Suspended sediment yield in the tropical rainforest with intensive forest management system

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1. Introduction

Vegetation cover change has a profound influence on the hydrological cycle. Reduction of vegetative cover by forest harvesting generally increases the average surface runoff volume and total water yield for a given area of land. Tropical Indonesian rainforest is managed by an Intensive Forest Management System (IFMS), which is officially started in 2002. The main activity of IFMS is selective logging for timber harvesting and intensive rehabilitation with line planting to enrich the standing stock [1].

In Southeast Asia with its great geological diversity, the study of runoff and soil erosion in tropical forests is dominated by research in the impact of selective logging [2] but concerning the IFMS in Indonesian rainforest is still limited [1]. Therefore, a need exists to investigate the hydrologic response of tropical rainforests managed under IFMS. This study investigated and evaluated the impact of IFMS phase on runoff and suspended sediment yield resulting from their respective forestry treatments using paired catchment method. This study uses 3 small cacthments. Catchment A was monitored as a control. Catchment B was supervised treated with standard IFMS. Catchment C was supervised treated with modified IFMS.

2. Methods

2.1 Study site and paired catchment observation

The study site was located in the headwater region of the Katingan watershed, one of largest watersheds in Central Kalimantan. The average annual rainfall in the period 2001–2012 was 3,631 mm, with the highest average monthly precipitation (353 mm) was occurring in November and the lowest average monthly precipitation (209 mm) was occurring in August. According to the forest climate classification system of Schmidt and Ferguson, the area is a type A (very wet) tropical rainforest (monthly average rainfall >100 mm).

The three-paired small catchments with similar physical catchment characteristics were established to analyze the suspended sediment yield (Fig. 1). The streamflow was measured using 90° V-notch weirs (0.9m x 1.4m x 3m) and water-level loggers with a time interval of 15 minutes. Sediment fluxes was measured using rising stage suspended sampler in the weir. The sediment flux was measured in the each phase of IFMS in the catchment B and C.

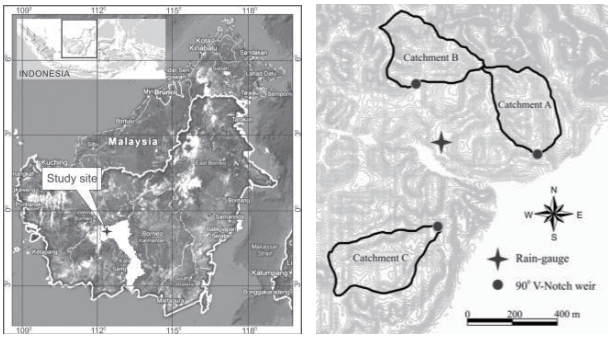

Fig. 1 Three paired catchment sites

2.2 IFMS

IFMS phases in the catchment B were logging road construction, selective logging, and standard intensive strip-line planting. Standard intensive strip-line planting is use a North-South or East-West direction to establish the line planting. IFMS phases in the catchment C were selective logging and intensive contour-line planting. The intensive contour-line planting is a modified rehabilitation method to reduce the surface runoff and soil erosion with considering the topographic condition (Fig. 2).

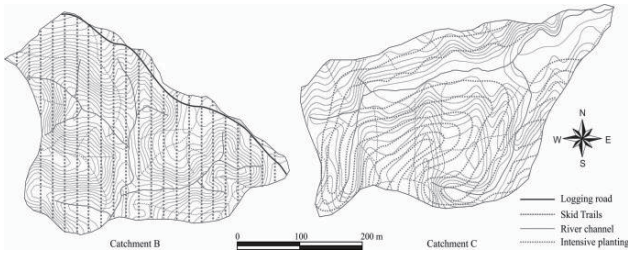

Fig. 2. IFMS in the catchment B and C.

Logging road in the catchment B has opened the forest area approximately in 0.45 ha or 5.2% of catchment B. A 4-m wide of skid trails was opened the forest area approximately 0.32 ha or 3.6% in the catchment B and 0.54 ha or 5.7% in the catchment C. Catchment B and C were treated with 3-m wide line planting. The intensive strip-line planting in the catchment B used 1.22 ha or 14% of area. The intensive contour-line in the catchment C used 1.33 ha or 14% of area. Total forest floor disturbance by IFMS phase in the catchment B and C were 22.8% and 19.7%.

3. Results and discussions

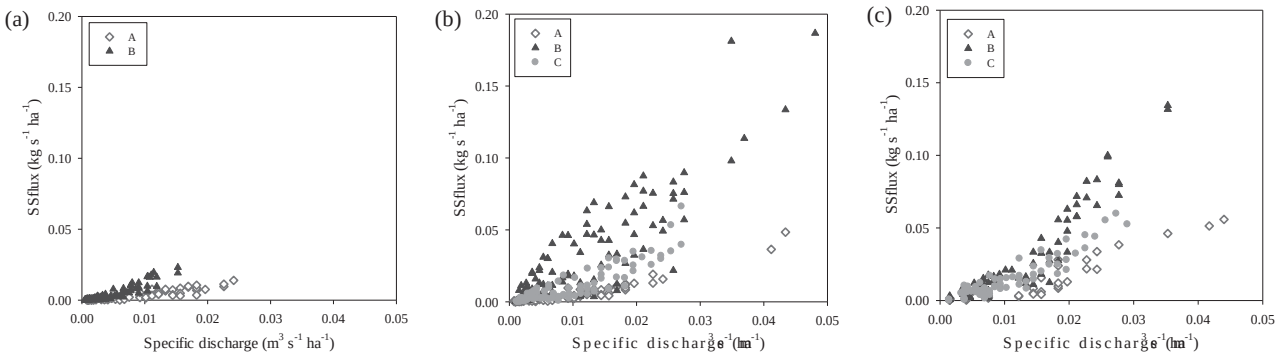

Fig. 3. Suspended sediment flux in the catchment A, B and C during investigation periods. (a) Logging road. (b) Selective logging. (c) Intensive line planting

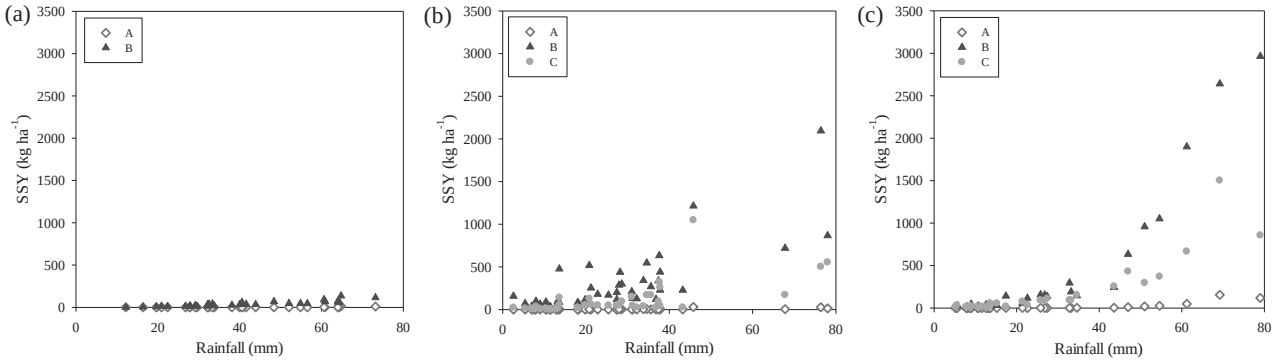

Fig. 4. Suspended sediment yield (SSY) in the catchment A, B and C during investigation periods. (a) Logging road. (b) Selective logging. (c) Intensive line planting

The difference of IFMS phase shown a different suspended sediment flux between catchment B and C, compared to A (Fig. 3). Fig. 4a. indicates that the logging road construction has significantly increased the suspended sediment concentration in the catchment B. In the 4 months investigation, catchment A and B produced monthly SSY of 0.013 t ha^{-1} and 0.58 t ha^{-1}. During 11 months investigation, catchment A, B and C produced monthly SSY of 0.034, 4.34 and 0.94 t ha^{-1}, respectively. Total SSY in the catchment B and C increased 124 times and 27 times higher than in the catchment A (Fig. 4b).

In the intensive line planting period, catchment B had the highest SS flux and SSY. Fig. 4c showed no large difference in SSY amounts in the rainfall amount less than 40 mm between the three catchments. The relationship between rainfall and SSY showed significant differences when the rainfall amount exceed than 40 mm. During 4 months investigation, monthly SSYs in the catchment A, B and C were 0.10, 4.59 and 1.90 t ha^{-1}, respectively. Total SSY in the catchment B and C increased 45 times and 19 times higher than in the catchment A.

The less canopy cover density may have increased the net precipitation and rain splash on the forest-floor, these will increase the rills and gullies erosion then increase the suspended sediment in the river channel. The vulnerability of Ultisol soil is indicated by the dramatically changes of SSY in the IFMS phase. The soil characteristics made the study area more sensitive to logging activities, which in turn augmented runoff and erosion.

4. Conclusion

This study demonstrated that SSY increased dramatically during all phases of IFMS. Changes in forest cover and destruction of soils are dominant factors impacting sediment yield. Proper protection of the forest floor with strict control over the logging activities and combine with intensive contour-line planting would also contribute to reduce impact logging in runoff and sediment yield.

References

[1] Suryatmojo, H., Masamitsu, F., Kosugi, K., Mizuyama, T. Impact of selective logging and intensive line planting system on runoff and soil erosion in a tropical Indonesia rainforest. *Proceedings of River Basin Management VI.* United Kingdom: Wessex Institute of Technology, pp. 288–300. 2011.

[2] Bruijnzeel, L.A. Hydrological functions of tropical forests: not seeing the soil for the trees?. *Agriculture Ecosystems & Environment*,104:185-228. 2004.