ha.

2. Research Methods

The method used was ground check-based survey. Firstly, land cover status recorded in 2000, 2003, 2006, 2009, and 2012 was overlaid and analyzed statistically using linear regression to observe the change and trend of each land cover class and their density. Secondly, LFR and critical maps was overlaid with the increase of cover crop density map which then figuring the description of critical land change on land where cover crop increases. Finally, analyses on the impact of LFR on the increase of land cover crop density and other spillover effect was conducted accordingly. Impact analysis was conducted to descriptively assess the increase of land cover density as well as its spillover impact consequently brought about by the achievement. Schematically, research stages can be described in the figure 1.

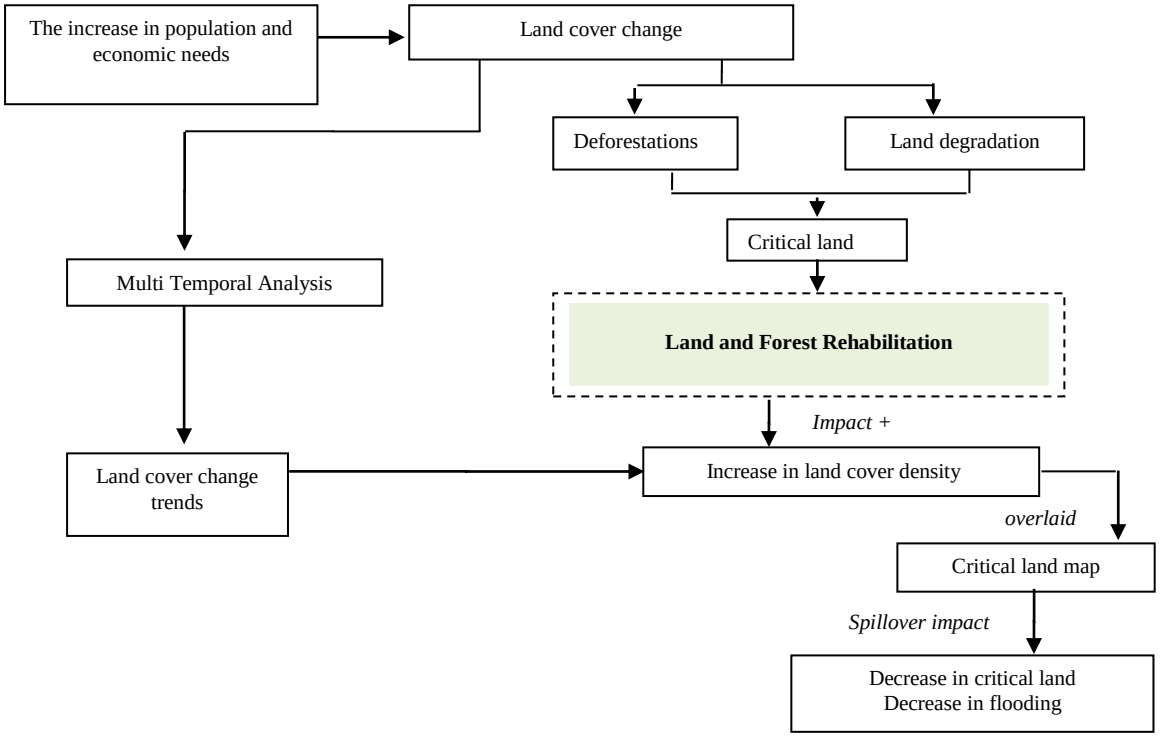

Figure 1: Research stage

2.1 Research Technique and Stages

- Location selection: secondary data recording were conducted prior to primary data collection, secondary data collected covering GIS spatial data to determine mapping and sampling location. Central Sulawesi was selected as the research region. Sites where LFR program conducted through vegetative and civil methods were selected as research samples.
- The collected data: primary data were collected at location treated as samples; observation and measurement covering LFR development, land cover condition, landform condition, critical land condition. Secondary data collected consisted of spatial data on land and forest rehabilitation, land cover, landform, critical land, Central Sulawesi in Figure, maps, and satellite imagery.
- Sample selection: purposive sampling method was used based on mapping for landform unit [10] and administrative boundary of sub-district.
- Data collection techniques: data collected through observation and visual analysis measurement, interview, literatures from related institutions, and thematic maps. The collected data categorized into two types, firstly, primary data, i.e., physical variables such as land cover, land and forest rehabilitation tree species, landform, as well as critical land. Secondly, secondary data such as maps, LFR data, land cover maps, and critical land.
- Data analisys: collected data were analyzed through descriptive and GIS analysis

2.2 Research Variables

Research variables were land cover change, land and forest rehabilitation and critical land.

2.3 Data Analysis

Data analysis description covers spatial data interpretation of land and forest rehabilitation, five-yearly land cover density rehabilitation and decrease amount of critical land.

3. Results and Discussions

3.1 Increases in Land Cover Density

From the spatial and temporal analysis between 2000 – 2012, it was identified the increase of land cover in 13 classes. Those classes were wetland (092 ha), marsh (1.63 ha), open land (8.50 ha), settlement (6.41 ha), ponds (0.93 ha), ice field (155.52 ha), savanna (0.0001 ha), dry land farming (79.18 ha), mix farming land (2,567.67 ha), bush (23,389.96 ha), crop land (0.35 ha), secondary mangrove forest (1.04 ha), dry land secondary forest (15,161.79) with overall size of 4,373.17 ha. The most outstanding increase in land cover occurs on bush land, secondary forest dry land and mixed farming dry land.

The increase in land cover density directly and indirectly due to land and forest rehabilitation program (LFR). The LFR Programme was implemented by government and non-government in Central Sulawesi 2012 covering an area of 62,958.80 ha. From this LFR coverage area, 15,643 ha have shown increase in land cover density, while the rest have not yet reached similar achievement because vegetation planted still relatively young in age (less than 2 years). From this 15,643 ha of the LFR land, there was an increase in land cover density to about 41,373.17 ha. This indicated that all LFR trees planted have change the land cover density and hence decrease the amount of critical land. Based on verified data, it was identified that reforestation activity including those carried out in village forest and mangrove were conducted accordingly, i.e., on the opened land and/or on the land where cover trees were not sufficient. Various criteria were used to base the LFR location selection including watershed, critical land and forest, vulnerable to landslide, drought and floods, vital object protection and ongoing RTT.

The increase in land cover density from the implementation of LFR programme can be seen from two aspects, i.e., decreasing critical land and potential of floods.

3.2 Decrease in Critical Land

As previously mentioned that from 13 classes of land cover managed by LFR progamme, there were only three classes indicated significant decrease in critical land namely, dry mixed farming land, bush land, and secondary

dry land forest. This three classes covering LFR area of about 5,046 ha but the increase in land cover encompassing an area 41,171.38 ha or about eight time as much as the covered area. Description about this achievements can be described as follows.

3.2.1 Mixed Dry Land Farming

The implementation of LFR on mixed dry land farming for an area of about 2,422 ha has given positive impact in the way that land cover density increased particularly for bush land, cash crop land, secondary marsh land, secondary mangrove land and secondary forest land to about 2,567.67 ha. This was followed by the decrease in critical land due to natural succession because land cover density exceeded the amount of land that received the LFR programme (Table 1)

3.2.2 Bush Land

The implementation of LFR on bush land for an area of about 1,879 ha has given positive impact in the way that land cover density increased particularly for secondary dry land forest and primary dry land forest to about 23,839.96 ha. This was followed by the decrease in critical land due to natural succession because land cover density exceeded the amount of land that received the LFR programme (Table 2).

3.2.3 Secondary Dry Land Forest

The implementation of LFR on secondary dry land forest for an area of about 745 ha has given positive impact in the way that land cover density increased particularly for primary dry land forest to about 15,161.78 ha. This was followed by the decrease in critical land due to natural succession because land cover density exceeded the amount of land that received the LFR programm3 (Table 3).

3.2.4 Aspect of decrease in floods potential and its implication to Surface Run-off Water

As previously mentioned, LFR programme has increased land cover density, decreased in critical land, reduced flood potentials that brought implication to decreased in surface water run-off. Related to surface water run-off, parameter used to determine whether watershed has suffered physical disturbances was run-off coefficient (C). Surface water run-off coefficient is the ration between the amount of surface water run-off over the amount of rainfall. C equals to zero (C=0) means that all rainfall water are distributed into interception water particularly infiltration water. Meanwhile, C equals one (C=1) indicates that all rainfall water are running as surface water. Description of surface water run-off coefficient used for land use can be seen in Table 4.

Referring to surface water run-off coefficient, following is the explanation of relation between land cover density particularly three land cover class that significantly critical land decease, i.e., dry land farming, bush land, secondary land dry forest with surface water run-off.

Table 1: The linkage between LFR and increase in land cover density and decrease in critical land on mixed dry farming land

Initial land cover	End-stage land cover (after LFR)	LFR (ha)	Critical land cass		Increase in land cover (ha)
			Year 2009	Year 2014	
Mixed dry land farming	Secondary dry land forest	1.505,00	Critical	Less critical	0,34
			Critcal	Less critical	412,26
			Less Critical	Potential to be critical	70,86
			Less critical	Not critical	0,39
			Potential to be critical	Not critical	0,003
	Sub total	1.505,00			487,09
	Secondary mangrove forest	-	Less critical	Potential to be critical	0,01
			Less critical	Not critical	0,56
			Potential to be critical	Not critical	0,0001
	Total	-			0,57
	Secondary marsh land	-	Potential to be critical	Not critical	0,86
	Total	-			0,86
	Cash crop land	155	Less critical	Potential to be critical	207,04
			Less critical	Not critical	645,21
			Potentil to be crritical	Not critical	0,0003
	Sub total	155			852,25
	Bush	762,00	Critial	Less critical	0,73
			critical	Potential to be critical	161,48
			Less critical	Potential to be critical	131,03
			Less critical	Not critical	623,45
			Potential to be critical	Not critical	310,0
	Sub total	762,00			1.226,88
Total		**2.422,00**			**2.567,67**

Table 2: The linkage between LFR and increase in land cover density and decrease in critical land on bush land

Initial land cover	End-stage land cover (after LFR)	LFR (ha)	Critical land class		Increase in land cover (ha)
			Year 2009	Year 2014	
1	2	4	5	6	7
Bush land	Primary dry land forest	-	Potential to be critical	Not critical	1.635,13
	Secondary dry land forest	1.729,00	Severe critical	Critical	807,87
			Severe critical	Less critical	6,83
			Critical	Less critical	0,25
			Critical	Not critical	0,0005
			Crtical	Potential to be critical	4.665,07
			Less critical	Potential to be	267,01

Initial land cover	End-stage land cover (after LFR)	LFR (ha)	Critical land class		Increase in land cover (ha)
			Year 2009	Year 2014	
1	2	4	5	6	7
				critical	
			Less critical Potential to be critical	Not critical Not critical	270,14 4.884,91
	Sub total	1.729,00			20.855,72
	Secondary mangrove forest	-	Less critical Potential to be critical	Not critical Not critical	0,18 0,00005
	Sub total	-			0,18
	Cash crop land	150,00	Potential to be critical	Tidak critical	572,008
	Sub total	150,00			898,92
Total		**1.879,00**			**23.389,96**

Table 3: The linkage between LFR and increase in land cover density and decrease in critical land on secondary dry land forest

Intial land cover	End-stage lnd cover (after LFR)	LFR (ha)	Critica land class		Area (Ha)
			Year 2009	Year 2014	
1	2	4	5	6	7
Secondary dry land forest	Primary dry land forest	745,00	Less critical Potential to critical	Not critical Not critical	13.510,94 1.650,83
Total		745,00			15.161,78

3.2.5 Mixed Dry land Farming

LFR programme implemented on mixed dry land farming has brought about increase in land cover density and has stimulated the land cover to become bush land, cash crop land, secondary mangrove forest, secondary marsh land and secondary dry land forest. The change into increased land cover consequently lowering C Coefficient meaning decreasing surface water run-off which is described in Table 4.

Table 4: Surface water run-off coefficient used for various land uses

No	Land uses	C
1	Empty farming land	0,3 - 0,6
2	Cultivated land with vegetation	0,1 – 0,25
3	Cultivation land without vegetation	0,2 – 0,25
4	Grass land	0,15 – 0,25
5	Forest/land with vegetation	0,05 -0,15

Source: US Forest Service, 1980 **[11]**

3.2.6 Bush Land

LFR programme implemented on bush land has brought about increase in land cover density and has stimulated the land cover to become, cash crop land, secondary mangrove forest, secondary marsh land and secondary dry land forest. The change into increased land cover consequently lowering C Coefficient meaning decreasing surface water run-off (Tables 5 and 6).

Table 5: Decrease in C Value of Mixed dry land farming to other land covers

Before		**After**		
Land cover	Value of C	Land cover	Value of C	Notes
Mixed dry land farming	0,14	- bush land	0,13	Decreasing surface water run-off
		- cash crop land	0,11	Decreasing surface water run-off
		- secondary mangrove forest	0,10	Decreasing surface water run-off
		- secondary marsh land forest	0,08	Decreasing surface water run-off
		- secondary dry land forest	0,06	Decreasing surface water run-off

Table 6: Decrease in C Value of bush land to other land covers

Before		**After**		**Notes**
Land cover	Value of C	Land cover	Value of C	
Bush Land	0,12	-cash crop land	0,11	Decreasing surface water run-off
		-secondary mangrove forest	0,10	Decreasing surface water run-off
		-secondary dry land forest	0,06	Decreasing surface water run-off

3.2.7 Secondary Dry Land Forest

LFR programme implemented on bush land has brought about increase in land cover density and has stimulated the land cover to primary dry land forest. The change into increased land cover consequently lowering C Coefficient meaning decreasing surface run-off water which is described in Table 7.

Table 7: Decrease in C Value of secondary dry land forest to other land covers

Before		**After**		**Notes**
Land cover	Value of C	Land cover	Value of C	
Secondary dry land forest	0,06	Primary dry land forest	0,05	Decresing surface water run-off

4. Conclusion

LFR programme has increased the land cover density, decreased the amount of critical land which is decreasing floods potential and surface run-off water. From 13 land cover types that experiencing increase in land cover density due to LFR, three out of them have shown significant indication. They were mixed dry land farming, bush land, and secondary dry land forest all with 5,046 ha of LFR implementation which contributing land cover density increased to amount of about 41,171.38 ha or eight times as much as before.

The relation between the increase in land cover density particularly in three land cover classes which is significantly experiencing decrease in the area of critical land (mixed dry land farming, bush land, secondary dry land forest) brought about implication of decreasing surface water run-off [12] [13]. This can also be explained that the LFR programme implemented on the three aforementioned land classes has increased land cover density by changing land cover into bush land, cash crop land, secondary mangrove forest, secondary marsh land and secondary dry land forest. Consequently, the increase in land cover density was followed by the decrease in C Coefficient indicating the decrease in surface run-off water..

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