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Research Article

Manokwari 2016 Floods: Effect of Five Land Use on Runoff and Sediment Characteristics in Arui Watershed, Indonesia

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Abstract

Papua is the final fortress of forests in Indonesia. However, floods recently occurred in Jayapura, Paniai, and Manokwari, among causes is improvement runoff and sediment. The purpose of this study is to find the effect of land use change on the hydrological behavior of runoff and sediment in the Arui watershed. Five treatments: forest, plantation, shrubs, rice field and settlements. Study of physical and chemical properties of soils and infiltration on 5 landuse. The results showed that settlement land use significant effect on the runoff, the amount of runoff in the settlement, because settlement dominated by a layer of concrete, paving, soil is hardened thus difficult infiltration and water, flows freely. The land use as forest a rainfall does not have a significant effect on runoff due to the big biodiversity. Rainfall in the rainy season on land use was significantly shrubs against runoff and sediment, caused by vegetation dominated by *Imperata cylindrica* and *Piper aduncum* make the land that is not maintained, open and as a pet food which so that water easily erodes and surface runoff. The use of rice field land for rain did not significantly affect runoff and sediment due to farmers who had applied soil and water conservation techniques such as mounds, use of organic fertilizers, alley cropping and intercropping. Value of infiltration five land use are slow and the medium with the highest infiltration on the use of rice field while the lowest settlement. Increased infiltration will reduce surface runoff affecting the flood.

Keywords: Runoff; Sediments; Rainfall; Five Land Use; Arui Watershed

Introduction

Flood on 29 February 2016 with high rainfall of 718 mm, begins with the overflow of the Arui river and then rises to a height of ± 2 meters. Based on the discharge data during the flood obtained Water discharge 1201.2 m^3s^{-1} [1]. The consequences of the floods were to erode the surface of the river's talud and cause grinding of the foundation, damage to agricultural land, the fall of several oil palm plants, damage to road and bridge infrastructure and flood inundation in several residential housing. Whereas on 14 January 2017 the flood occurred again in the Arui watershed area. Floods that have hit parts of Indonesia as if to make us aware of the decline in the quality of our environment.

Main factor of floods are high rainfall, another land use change dominated by oil palm plantation, drainage density, watershed shape, the slope of Watershed, river gradient and river meandering. The impact of high rainfall and previous rain makes the soil saturate quickly so that the infiltration decreases, finally the water pooled or flowed on the ground. Along with surface runoff will carry sediment infiltrated if already saturated will continue runoff until in a river or body of water. Studies have focused on monitoring the influence of changes mainly caused by deforestation and afforestation processes in land cover [2,3]. The impact of forest harvesting on runoff has been investigated for a century mainly using paired watershed experiments [4,5]. The results show that forest harvesting can significantly increase annual runoff, magnify peak flow particularly small magnitudes of peak flows and change low flow of dry season [6-9].

The use of land has an impact on increasing surface flow considering that on land that tends to be dense, water will reduce infiltration compared to loose soil. There are important differences in the hydrological and erosional functioning of the different land uses/cover types [10]. Runoff and sediment studies of several land uses are important because studies that have been carried out are limited to logged-over (Wagenbrenner., *et al*. 2016) selective logging (Suryatmojo., *et al*. 2011), investigated impacts of land use on runoff and soil erosion in Hilkot watershed [11], analyzed the characteristics, regulation of and correlation among the slope rainfall-infiltration-runoff, erosion, and sediment under different vegetation types [12,13]. Nevertheless, the origin and implications of the runoff fluctuations are of great general scientific interest and may also play a key role in specific technical applications such as regulation strategies for hydropower [14,15].

According to MoLEF [16] there are 5 types important land use such as forest (50.60%) plantation (21.46 %) shrubs (7.28%) rice field (14.58%) settlements (5.84%), therefore land uses forest is very dominant while the smallest settlements. The use of forest-dominated land when rainwater is temporarily held in the canopy then flows to the surface of the soil through the flow of stems and canopy blossoms. Surely the rainfall to until the soil surface requires a relatively long time compared to the open area. Closing the land with various vegetations can increase infiltration because the roots of plants will increase the granulation and porosity of the soil, besides that it also affects the activity of microorganisms which results in increasing soil porosity [17]. Likewise, forest area dominated infiltration tend to be very large because it occurs gradually following the amount of water that reached the ground. But why the floods in 2014, 2016 and 2017?

Runoff and sediment into a very important part in the management of the flood-prone area, given the run-off and sediment into a serious threat. Among runoff will increase erosion resulting in deterioration properties such as chemical and physical soil nutrient loss, increase soil density and penetration resistance, decreasing soil infiltration capacity and ability to hold water. The similarity to according [18,19] effects of land use changes include variations in surface roughness, the organic content of the soil, the soil structure and infiltration rate, and the hydraulic connectivity within a catchment. These alterations often have important effects on the spatial and temporal dynamics of hillslope hydrology and sediment production, transport and delivery to rivers [20,21]. The result the reduced productivity of the land and filling of groundwater. Damage in the soil precipitate, water body such as lakes, reservoirs and downstream, making the capacity of the water body to be reduced. With the reduced capacity of water reservoirs which then function normally to prevent flooding, water supply, and power generation will not function.

Sedimentation and runoff increased from the beginning should be prevented by soil and water conservation techniques correctly. Sedimentation can cause shallow rivers, reservoirs and other water bodies so that when heavy rainfall will fill the shallow rivers, the water will be abundant and a flood will occur. The runoff will reduce infiltration and accelerate erosion which affects waterways, rivers and overflowing reservoirs that can cause flooding. Therefore it is necessary to determine the amount of run-off and sediment on forests, plantations, shrubs, ricefields/cropping and settlements in Arui watershed. The purpose of the study was to analyze the extent of the effects of runoff, sediment, and their consequences.

Research Methodology

Location took place in LPF, the natural tropical rainforest of West Papua. The location is situated in 00 43’ S - 00 57’ S and 1330 40’ E - 1330 48’ E. Annual mean of rainfall range from 3000 to 4000 mm and quite moist in which daily moisture is between 75 and 85 %. The maximum temperature on average account for 320 C. Soil properties were analyzed in the upper 15 cm of the soil profile. The samples used for the laboratory analysis in Agricultural faculty of UGM were first air-dried, lightly ground and screened through a 2-mm sieve. The soil particle size distribution was determined using the pipette method [22] and the soil pH was measured using an electrode pH meter on saturated soil paste using distilled water. Soil moisture using gravimetric method, permeability using permeameter tool, available P and available K using colorimetric/spectrophotometer method, total N using Kjeldahl method, Organic matter was evaluated using the Walkley and black method [23]. Measurements infiltration using a double ring infiltrometer at 5 land use: forest, ricefield, plantation, settlement, and shrubs. Formula infiltration by Linsley [24] the following:

$F = fc + (fo+fc)e^{-kt}$ [1]

Note: F = Infiltration capacity at t (cm h^{-})

fc = Infiltration capacity at t (cm h^{-})

fo = Infiltration capacity when t is large (cm h^{-})

e = Number napier

t = Rainfall starts

k = Constant

Class	Category	Infiltration (cm h-)
I	Very low	< 2,5
II	Low	2,5 - <15
III	Medium	15 - < 28
IV	Height	28 - < 53
V	Very height	53

Table 1: Classification of infiltration value.

Source: ILRI [25].

Measurements of runoff and sediments were made in five plots of size 1 x 1m with a time of rainfall of 30 rain. Rainfall measured with ombrometer with an area mouth of 100 m2 laid research location. Every rainfall event is measured by the amount of rainwater, water that is included in the observation plot and sediment. Sediment was obtained by filter paper (Whatman type 934-AH with pore size = 1.5 μm and 55 mm diameter) then in oven with a temperature of 1100 c and weighed mass of sediment attached to filter paper (APHA 1995; SNI 2004). The amount of runoff is obtained by jerigen a volume of 40L and then recording the volume of water collected for each runoff.

A completely randomized design with five replicates was performed in order to enable comparisons among the treatments. One-way ANOVA was used to compare the effects of five land use treatments to physical and chemical properties of the soil. Three-way multivariate analysis of variance was conducted by SPSS 17 to determine the impact of rainfall on runoff and sediment. The treatment effects were considered significant at PB 0.05. The Fisher least significant difference (LSD) test at PB 0.05 was used for mean separation. The correlation analysis was carried out between runoff as the dependent variable to the rain amount and the vegetation cover treatments as the independent variable to the rain amount. Moreover, the correlation between runoff as the independent variable to the rain amount accompanying sediment load as a dependent variable to the rain amount was tested.

Result and Discussion

Soil properties

Table 2 alluvial soil (36 %) in the formation process is very dependent on the parent material from the soil and topography, has a fertility rate that varies from low to high, medium to coarse texture, and contains organic matter from low to high and the pH of the soil ranges from sour, neutral, to alkaline, base saturation and cation exchange capacity also vary because it depends on the parent material [26]. Alluvial soils show the initial development is usually moist or alkaline for 90 consecutive days. Generally, it has a cambic layer, because this land has not yet developed and most of this land is quite fertile. Alluvial or Inceptisol are soils that have epipedon and okrik, albik horizon [26].

Soils	Area		
	(m^2)	(Ha)	%
Alluvial	82.836.041	8.284	36
Complex Podsolik	47.062.517	4.706	20
Latosol	7.827.316	783	3
Red Yellow Podsolik	94.573.707	9.457	41
Total	232.299.582	23.230	100

Table 2: Soil in Arui watershed.

Source: MoLEF [16].

A very real difference can be found in epipedon, where the epipedon never in rice field granular structure and dark brown color (10 YR 4/3). According to Foth [27] suggested that alluvial soil varies from one area to another. Some deposits can be limestone, metamorphic rocks, silt deposits and can also be volcanoes mixed with organic matter. States that alluvial soil is gray to brownish. The texture of the soil is clay or clay, has a hard consistency in dry and firm in humid times. The elemental content is relatively rich and a lot depends on the parent material [28].

Red yellow podzolic soil with an area of 41% dominates in the Arui watershed with characteristics of clay or sandy texture with a low pH and has a high content of aluminum and iron. Another characteristic that can be found in red-yellow podzolic soil is the shelf life of nutrients is very low. Red yellow podzolic soil is generally located in areas that have a wet climate with rainfall of more than 2500 mm per year and many are found in areas with mountain topography.

Physical and chemical properties of soil

Physical and chemical properties of the soil is naturally relatively unchanged. The formation of this soil properties depending on soil parent material, organisms, climate, time and topogafi. Some physical and chemical properties of soil as table 3.

The soil structure in the Arui watershed is granular and crumbly. Characterized as for granular fine, very small, rounded, relatively non-porous, while the soil structure is relatively porous soil crusts are small and round, does not match the adjoining aggregate. Crumbly textured soil tends to increase infiltration and reduce sediment because the soil has many fractions of clay and dust. According to Zhang., *et al.* [12] thickness of the sand layer on the loess slope significantly influenced runoff and sediment production processes and mechanisms. The character of the land has an impact on low infiltration.

Landuse	Structure	Permeability (cm h^{-1})	Texsture
Rice field	Granular	1,25 (Rather low)	Dusty clay
Settlement	Remah	2,26 (Midle)	Dusty clay
plantation	Remah	0,37 (Low)	Dusty clay
Forest	Granular	0,34 (Low)	Sandy clay
Shrubs	Granular	1,14 (Rather low)	Dusty clay

Table 3: Physical properties of soils on 5 landuse.

Granular soil structure and crumb generally provide opportunities aeration and water movement, because the soil has good aeration allows air out so that the water can get in. However, in 5 land uses with land that has a granular and crumb structure, on the other hand, the water entering the soil is very slow. Slow water infiltration is possible because of the shallow depth of the groundwater. The shallow of the groundwater results in easily saturated water because the soil pores have been filled with water. If the soil pores are filled with water, water cannot enter the soil.

In 5 land use soil structure is granular and crumbs with characterized fine, very small, rounded, relatively non-porous. These characteristics are relatively small and rounded porous soils, incompatible with adjoining aggregates and have an impact on the process of is infiltration very low. Granular and crumb structure generally provide aeration and water movement opportunities, since well-aerated soil allows air to flow out so that water can enter. However, on the 5 land use with granular soil structure and crumbs, texture water entering the soil is very slow. The slow infiltration makes it possible for shallow water depths to make water easily saturate because the soil pores have been filled with water. If the soil pores are filled with water, the water cannot enter the soil, it will pool or flow on the surface.

The soil characteristics the Arui watershed among others: soil pH predominantly slightly acidic, available P is moderate to high, organic materials are low to very low, low Total N, available K is high to very high, very shallow groundwater and moisture lowest 25.06 to 51.48. It is expected to be made canal groundwater levels are getting down and gradually improve soil pH. Currently, the land in the watershed Arui throughout the year is always wet, impact on poor soil characteristics (physical and chemical properties of soil which is bad).

Land use	Moisture content (%)	pH (1:5) (H_2O)	BO (%)	Total N (%)	Available P (%)	Available K (%)
Rice field	51,48	5,92 (Rather acid)	1,89 (Low)	0,20 (Low)	0,04 (Height)	0,06 (Very height)
Settlement	30,43	6,13 (Rather acid)	0,54 (Very low)	0,10 (Low)	0,05 (Height)	0,07(Very height)
Shrubs	35,31	6,83 (Neutral)	1,76 (Low)	0,20 (Low)	0,04 (Height)	0,10 (Very height)
Plantation	28,,99	5,92 (Rather acid)	2,17 (Medium)	0,16 (Low)	0,03 (Height)	0,05 (Height)
Forest	25,06	7,76 (Rather alkaline)	0,82 (Low)	0,05 (Low)	0,03 (Height)	0,09 (Very height)

Table 4: Soil chemical properties on 5 landuse.

Source: Soil Laboratory Faculty of Agriculture UGM, 2017.

Red yellow podzolic soil has clay or sandy texture characteristics with low pH and contains elements of aluminum and iron is high. Another characteristic that can be found on the ground podsolic is the shelf life of nutrients is very low because it is clay, the move lower, saturation elements of a base such as K, Ca and Mg low so as not adequate for crops, levels of organic materials is low and there are only an at ground level only, and storage of water is very low so prone to drought. Improvements in the physical properties of this soil can be overcome by improving the resilience properties of water storage. Meanwhile, the improvement of chemical properties can be done by improving the nutrient content in the soil. Podsolic/ultisol soil is a land with an argillic horizon or acidic candlestick with low base saturation. This soil is generally grown from the old parent materials, are found in areas clay rock parent material. This soil problem is a sour reaction, high Al content so that it becomes a plant poison and causes fixation of P and low nutrients.

Runoff on five land use

Runoff is all the water flowing towards the soil surface water bodies such as rivers, lakes, water, reservoirs and the sea. Runoff on five land use such as table 5.

Rice field	Plantation	Shrubs	Settlement	Forest	Rainfall
0.6	0.52	3.25	0.6	0.54	5.53
1.1	1.7	1.5	2.25	0.22	5.26
2.0	6	4	2	4	26.32
4.0	5	0.6	2.1	3	13.16
0.7	5	10	9	4	19.74
3	8	1.5	13	5	13.16
1.5	15	0.25	0.5	0.75	6.58
21	21.4	6.5	22	1.1	39.47
0.6	0.75	8	13	0.5	26.32
20	21	10	20	18	39.47
8	11	1.5	9	2	20.00
2.1	2	10	1.5	3	55.26
6	6.5	10	10	7	65.79
20	18	13	11	12	26.32
12	18	10	19	20	13.16
Total 90	109	75	128	78	375.53
Average 6 Infiltrasi 9.03 (76%)	7,27 17,76 (71%)	5 20.03 (80%)	8,53 16.5 (66%)	5,2 19.83 (79%)	25.03

Tabel 5: Runoff and rainfall (mm) on five land use at dry season.

Table 5 the runoff biggest in the dry season occurs on land use settlement (8.53 mm), whereas the lowest in the shrubs (5 mm). Allegedly the increased runoff dominated by open land and the surface of the land is filled with layers of concrete, paved roads, hardened so that it is difficult to infiltrate and water flows freely. Besides that, Alluvial soil in Arui watershed which is quite dominant in light gray color is physically hard if it is dry and sticky if it is wet. In the dry season, the nature of alluvial soil that is hard and incandescent inhibits infiltration, thereby enlarging runoff surfaces. However, the low runoff in the dry season on land use shrubs for many plants, when it rains a lot inhibited by organic matter, litter and undergrowth so the water tends to be infiltrated consequently little surface runoff. According to Abari., *et al*. [29] the presence of organic forest floor materials, such as litter layer and woody debris, is very important in preventing soil detachment, providing surface roughness and reducing runoff and soil particle movement downslope.

Runoff of 8.53 mm meaningful when it rainfall 25.03 mm so the infiltration of 16.5 mm (66%). Thus when it rainfall in the dry season more water infiltrated than the surface flow (34%). In the Arui watershed area> 65% of the rain is infiltrated into the soil, meaning more water is stored in the soil than is wasted into water bodies such as rivers, reservoirs, situ and sea. Regression analysis of variance between rainfall and runoff in 5 land use at dry season (Table 6).

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	11.194	10.445		1.072	.312
Rice field	0.752	1.456	.318	.516	.618
Plantation	-0.415	1.441	-.172	-.288	.780
Shrubs	2.908	1.493	.703	1.948	.083
Setlement	0.044	.946	.018	.047	.964
Forest	-0.980	1.087	-.342	-.901	.391

Table 6: Regresion analysis of variance between rainfaal and runoff in dry season.

Analysis showed a significant relationship ($p \leq 0.005$) on land use shrubs runoff against rainfall, whereas in forest land use it did not significantly influence. Shrubs vegetation dominated by Imperata cylindrica and Piper aduncum makes the land that is not maintained, open and as a foraging animal. Thus when the water will easily flow towards the lower area. Areas with a land surface that tends to be open have no barrier for water to pass through the surface, so that water is easy to runoff. In addition, the Arui watershed shape will affect the amount of runoff and sediment. According to Mahmud., *et al.* [30] Arui watershed shape is elongated/rather oval.

According to Paimin., *et al.* (2010) the watershed shape affects the time of water flowing into the outlet. The more rounded the watershed means the shorter the time it takes to reach the outlet, the higher the flooding fluctuations occur. Conversely increasingly oval form of the watershed, water the longer the outlet. Similarly, according to Wirosoedarmo., *et al.* [31] the form of a bird feather basin (elongated) produces relatively small flood peak discharge values with relatively long peak flood times. The watershed forms more round, there are many turns and if the river is more shallow then when the rainfall is high the runoff will be easily restrained and cause puddles. However, if the watershed forms are more rounded even though the rainfall is high but there are no turns and deep rivers then the water easily flows/does not stagnate to get downstream and easily water up to the sea. The shape of the watershed is rounded if there is a change of land use will decrease the water quality, the peak discharge value will be bigger and relatively fast to flood [31].

In the dry season of forest land does not affect significant rainfall to runoff. The main function of forests in relation to hydrology is a runoff barrier that has a high slope so that the rainwater that falls in the area retained and seep into the ground next will be groundwater. The groundwater in the upstream is a reserve of water for the water resources of the river. Therefore the well preserved forest will provide benefits in the availability of water resources in the dry season, on the other hand, deforested forests will be disastrous for residents upstream and downstream. However According to Abari., *et al.* [29] rainfall and vegetation cover played an important role in determining the magnitude of runoff.

The diversity of vegetation Arui watershed species ranging from seedling to trees is 1.55 - 1.81 categorized as moderate. The four types that are always present and dominate at all levels of seedlings, sapling, poles, and trees such as *Pometia pinnata, Teijsmanniodendron bogoriense, Chisocheton ceramicus and Horsfieldia irya*. The four stands are wide leaf types and are generally oblong in shape with the characteristics of elongated leaves, the length of the leaves is approximately 2.5 x the width of the leaves. The three types of compound types are straight leaves, only *Horsfieldia irya* is the single leaf. Vegetation of broadleaf, when rainwater will be captured more in the canopy compared with the erect leafy needles. When the water is stuck on the canopy, when the canopy is saturated, the water will slowly flow to the surface of the soil either through the steam flow. The time of the water until the surface of the soil in the wide leaves will be relatively longer than the needle-leafed canopy.

However, vegetation stand during the dry season broadleaf will withstand sunlight, increase transpiration, reduce evaporation of water from the soil, lower air temperature and maintain air humidity. Considering that evaporation from small soil, the water below the stand will be bound to the soil so that the groundwater reserves are relatively large [32]. The canopy of *Pometia pinnata, Teijsmanniodendron bogoriense, Chisocheton ceramicus* and *Horsfieldia irya* is atterms's with the characteristic rounded, large crown diameter, has a very dense and lush leaf. This canopy is a pattern of adaptation to upright areas with high rainfall. The atterms's canopy when rainfall will break water, reduce kinetic energy, intercept water and pass water through the stems and leaves longer and larger so that the amount of water that reaches the soil surface and infiltration tends to be greater. Similarly according also to Adélia., *et al.* [10] Rainfall interception by the plant has two main consequences, the most important being that it reduces the erosive power of impacting raindrops. But on the kind of slim canopy (Schoute's), when rainwater is only temporarily halted, fast to the ground and infiltration. As a result, water is easily saturated and flooded soil surface which then flows on the surface soil.

Table 7 runoff in the rainy season was greatest on land use settlement (6.07 mm), whereas the lowest in the forest (2.93 mm). Runoff of 6.07 mm (18.1%) a meaningful of 33.93 mm rainfall percolation of 28 mm (81.9%). Thus when it rains in the rainy season more water infiltrated than the surface flow (18.1%). In the Arui watershed area> 81% of the rain is infiltrated into the soil, meaning more water is stored in the soil than is wasted into water bodies such as rivers, reservoirs, situ and sea. Regression analysis of variance between rainfall and runoff in 5 land use at rainy season (Table 8).

Analysis showed a significant relationship ($p \leq 0.005$) on land use shrubs runoff against rainfall, whereas in ricefield land use it did not significantly influence. In the use of ricefield land that tends to open, but there is insulation that blocks the surface flow rate. Rice field is a very important land in Indonesia because it is the main natural resource in rice production. At present, the existence of fertile irrigated rice fields is threatened by the incessant development of industrial estates and urban expansion so that the

Rice field	Plantation	Shrubs	Settlement	Forest	Rainfall
14	15	10	15	17	17.10
17.5	14	12	17	7.5	13.16
1	4	1	3	1.2	19.74
20	10	10	20	2	14.47
1.5	5	1	5	1	16.32
2.5	2	3	2.5	3	13.16
4	2	5	6	2.5	14.47
3	3.5	10	3	2.5	46.05
5	18.5	9.5	5.5	1.7	26.32
14	5	3	10	2.5	14.47
2	20	10	3	10	34.21
3	2.5	9.5	4	2.5	13.68
9	1.1	9	5	8.5	28.95
3	4	9.5	4.5	3.5	197.37
5	5	9.7	1.5	11	39.47
Total 83	86	74	91	44	508.94
Average 5.53 Infiltration 8.4 (83.9%)	5.73 28 (83.1%)	4.93 29 (85.5%)	6.07 28 (81.9%)	2.93 31 (91.4%)	33.93

Table 7: Runoff and rainfall on five land uses in the rainy season (mm).

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	17.381	31.687		.549	.597
Ricefield	-5.158	6.773	-.701	-.762	.466
Plantation	-2.080	2.737	-.285	-.760	.467
shrubs	6.657	4.545	.536	1.465	.177
Setlement	3.050	7.429	.379	.411	.691
Forest	-0.625	3.559	-.063	-.176	.864

Table 8: Regresion analysis of variance between rainfall and runoff in rainy season.

area of paddy fields decreases, because it is conserved for non-agriculture. The use of dry land for wetland rice can cause changes in the morphological properties and physical-chemical properties of the soil permanently so that it can cause changes in soil classification [26]. Whereas in rice fields originating from wetlands, these changes are not very clear [33].

Sediment on five land uses

Sediment is one important part and is output in the watershed. More or less sediment is an indicator of the watershed, so that if excessive can lead to superficiality-shallowness of rivers, reservoirs, and other water bodies. In large quantities in the event of high intensity rainfall will fill the shallow rivers are thus water would overflow and flood disaster happened. Sediment in five land uses in the dry season is listed in table 9.

Table 9 shows the greatest sediment on plantation land use (50,83gr), whereas the lowest rice field (17:38 gr). Land use plantation has an area of 21.46% of Arui watershed. Plantation which is dominated by oil palm plantations is a big challenge in watershed management. Because oil palm plantation has an area of 4981.3 ha (21.46%) ranked second after the forest 11745.3 ha (50.60%). Area of Red yellow podzolic soil 401% of the watershed Arui region with clay texture properties, saturation of basic elements such as K, Ca, and Mg is low so that it is adequate if for year crops such as oil palm plantation. Besides, the characteristic of Red yellow podzolic soil organic matter levels are low and only found at ground level only, and storage of water is very low so prone to drought. Several

Rice field	Plantation	Shrubs	Settlement	Forest	Rainfall (mm)
1.2	0.9	4.5	0.4	0.6	5.53
1.2	1.6	1.02	1.2	0.2	5.26
12.55	202.16	12	4.64	63.27	26.32
30.25	83.8	7.30	12	112.57	13.16
4.02	30.95	21.51	19.25	22.59	19.74
5	51.51	4.35	31.11	24.38	13.16
5.53	15.05	8.26	7.18	17.66	6.58
36,68	172.08	34.57	60.52	21.82	39.47
11.34	15.86	11.88	97.75	7.6	26.32
36.68	80.22	25.57	83.3	13.37	39.47
9.40	12.64	12.75	12.91	8.86	20.00
8.42	9.03	19.38	12.75	13.67	55.26
43.72	7.1	8.45	8.28	13.59	65.79
19.36	14.02	42.75	9.13	22.68	26.32
35.39	66.17	70.4	72.53	19.78	13.16
Total 260.74	762.59	284.69	432.95	362.64	375.53
Average 17.38	50.83	18.97	28.86	24.18	25.03

Table 9: Sediment (gr)on five land uses at dry season.

oil palm plantation sites have entered the second cycle, allegedly clearing land for planting oil palm seedlings to trigger high sediment on the river bed in Arui watershed. Sediments/parts of a material transported by water from a site that is eroded and enters the water. According to Mueller., *et al*. [34] found that land use change has larger impacts on sediment yield than climate change. Damage to soil erosion occurs in the form of deterioration of chemical and physical properties of soil such as nutrient loss, increased density and resistance of soil penetration, decreased infiltration capacity and soil capability in water retention [35].

Deforestation to be used as plantation land is not yet safe, as is selective logging. The selective logging has decreased the forest canopy cover and significantly influenced runoff and sediment yield [29]. Plantations have different characteristics from forest plants. The strength of plantation crops in rainwater retention is not equal to the strength of forest plants usually have aged decades with roots thrust deep into the ground. Therefore the risk of increased runoff, landslides and mudflows is still a threat to this area. The effect on river water quality is almost the same as opening agricultural land. Another consequence of the shifting of land functions in the upstream area (replacing hardwood species into annual productive plants in water catchment areas) is the cause of the overflow of a number of large rivers which have resulted in the destruction of several river estuaries. As according to Guzha et al. conversion of forest to pasture may lead to important changes in runoff generation processes and water storage. Regression analysis of variance between rainfall and sediment in 5 land use at dry season (Table 10).

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	20.389	8.114		2.513	.033
Ricefield	1.001	.384	.824	2.608	.028
Plantation	0.034	.092	.115	.366	.723
Shrubs	-0.279	.298	-.284	-.936	.374
Setlement	-0.088	.170	-.161	-.517	.617
Forest	-0.274	.208	-.433	-1.322	.219

Table 10: Regresion analysis of variance between rainfall and sediment at dry season.

Analysis showed a significant relationship ($p \leq 0.005$) on land use ricefield the amount of sediment to rainfall, while in land use shrubs did not significantly influence. Rainy and dry seasons have an influence on the amount of sediment transport sediment 5 land use in listed (Table 11). When the rainy season increased water, the soil is easily saturated, if the land open water carry runoff sediment particles in a land no vegetation. According to Zokaib and Nazer [11] seasonality plays important role in water scarcity, which could be managed with better water management policies.

Rice field	Plantation	Shrubs	Settlement	Forest	Rainfall (mm)
42.77	152.48	19.84	70.42	15.24	17.10
109.77	20.59	22.73	84.09	10.24	13.16
5.21	29.33	7.42	17.34	6.51	19.74
36.61	33.87	16.35	69.99	43.88	14.47
39.64	47.56	23.27	51.11	5.1	16.32
40.68	19.22	18.32	16.05	12.29	13.16
21.8	15.28	14.03	19.8	13.85	14.47
10.02	16.38	15.48	6.94	10.99	46.05
44.9	36.8	34.55	42.04	105.59	26.32
172.03	48.18	46.03	10.23	18.01	14.47
52.95	49.2	9.96	10.39	9.57	34.21
26.95	26.72	17.01	18.17	5.48	13.68
28.09	13.55	15.72	13.87	16.56	28.95
19.31	7.71	17.62	10.66	8.24	197.37
38	15.26	19.23	4.08	25.96	39.47
Total 688.73	534.13	297.56	445.18	307.51	508.94
Average 45.91	35.61	19.84	29.68	20.50	33.93

Table 11: Sediment (gr) in five land uses at the rainy season.

Table 11 shows the largest sediment in ricefield land use, while the lowest is in shrubs and forest. With high rainfall intensity almost all the water flows on the surface of the soil, especially before it was raining anyway, so only a little water is absorbed into the soil. According to Li and Gao [36] precipitation has a more significant impact on runoff than on sediment yield. But the dry season despite the rain, the soil is not easily saturated so much water is absorbed into the soil, runoff and sediment particles that drift relatively little. One of the most important factors that typically explain the amount of sediment transport is seasonal variation [29]. Regression analysis of variance between rainfall and sediment in 5 land use at dry season (Table 12).

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	40.141	39.916		1.006	.341
Rice field	-0.604	.663	-.552	-.911	.386
Plantation	-0.247	.460	-.186	-.536	.605
Shrubs	2.317	3.248	.476	.713	.494
Setlement	-0.194	.643	-.111	-.302	.770
Forest	-0.485	.778	-.266	-.624	.548

Table 12: Regresion analysis of variance between rainfall and sediment in rainy season.

Analysis showed a significant relationship ($p \leq 0.005$), on land use shrubs between sediments on rainfall at rainy season while those on ricefield land use did not significantly influence. The risk of deforestation to be used as agricultural land is as large as deforestation. Decreasing river water quality can occur due to erosion with increasing suspended solids in river water as a result of sedimentation. It will also be followed by increasing water fertility with increasing nutrient content in river water.

Rainy and dry seasons have an influence on the amount of sediment transport. Most forests are converted into agricultural land has a slope of over 25%, so if they do not take into account the conservation of soil, such as setting the cropping, terracing, and others, it will result in the entry of fertilizers, sediment and pesticides into river water carried away by water runoff. Beneficial forest for soil and water conservation Kodoatie and Sugiyanto (2002) cited

Senawi (2009) if the forest when converted into rice fields then streamflow will rise to 2.5 to 9 times the the discharge.

Infiltration at five land use

Table 13 shows the capacity of infiltration (cm h-1) in plantation is at 9.9 (slow) in settlement, 10.9 (slow), forest 15.04 (medium), plantation 17.82 (medium) and rice field 22.75 (medium). The infiltration capacity at 5 land use between 2.5 - < 15 (cm h-1) and 15- < 28 (cm h-1) based on infiltration classification classified as slow and medium with the highest infiltration was in the land use of rice fields while the lowest was a settlement. According to Arsyad [35]; Triatmodjo [37] when the soil is still dry the infiltration rate increases after the soil saturated the infiltration rate decreases and becomes constant. Further, according to Triatmodjo [37] after the wet soil, the capillary motion is reduced due to reduced capillary forces that cause decreased infiltration rate. The supply of rainwater into the soil is very meaningful for most plants in place of infiltration and the surrounding area. In large infiltration soils, the possibility of low erosion occurs. According to Zokaib and Naser [11] to control runoff and erosion and to better utilize runoff water, vegetation and organic matter content of the fields should be improved to increase infiltration rate. This is due to the absence of surface runoff if there is no surface flow then when it rains water directly into the soil and stored in the soil.

Time (hours)	Pm (cm)	Tg (cm)	Sw (cm)	St (cm)	Ht (cm)	$t^{-0,5}$	KIpm	KItg	KIsw	Kist	KIht
0,0083	0,4	0,05	1	8	7	1,41	9,91	10,9	22,75	17,82	15,039
0,017	0,3	0,04	1	8	7	1	8,17	8,89	18,59	14,53	12,21
0,025	0,3	0,3	0,9	7	6	0,82	7,4	7,99	16,75	13,07	10,957
0,033	0,2	0,3	0,9	7	5	0,71	6,94	7,45	15,65	12,2	10,21
0,042	0,2	0,2	0,7	6	5	0,63	6,62	7,08	14,9	11,61	9,6997
0,05	0,1	0,2	0,6	5	3	0,58	6,39	6,81	14,34	11,17	9,3233
0,085	0,1	0,1	0,5	4	3	0,53	6,21	6,6	13,91	10,83	9,0308
0,067	0,1	0,1	0,3	3	2	0,5	6,07	6,43	13,57	10,56	8,795
0,075		0,1	0,1	2	2	0,47		6,29	13,28	10,33	8,5997
0,0835			0,1	1	1	0,45			13,04	10,14	8,4345
0,092			0,1	1	1	0,43			12,83	9,97	8,2923
0,1					1	0,41					8,1683

Table 13: Infiltration capacity in five land use.

Note

1. IPm/Settlement Infiltration, by the formula F = 4,21t^-0,5 + 3,96); KIPm: Settlement infiltration capacity (cm h^{-1}).
2. ITg/Shrubs Infiltration, by the formula F=4,92t^-0,5+3,97; KITg: Shrubs infiltration capacity (cm h^{-1}).
3. ISw/Rice field infiltration Infiltrasi Sawah, by the formula F=10,05t^-0,5+8,542; KISw: Ricefield infiltration capacity (cm h^{-1}).
4. ISt: Plantation Infiltration, by the formula F=7,95t^-0,5+6,58; KISt: Plantation infiltration capacity (cm h^{-1}).
5. IHt: Forest Infiltration, by the formula F=6,83t^-0,5+5,38; KIHt: Forest infiltration capacity (cm h^{-1}).

Several factors affect infiltration include initial water supply (initial moisture), climate, soil cover conditions, soil surface conditions, organic matter, and physical properties such as soil structure, soil texture, permeability and soil color [38]. Remah soil structure will give greater infiltration capacity than soil clay. One of the factors affecting the magnitude of infiltration is the type of stand. Because each stand has a different ability to absorb and save water. According to Linsley., *et al*. [24] plants that cover the soil well add infiltration capacity through the addition of organic matter. A tight and thick canopy will hold/hold more water dan infiltration for a considerable length of time than canopy rarely [38,39].

Canopy conditions increase the amount of rainwater that reaches the soil surface and thereby enlarge the soil infiltration. The number of plants covering the soil, such as grass or forest, can increase soil infiltration [37]. Rainfall in vegetated areas, many are temporarily suspended in canopy, twigs, trees, leaves or litter slowly entering the soil. With relatively poor physical and chemical properties of soil characterized by low agricultural productivity then to improve is made for canalization. Besides the shallow groundwater and low infiltration rate make the water flooded so that if the rain of high intensity of the flow of the larger surface that can cause flooding.Thus, to reduce and prevent flooding needs to be done canalization.

Conclusions

Settlement land use significant effect on the runoff, the amount of runoff in the settlement because settlement dominated by open land, and the soil surface is filled with a layer of concrete, paved roads, soil hardened thus difficult infiltration and water flows freely. The use of land as a rainfall forest does not have a significant effect on runoff due to the diversity of vegetation. Watersheds are categorized as moderate dominate such as Pometia pinnata, Teijsmanniodendron bogoriense, Chisocheton ceramicus, and Horsfieldia. Rainfall in the rainy season on land use was significantly shrubs against runoff and sediment, caused by vegetation dominated by Imperata cylindrica and Piper aduncum make the land that is not maintained, open and as a pet food which so that water easily erodes and surface runoff. The use of rice field land for rain did not significantly affect runoff and sediment due to farmers who had applied soil and water conservation techniques such as mounds, use of organic fertilizers, alley cropping and intercropping. Value of Infiltration five land use are slow and the medium with the highest infiltration on the use of rice field while the lowest settlement. Increased infiltration will reduce surface runoff affecting the flood.

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