Salacca sumatrana Becc as an erosion retaining plant in catchment of salak plant area at west Angkola North Sumatera Indonesia

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ABSTRACT

Nasution Y, Rasyidin A,Yulnafatmawita and Saidi A.2018. Comparison of Sediment Trap in the Water Catchment Area of Salak and Non-Salak Land at the West Angkola Subdistrict. Salak Padangsidimpuan (*Salacca sumatrana* Becc) is the specific superior fruit in Padangsidimpuan city and South Tapanuli. This research aims to comparison of sediment trap on Water Catchment Area (WCA) of salak and non-salak land. Research was conducted on the type of mineral soil in West Angkola District with altitude of place 350 - 880 m above sea level. The study period starts from October 2016 to September 2017. This research used survey method and the calculation of sediment measurement using evaporation method. Statistical analysis used to determined the sediment catch on WCA of salak and non-salak land was by using regression. The result of sediment trap on WCA non-salak land was 57.46 tons/ha/yr whereas in the erosion salak area was 4.19 tons/ha/yr, Linear regression on WCA of salak results show determinant coeficient ($R^{2)}$ was 0.02 while WCA non salak was 0.003. Thus there are differences in the amount of sediment in WCA of salak and non-salak land. Salak plants can withstand rainwater so as to reduced run off rate and erosion hazard by suppressing sediment rate.

Keywords: Sediment Trap, Land use and Salak Padangsidimpuan

A. INTRODUCTION

Erosion is an occurrence that can harm humans by reducing the ability of natural resources, namely land to support food security. in addition to damaging natural resources, erosion events can potentially reduce living biodiversity and damage the ecosystem balance. This is very threatening to the survival of all beings on earth. Soil erosion negatively affect the soil quality and decreasing agricultural efficiency [1]. Soil is a central component of terrestrial ecosystem and a fundamental of constituent in sustaining life on earth [2].

The effects of erosion produce sediment in the river flow which impacts the silting of the river. On the other hand, sediment is an indication of the amount of erosion. On one hand, the vegetation changes the flow structure and the sediment transport [3]. Recently, many suggestions are echoed that vegetation has a role in maintaining the sustainability of natural resources and the environment [4] therefore the vegetation is maintained as a land cover in controlling erosion and refreshing the air.

Vegetation directly affects the amount of sediment. The denser of vegetation and the land, the more covered the land in the catchment, this can reduce the amount of sediment in a river in the catchment area. The vegetation cover will have a direct effect on the soil erosion rate and deforestation and conversion to residential areas are the most significant factors in erosion induced by land use change [5]. Rainfall lost to vegetation interception is most prominent under condition of lower rainfall intensities and may strongly influence erosion rates under such conditions [6].

Salak land are arable land of salak farmers in Angkola Barat sub-district, North Sumatera. Generally, farmers undertake to cultivate these plants traditionally with no tillage and rejuvenation. Furthermore, farmers only take the yield from this plant without fertilization. in addition to salak plants farmers also planted perennials as shade plant for salak plants because these plants not tolerate toward full radiation. Land conditions in general by topography of slopes to hilly and salak plants still produce planted on sloping land, so that sloping land is still employed as cultivated land.

The vegetation of salak land is different from not salak land. Salak land catchmen area has a land use with zalacca-based agroforetry system in the west Angola sub-district, whereas in the catchment area of non-salak, there is no salak population but the land is overgrown with annual crops. Sediments contained in rivers in zalacca and not zalacca catches are unknown, so information is needed regarding the difference in the amount of sediment in two different catchment areas. This study be required to determine the effect of different land uses.

The aim of the present study is to estimate trends in soil erosion potential on different catchment. area of salak land and not salak. This study informs the heaviest erosion hazards among the two land uses. thus erosion hazards can be improved to subsequently carry out conservation actions for the sustainability of natural resources and the environment in southern tapanuli.

Materials and Methods

Location and discription

The study was conducted in theWest Angkola district, with a height of 350 - 880 m asl The study period started from October 2016 to March 2017. Soil type is classified as dystropepts with andesitic rock formations of volcanoes. The area of eastern angkola is 184.86 km lies on 01o 27’ 19” to 01o 28’ 48” N and 99o 18’ 55” to 99o 04’ 00” E. Tropical research location with rainfall every month throughout the year. Mean annual precipitation is 2691 (2016-2017). The topography of the area is sloping and hilly 720 m above sea level. Observations were made on different catchment and different forest species, the land use salak areas generally be planted by salak based agroforestry system and land use not salak areas be planted by annual plant (Fig.1). The surface soil type clay loam. Location determination based on land unit, start out date 1-30 per month during one year (from Oktober 2016 to September 2017). The soil in this basin is primarily of the Dystropept, tropis forest, and sedimentary.

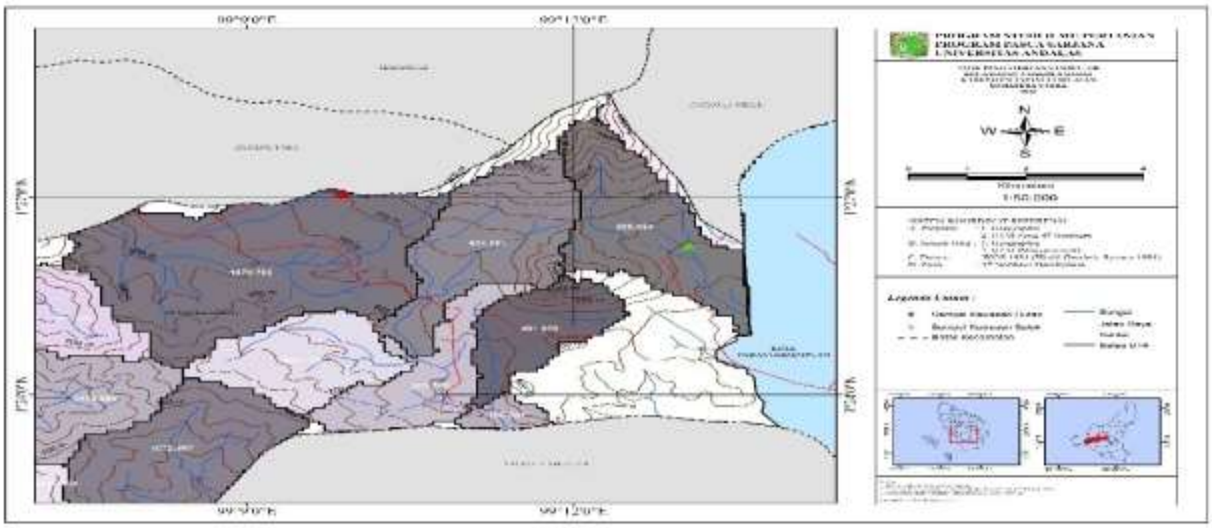

Figure 1. The catchment area map in west Angkola

Erosion observations

The location of the observation point is determined by the following steps:

a. Determine the location of the river on the salak area at the West Angkola with the use of agroforestry based salak land system.

b. Determine the location of the river on non-salak- land

c. Determine the point of observation in accordance with the objectives of the study

Sediment analysis is needed to determine the amount of sediment production and erosion rates. The amount of suspended load can be calculated from the relationship between the recording of discharge and the recording of sediment concentrations in the study area. Assuming that the sediment concentrations are evenly distributed across the entire cross-sectional section of the river, the drift sediment discharges can be calculated as a result of the multiplication of sediment concentrations [7] and flowrate formulated as follows:

$$Qs=QxCsxK \quad (1)$$

Qs = sediment (ton / day)

. Cs = Concentration of flyover or sediment concentration (mg / l)

Q = Flow debit (m^3)

K = 0.0864

Results and Discussion

The difference in land used salak and not salak

The river water sampling in West Angkola was determined based on the catchment area map. This map can inform the extensive of water catchment in each sub-watershed be required in the study (Fig 1). West Angkola sub-district is one of the centers of Salak in North Sumatra. The topography of the area is bumpy up to hilly with many slopes on the side of the hill. Generally sloping land is planted with salak with zalacca-based agroforestry systems [8]. The catching area of salak and non-zalacca is determined by the Arc Gis program 10.3 with satellite imagery.

Dense salak covered 929,854 ha 25.18 percent of the study area, while not salak aproximately 1970.70 ha 53.36 percent of the area. Land use salak covered and not salak of respectively catchment. Detailed information about the catchment area are shown in (Fig 1) 1092.33 ha 21.45 percent built up areas and scrub land covered. While information about the area salak land use are shown in Fig.2.

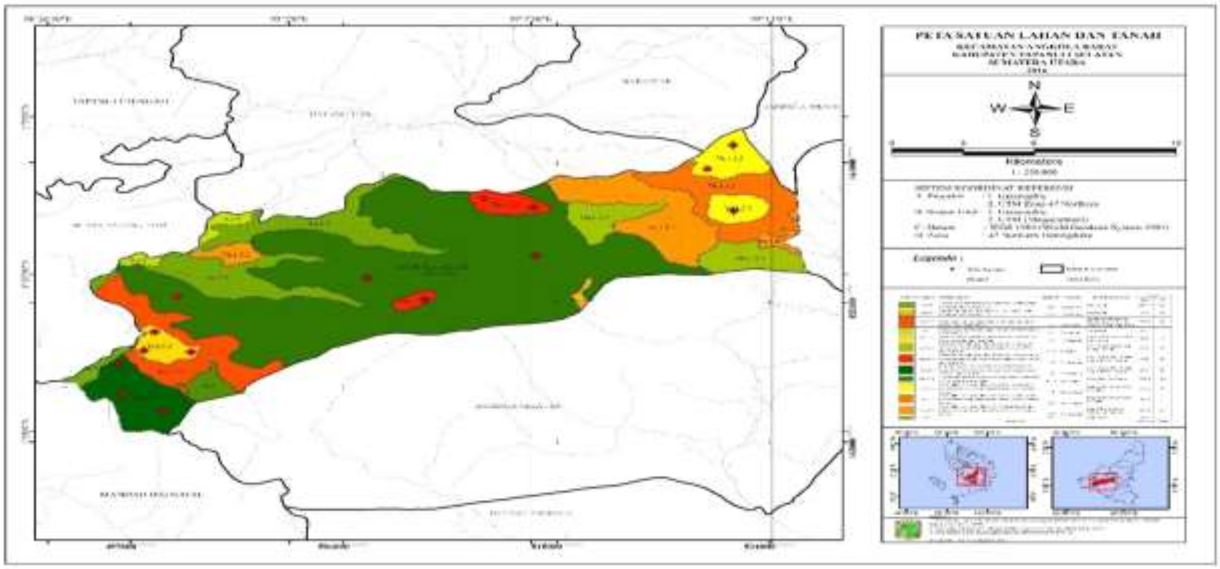

Figure 2. Salak land use map

Non-salak land use is generally be planted with annual crops such as rubber, coconut, avocado, cinnamon and others. At while it is rain the non-zalacca land use effect to rainfall interception through the canopy and most of the rainwater becomes runoff further it flows to the river containing deposits (Fig. 3a). On the other hand the salak land use likewise encounter the same case however the rainfall interception was greater, eventually runoff was less and water flowed through infiltration flowing into the river with little sediment (Fig. 3b).

Figure 3a. The water catchment area of salak land drains stream with a little sedimen

Figure 3b. The water catchment area of non salak land drains stream with sediment

Sediment in salak land use has a small amount when compared to non-salak land (Fig. 3a;3b) shows that the type of vegetation affects interception while the rainy period and reduces the amount of runoff containing sediment. Previously reported by [9] that the sediment yield showed a significantly decrease with increasing forest coverage , because the forest cover provided greater protection, even while the annual precipitation increased. It is expected that the turbidity levels of the re-vegetatited sites will then decline further [10]. Specific practised conservation agriculture (annual precipitation, croping region and crop type) take effect on improves aggregate stability, reduces soil erosion and increases the infiltration and conervation of soil water [11]. In the other researches inform the different vegetation the results indicate that land use changefrom forest area to settlements will be the most significant factor in erosion induced by land use change, showing the highest correlation among erosional factors [12].

The impact of vegetation on sediment yield in the respectively river

The results measurements of sediments on two rivers in different water catchments at period occur of rain in the course of 1 year are shown in the following table. Sediment measurement results are calculated through evaporation methods conducted in the laboratory. and the data in this table is obtainable from the formula of sediment concentration multiplication, river flow and constants

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Table 1. Sediments in the catchment area of salak and not salak in west Angkola

NO	Month	Rainfall (mm)	River sediment in salak water catchment area		River sediment in not salak water catchment area	
			Cs (mg/l)	Qs (ton/day)	Cs (mg/l)	Qs (ton/day)
1	October	387	726.47	188.3	195.88	1210.078
2	November	318	2187.49	566.99	296.23	1830.002
3	December	437	708.59	183.66	252.61	1560.532
4	January	372	725.07	187.94	3476.02	21473.47
5	February	171	477.94	123.88	1470.82	9086.14
6	March	200	1685.41	436.86	5202.16	32136.88
7	April	212	0	0	5538.46	34214.4

8	May	132	0	0	80.56	497.66
9	June	107	812.74	210.66	230.32	1422.804
10	July	38	1040.31	269.65	334.41	2065.873
11	August	179	3079.42	798.19	349.24	2157.453
12	September	138	3576.39	927	905.19	5591.919
		2691	15019.79	3893.13	18331.91	113247.20
	The catchment area (ha)			929,854		1970.70
	Quantitiy of erosion (ton/ha/yr)			4.19		57.46

Cs : Sediment concentration, Qs : Sediment debit

The amount of sediment was measured in the salak and non-salak water catchment areas be based on rivers represents the watershed (Fig. 2).The water catchment area of Salak land is 929,854 ha and not Salak 1970.70 ha. The quantity of sediment be divided with the catchman area so as available the amount of erosion in one hectare area for a year. In West angkola areas where annual precipitation is 2691 mm for a year (table1) soil erosion rises as precipitation increases where land use is not salak areas which is chiefly due to protection of soil surface by the vegetation cover. However these case not occur in the land use salak areas, when the annual precipitation increases doesnot effect the soil erosion therefore tightly vegetative cover.

Salak land use greatly affects the amount of sediment flowing into the river which is characterized by a smaller amount of sediment compared to non-salak land use (Table 1). This case deal with the type of vegetation that grows in the catchment area. [13] found that effective biological practices for improving soil properties throughminimizingerosion. Low percent of runoff to rainfall were also reported under different land use systems by [14] that minimum soil loss during the study was observed in the plot under tea (*Camellia sinensis* L)(6.9 t ha^{-1} yr^{-1}). [15] investigated that the results showed a significant reduction of average potential soil erosion equal to 25.6% (from 18.65tha−1yr−1 to 13.86tha−1yr−1) when the MOLA (Multi-Objective Land Allocation) land use plan was followed.

The difference in the amount of sediment at the location of salak and non-salak land catchments in Angkola Barat sub-district is shown in the following Figure 4.

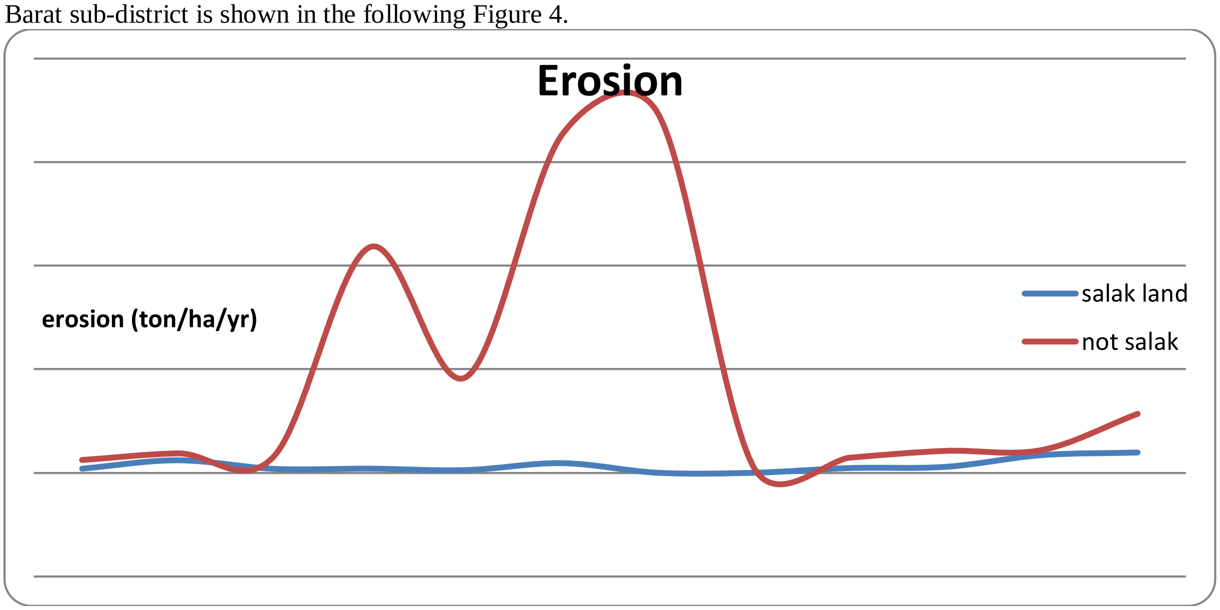

Figure 4. Comparison of the number of sediments in the salak and non-salak catchments

Before assessing the zonal differences of catchment area of salak land and not salak, previously determined by the catchmant area map by way of satellite to find out the differences in land use.

The collection of water samples is carried out while the rain falls. The water sample include the sediment is dried by evaporation method so as obtainable quantity of sediment be required to counting within research. The amount of sediment is higher in not salak water catchment area rather than salak land the quantity of erosion lost in the catches of salak and not salak (Fig.4) was tested by independent sample T test with the results of Sig. (2-tailed) = 0.024, that is 0.024 <0.05 i.e. there is a difference between the amount of erosion in two different salak catches.

Differences in land use were considered in this study, the results of erosion counting occur a significant distinction. Erosion on salak land is much lower than non-salak (Fig. 2). This is due to the fact that salak plants have the potential to hold rainwater and reduce runoff. Comparatively the land use dynamics have a higher effect on sediment yield than stream flow. According to [16] that Land use change causes an increase in erosion riskn from 12.54 to 15.17 t/ha. The soil loss in unstreated catchment 14.1 t^{-1} despite of its being unstreated with soil conservation measures and being steeper than other catchment [17]. Three scenarios of the catchment land use were distinguished (basic, first and second), the basic including a spring oat crop the first oat ang potato crop and second by grassland In the basic scenario, mean annual top-soil loss was 8.01 Mgha−1, in the first it was 16.99 Mgha−1, and in the second, 6.02 Mgha−1 [18].

Rainfall for 1 year at the research site is shown in Figure 5. Observations start out from October 2016 to September 2017.

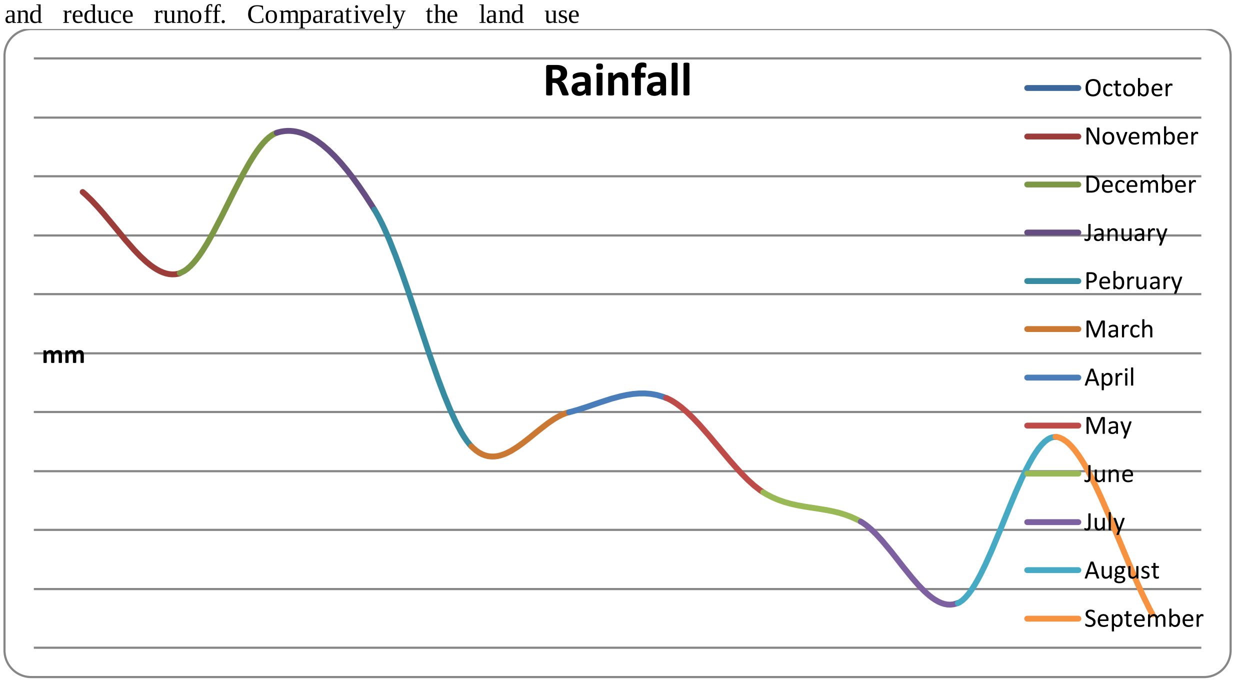

Figure 5. 1-year rainfall graph in West Angkola

Rainfall measurement for 1 year at the research site result rainfall data with two of the highest peaks, specifically December and April (Fig. 5). In the course of the rainy period of 1 year there is a slight rainy month in July. The highest rainfall occurred in October to December whereas the lowest was in June through the research period at West Angkola. The same state likewise occur to the research reported by [19] that increases in rainfall for the months of October and November an a shift in the occurence of maximum surface runoff. When rainfall attain the next highest peak at this point the rain drops result the highest potential kinetic energy that be able disintegrate soil particles on the surface. Previously reported by [20] force may give rise to kinetic energy with boundary that affect the process of soil erosion. Subsequently reported by [21] that climate change effects can change the rainfall pattern (amount, intensity, frequency, duration) of a study area. Rainfall erosivity can increase due to increased rainfall which may increase the power to detach and carry soil particles.

Rainfall varies between 100-500 mm per month (Fig. 5) at the study site only in July which includes dry months so daily rainfall indicates that this number is still in the moderate category for the growth of salak plants. The mean rainfall in the amount of 500 mm has the potential for runoff and erosion in this case from October to December at the study site. The similar is observed in [21]; and [22] that rainfall at an intensity of 400-500 mm has the potential for runoff and erosion.

The effect of rainfall toward erosion on different vegetation

The relationship between erosion and rainfall on salak water catchment in this study is shown in Figure 6a. The result indicated that , there is no significant relation between them (R^2 : 0.020).

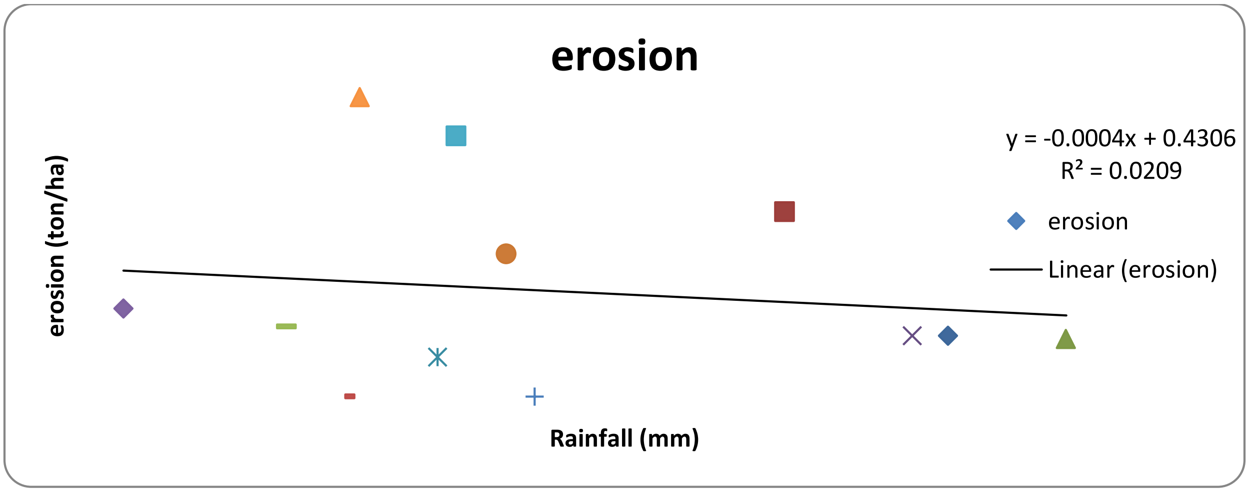

Figure 6a. Rainfall Relationship with Erosion on salak land

Generally, rain affects the amount of erosion, but in this study the effect of rain on erosion is not a significant thereby positive effect of salak vegetation which reduces erosion hazard. In this occurrence salak land is a vegetation that can withstand falling rainwater thereby reducing runoff. thus rain does not always directly affect the amount of erosion. [23] found the relationship between high intensity rainfall and soil erosion has a non-linear relationship while in low intensity rain has a linear relationship. Similar to the results of [24] that with increasing precipitation, sediment yield is a decreasing trend.

The relationship between rain and erosion at this study has a negative correlation (Figure 6a) shows that high rainfall does not significantly affect the possibility of soil erosion in conditions of land with dense land cover by salak plants with agroforestry systems further resisting the interception of rain so as to reduce the amount of rainfall falling to the surface. Salak Padangsidimpuan plants have different morphology with other types of salak, salak plants is longer and wide and the stems are large and sturdy so as to hold the fall of rain water to the soil surface [25]. [26] point out that significantly lower soil erosion risk in protected areas with vegetation and high annual rainfall amount. The same result stated [27] that rainfall affects the amount of sediment but other factors play a role such as the type of vegetation, the slope of the land and the soil properties. The study of sediment and nutrient by [28] that increases the intensity of remediation at catchment can reduce sediment.

The relationship between erosion and rainfall on catchment of not salak in this study is shown in Fig. 6b. The results of linear regression analysis of the relationship between rainfall and the quantity of sediment possess a positive correlation, i.e. when rainfall increase therefore the quantity of sediment more and more high. Types of vegetation not considerable have a role on effect the rainfall toward sediment. The similar was found by [29] that the rainfall is characterized by hight intensity ften exceed soil infiltration rate to cause surface water runoff. Versaly by [30] ; [31] found the effect of these variation of seasonal rainfall throught observed for January, April and July result conditions with generally depressed runoff , this months resfectively rainfall is relatively low, therefore not give rise to surface runoff.

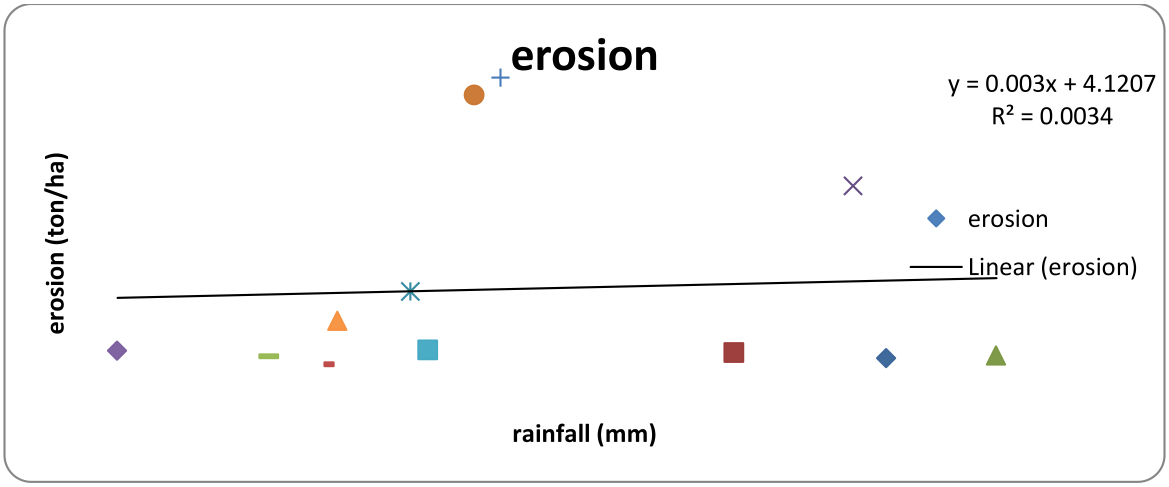

Figure 6b. Rainfall Relationship with Erosion on non-salak land

The determinat of koeficient R^2: 0.003 (fig. 6b), in this study indicate that the rainfall with erosion have a weak relationship, erosion tends to increase with increasing rainfall. The vegetation of not salak catchment could not prevent erosion, evidenced by the greater amount of erosion occurring in the catch not salak, rather than salak (Table 1). In this case non-salak land has vegetation however this land cover cannot inhibit erosion, likely due to the type of plant and its density, The relationship of vegetation cover with the amount of erosion reported [32] that vegetation coverage was linked to annual precipitation, and increased steadily with precipitation until a value of 500 mm was reached, after which it remained stable, vegetation reduce the sediment concentration.

Catchment of not salak are areas consisting of various trees such as forest wood which can also hold rainwater however not so plentiful similar salak trees in holding rainwater. The relationship of rain with erosion in the catchment instead of salacca (Fig. 6b) indicated that soil erosion increases linearly with rainfall, in this connection only rainfall directly affects erosion whereas other factors such as vegetation, slopes and soil types have minor effect. [33] point out the high intensity and short duration caused more surface runoff and soil loss under all vegetation types.

Increased erosion along with the increase in rainfall (fig. 6b) this occurs because the surface of the land in the catch of not salak cannot drain water through infiltration but rain water is flowed as runoff which eventually flows sediment to the river. Differences in soil cover vegetation induce differences in the ability of the soil to infiltrate water into the soil. [34] point out differences in erosion in two different land cover areas where conventional agricultural land has greater erosion than conservation agriculture. Furthermore the main factor affecting erosion in addition to rainfall is land cover likewise reported by [35] the maximum runoff was obtained from under famer's practice whereas minimum soil loss under contour staggered trenches. Land use / land cover influence dense vegetative covered type significantly affected the amount soil erosion[36].

The land use of salak in Angkola Barat is very susceptible to erosion due to consideration of land topography. generally salak is cultivated on mountain slopes however salak plants are cultivated with agroforestry systems therefore the land is permanently closed [8]. Salak Padangsidimpuan plants have the morphology of the stems because they are wrapped in midribs with long and wide leaf midribs therefore these plants can withstand rainwater through interception [25]. Furtheremore rainwater retained by salak plants results in reduced runoff and increased infiltration. This is evidenced by the lower number of erosion in salak catchments compared to catches of non salak (Table 1).

Erosion factors including rainfall, vegetation, slope, soil type and management greatly affect the amount of erosion, from the results of this study the most influential factors are the type of vegetation or land cover (Fig. 6a:6b) where the dominant type of land cover affects the amount of sediment without reducing the role of other factors. Previous stated by [37];[38] that when erosion rates can be quite high, much of this is because of the disturbance of the soil surface and land use.

D. CONCLUSION

Erosion, land use and vegetation of salak land are important aspects in this study. Salak plant has a certain character, i.d. the morphology of a stout stem and the stem is wrapped by a leaf midrib, the leaf midrib is wider and thus can hold water by way of rainfall interception. Salak land and non-salak land are two different vegetations that influence river sediments in their respective regions. Erosion on salak land is lower than non-salak land. This indicated that salak land has a type of vegetation that can reduce the effects of erosion.

The relationship of rainfall to erosion on salak land has a weak correlation, this is indicate by vegetation that can withstand the effects of rain on runoff. while the relationship between rainfall and erosion on non-salak land shows a positive correlation, that is when rainfall increases, the amount of erosion also increases. The results of this research idicated vegetation factors are very dominant in influencing the amount of erosion compared to other factors. Salak land use is role in maintaining the land from the effects of erosion in the south tapanuli area.

Conflicts of Interest

There is no conflict of interest regarding the publication of this paper

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