Influence of different forest management activities on rainfall interception in Central Sulawesi, Indonesia

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introduction

In recent years, management activities such as selective logging or conversion to agroforest have altered the vegetation structure of many tropical forests. However, little is known about the hydrological impact of these more gradual changes in vegetation structure. We investigated differences in rainfall partitioning, the splitting of rainfall into interception, throughfall and stem flow, along a gradient from natural forest (**A**), over forest after small timber extraction (**B**) and forest after large timber extraction (**C**) to cacao agroforest (**D**; Figs. 1 & 2). Significant effects of these different management practices on above-ground hydrological processes are expected to be directly linked to altered conditions in water retention, water availability and erosion hazards.

objectives

- To analyze the stand structural characteristics presumed to be important for rainfall partitioning.
- To determine rainfall partitioning into throughfall, stemflow and interception.
- To quantify interception and water yield as results of different forest use types.

methods

Twelve study plots in the surrounding of the Toro valley (four land use types with three replications, Fig. 1) were equipped with 30 throughfall gauges and 10 stemflow collectors each. Gross precipitation was measured nearby each plot. The research sites were monitored on a daily or weekly basis for 14 months.

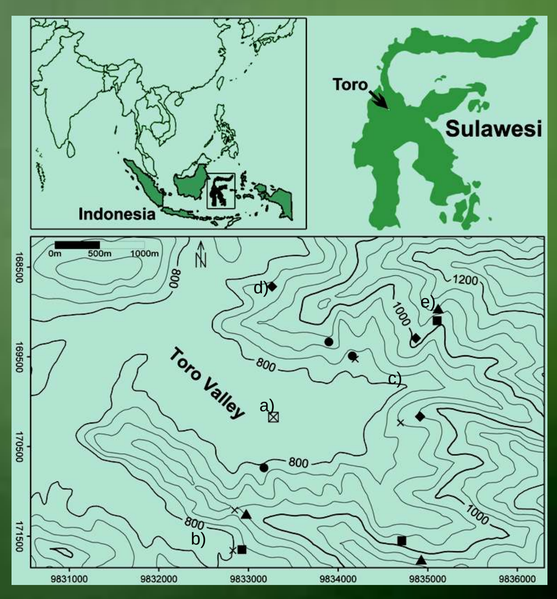


Fig. 1. Location of the study sites in the Toro Valley. Indicated are the different research plots: **A** (▲) **B** (■) **C** (◆) **D** (●), the rain stations: permanent (×) automatic (☒) and the locations of photos Fig. 2 a-e



Fig. 2. Pictures of the Toro valley surrounded by forested hills (a), rice terraces with adjacent forest gardens (b), cacao agroforest (c), the diverse land use mosaic in the hills surrounding the Toro Valley (d), and the natural forest (e).

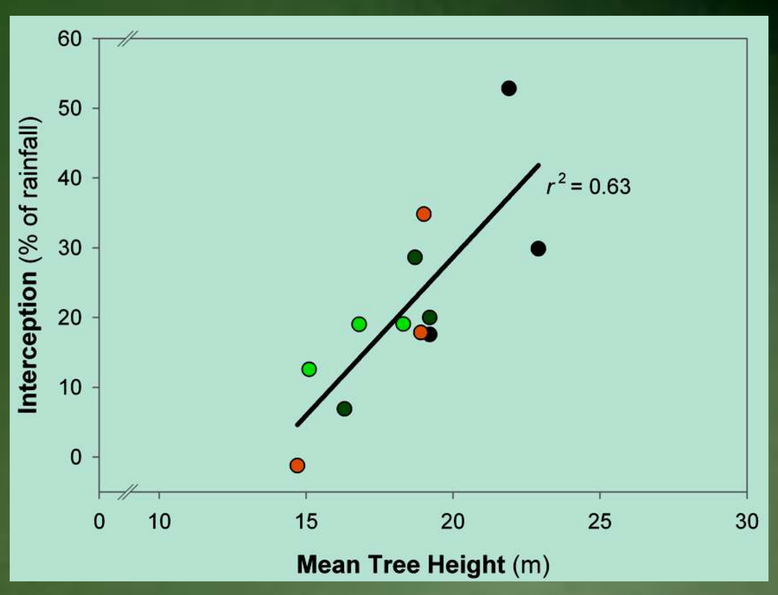


Fig. 3. Rainfall interception (in percent of gross precipitation) as a function of mean tree height (dbh ≥ 10 cm) in the 12 study plots: ● natural forest (A), ● forest after small timber extraction (B), ● forest after large timber extraction (C), and ● agroforest (D).

results

Stem density, basal area, and maximum tree height decreased along the gradient of use intensity (Tab. 1). The absolute leaf area index (LAI), however, remained relatively unaffected while its spatial variation increased as it did for canopy openness.

Highest interception was recorded in a natural forest plot while the lowest rate was found in an agroforest. Stemflow accounted for less than 1 % of gross precipitation in all plots (Tab. 1). Stand height correlated strongly with interception (r^2 = 0.63; Fig. 3). In a multiple regression, tree height combined with LAI, improved the explained variation of interception (r^2 = 0.81).

Tab. 1. Structural and corresponding hydrological characteristics of the study sites in: natural forest (**NF**), forest after small timber extraction (**STE**), forest after large timber extraction (**LTE**), and agroforest (**AF**).

Use type	Slope	Stem density dbh > 50 cm	Basal area	Tree height		Leaf area index		Canopy openness	Throughfall		Stemflow	
	deg	n ha^{-1}	m^2 ha^{-1}	Ø m	max m	m^2 m^{-2}	CV %	CV%	% of Rf	mm yr^{-1}	% of Rf	mm yr^{-1}
NF	**23.4**	**77.3**	**56.6**	**21.3**	**46.9**	**6.2**	**19.8**	**55.0**	**66.1**	**1810**	**0.45**	**10**
± SD (n=3)	*7.9*	*23.2*	*10.4*	*1.9*	*5.9*	*0.4*	*4.6*	*3.3*	*18.0*	*18*	*0.1*	*0*
STE	**34.0**	**74.7**	**54.7**	**18.1**	**41.2**	**5.3**	**19.7**	**50.6**	**80.7**	**2265**	**0.74**	**16**
± SD (n=3)	*3.3*	*15.2*	*12.8*	*1.5*	*2.5*	*1.0*	*0.9*	*1.3*	*11.0*	*11*	*0.2*	*0*
LTE	**30.1**	**48.0**	**43.1**	**16.7**	**39.1**	**5.0**	**28.7**	**57.3**	**82.4**	**2265**	**0.69**	**15**
± SD (n=3)	*5.0*	*20.4*	*9.7*	*1.6*	*6.3*	*0.2*	*3.7*	*9.1*	*3.7*	*4*	*0.0*	*0*
AF	**32.2**	**27.3**	**19.6**	**17.5**	**37.0**	**5.4**	**28.0**	**79.0**	**82.0**	**2160**	**0.88**	**20**
± SD (n=3)	*10.1*	*22.6*	*9.6*	*2.4*	*7.4*	*1.1*	*3.1*	*12.4*	*18.2*	*18*	*0.1*	*0*

conclusions

Forest structure already responded to low intervention and reflected the intensity of the forest use. When considered separately, tree height, not LAI, showed the highest positive impact on interception. This suggests that turbulent energy exchange may provide more available canopy storage for higher trees as they may dry off faster after rain.

Especially the agroforests showed high heterogeneity of their canopies which resulted in increased channeling of throughfall and thus in lowest interception capacity. This indicates a manifold relevance of large remaining shade trees.

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