FLOOD-PLAIN UTILIZATION IN SOME BEDADUNG'S SUB-WATERSHED FOR PADDY CULTIVATION IN ORDER TO SUPPORT FOOD SECURITY

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Abstract

Along with the rapid growth of population on Java island, many land-uses were change as residential and agricultural-field. One consequence of these conditions was the increased sensitivity of the environment against climate change like floods in the rainy season and drought in the dry season. The purpose of study were identifying the floodplain area in several sub-watershed in Bedadung's watershed due to utilization of paddy cultivation as an alternative to use of marginal land to reduce the rate of catchment deforestation. The research was conducted in several sub-watershed that are part of the Bedadung watershed i.e : Kaliputih, Dinoyo and Kaliwates. Soil characteristics and climatic data were collected from Bappeda Jember, BP-DAS and BMKG. Sub-watershed boundary was identified using Indonesia's Earth Map scale 1: 50,000, while the floodplains, land uses and slope based identifified by satellite imagery. Image analysis performed by open source GIS software, and the risk of crop failure analysis obtained from the data overlay cropping patterns and the incidence of flooding during the last 20 years. The results showed that the the largest floodplain that can be utilized for paddy cultivation expansion was in Kaliputih (48.02%), whereas the highest production level achieved by the Dinoyo and Kaliputih (70 tons) and the highest level of productivity achieved by the Kaliwates and Dinoyo (4 ton.ha^{-1}). Level of risk of crop failure due to environmental sensitivity in each sub-watershed was 67% for Kaliputih, 48% for Kaliwates and a 35% for Dinoyo.

Keywords : *Watershed, sub-watershed, floods, floodplain, and deforestation.*

Introduction

Bedadung's watershed is a watershed that is in the south and east of the Argopuro's Mountains. The old of geological age brought consequences to the high levels of weathering on the surface and sub-surface area. Generally, areas in the south Argopuro have a high rainfall that has range between 3000 - 5000 mm per year. High rainfall inevitably increases the risk of flash floods and landslides in the area. Data on the incidence of debris flows and landslides from Kesbanglinmas Office of Jember Regency was indicate high quantity at 35-52 events each year and peaked in 2006 when 70% area of Kaliputih sub-watershed was eroded. The incident has killed as many as 119 people, injured hundreds of people, 7.605 people has to evacuated. Damages and material losses was about 60 billion rupiah (Hermiyanto et al, 2010).

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The one of landslide trigger was the presence of forest conversion. The high level of demand for house and settlement also the need for employment in agriculture has brought a logical consequence of the expansion of marginal lands such as dry land, sloping land and rainforest. Encroachment has reached 80% of the total watershed Bedadung with altitude up to 870 m above sea level. Cultivation of seaseonal crops has expanded the use of sloping land with landuse as bush land, plantations and rainforest.

Floodplain is an area which will be logged during the rainy season when the water flow reaches peak but could be plain and ready for planting when water flow decreases during the dry season. The highly rainfall in the catchment area of Bedadung watershed made the area has a possibility to flood eventhoughn during dry season. Most rainfall occurs as orographic rain that is rain that occurs due to increased pressure on the cloud as it passes through an area with high altitude. Indian Ocean on the south of Jember Regency was major suspect of water vapor source in the form of mountains and plateaus stretching Argopuro through Jember, Bondowoso, Situbondo and Probolinggo are regions where orographic rain occurs especially in the Bedadung's watershed.

The floodplain in the Bedadung's watershed is an area of alluvial loam to sandy texture. The particles are tersedimentasi along the floodplain has a high fertility rate. Thus, although shallow soil solum, a key process in rice cultivation such as siltation and water can still be made. The Objective of these research were to showed the floodplain as an alternative concept of Marginal-land that could be use as cultivation places with Inlet's minimum damage and Identification floodplain area that could be use on Paddy cultivation and when it could be doing on Bedadung's sub-watershed.

Material and Methods

The research was conducted on July 2011 - Feb 2012 in three sub-watersheds that were a part of Bedadung's watershed, . The sub-watershed were Kaliputih, Kaliwates and Dinoyo is administratively in the Panti sub district (Kemiri, Panti , Suci and Serut villages), Sukorambi sub district (Karangpring and Durjo villages) and Kaliwates Sub district (Kepatihan and Kaliwates villages) Jember. Analysis of Soil Characteristics was used on Climatology Lab., Soil Fertility and chemistry Lab., also Soil Physics and Conservation Labs.

The materials was used into these research were topographic maps to delineate the boundaries of sub-watershed and satellite imagery to determine the floodplain area and land use. Tools for field verification were GPS to determine position verification point and the sampling point, roll meter to measure soil depth, and some plastics for soil and water samples. Meanwhile, to calculate the area of the floodplain using opensource graphics processing software.

Some secondary data was collected from various agencies and deep interview with among farmers and society. Some data were collected such as rainfall, times and area of flooding and landslides , varieties of rice planted on floodplain, also production and productivity. Rainfall data obtained from Keputran-Durjo Plantation for Kaliputih sub-watershed, PDP (Regional Plantation companies of Jember Regency) for Kaliwates sub-watershed and Sentool Plantation for Dinoyo sub-watershed. Data floods and landslides was collected from Kesbanglinmas Office of Jember Regency, while data varieties, production and productivity was collected by depth interview with the community. While production and productivity's data of rice varieties obtained from indepth interviews with local farmers.

After a sub-watershed was determined from topographic maps, the shape overlayed with satellite imagery to determine land use and boundaries of floodplain. Measurement of floodplain was calculated by opensource software while floodplain and land suitability for rice verified by laboratory analysis and field surveys to assess the suitability floodplain. Risk analysis was determined by calculating the volume, debit and duration of flooding also water flow direction with capacity of floodplain boundaries modelling. The rainfed analysis was calculated based on dasarian and monthly rainfalls data. Rice plants grown in the floodplain are considered less likely to succeed when the water level ≥ 10 cm rain for five consecutive days or ≥ 40 cm rain during the day (Ikeda et al, 2006). Risk value of Paddys cultivation determined based on the successful cultivation as long as one year followed planting date of the farmers.

Result and Discussion

Generally the productive land that can support to food security was distinguished on land use. Spatial analysis performed referring to the map of the earth map which is the land use divided into four, namely forests, plantations, dry-land and paddy-soil. Settlement did not include on deleniation boundaries because not included in the category of productive land. The results of spatial analysis at sub-watershed Kaliputih, Kaliwates and Dinoyo was presented in Table 1. The results of watershed dileniation showed the largest sub-watershed area was on Dinoyo (5477.04 ha) then followed by Kaliputih sub waterhed (3529.77 ha) and Kaliwates sub-waterhed (1972.37 ha).

Table 1 shows the land use based on the degree of slope on each sub-watershed and floodplain studies. The analysis showed that not all land uses are on the slopes of each of these classes. In terms of land use, spatial analysis shows that the largest land use in the sub-watershed is forest with an area Kaliputih 2083.89 ha (59.04%), in Kaliwates was dry-land with an area dominated by 923.24 ha (46.81%) , whereas in Dinoyo almost evenly between Forests, Plantation and dry-land each with an area of 1798.05 (32.83%), 1330.23 ha (24.29%) and 1344.06 ha (24.54%).

In general, dry-land and paddy-soil were on slopes-class 0-5% in Kaliputih sub-watershed, while the slope on Kaliwates sub-watershed are in class 5-8%. Meanwhile Dinoyo sub-watershed has specific characteristics which are dry-land commonly found on the slopes with a slope-class of 40% and rice lands identified in slope between 15-25%. According to the Ministry of Forestry's recommendations, the condition in sub-watershed Kaliputih included in the ideal category. While the sub-watershed Kaliwates and Dinoyo are in contrast to Kaliputih sub-watershed because the slope class 15-25% recommended for plantation and slope class >25% recommended for the forest. On the other hand, the use of good forest land conservation, primary and secondary forests and plantations are found on the slope class 8-40% in all sub-watershed study. This was in accordance with the recommendations and the Ministry of Agriculture and Ministry of Forestry.

Table 1. Land Uses and Slope From Spasial Analysis on Kaliputih, Kaliwates and Dinoyo Sub-Watershed

Sub-Watershed	Slope (%)	Land uses area (ha)					TOTAL
		Forest	Plantation	Dry land	Paddy Soil	Floodplain	
KALIPUTIH	0-3	232.76	-	-	-	28.67	261.43
	3-5	-	59.10	413.73	177.31	34.29	684.44
	5-8	-	-		-	25.50	25.50
	8-15	523.71	47.10	-	-	22.98	593.79
	15-25	330.88	110.67	-	-	42.32	483.87
	25-40	923.28	432.75	-	-	41.33	1397.36
	>40	73.35	-	-	-	10.02	83.37
KALIWATES	0-3	-	-	32.20	-	9.25	41.45
	3-5	-	-	31.10	-	8.48	39.58
	5-8	-	-	256.81	385.22	5.26	647.29
	8-15	176.47	923.24	-	-	14.76	1114.47
	15-25	44.04	-	-	-	3.52	47.56
	25-40	147.49	-	-	-	5.65	153.14
	>40	39.10	-	-	-	4.27	43.37

Sub-Watershed	Slope (%)	Land uses area (ha)					TOTAL
		Forest	Plantation	Dry land	Paddy Soil	Floodplain	
DINOYO	0-3	-	-	82.97	-	32.26	115.23
	3-5	-	-	45.59	-	22.12	67.71
	5-8	-	181.24	543.73	543.73	32.18	1300.88
	8-15	96.07	435.16	435.16	290.11	35.69	1292.19
	15-25	264.74	294.27	-	-	26.88	585.89
	25-40	1437.23	419.56	365.17	-	17.42	2239.38
	>40	-	-	-	-	4.32	4.32

Based on the total area of the floodplain, the largest of floodplain was identified on Kaliputih sub-watershed (205.11 ha), followed by Dinoyo sub-watershed (170.87 ha) and the smallest are in Kaliwates sub-watershed (51.19 ha). When compared with the total area of sub-watershed, obtained a value of 5.81%, 3.12% and 2.53% for sub-watershed Kaliputih, Dinoyo and Kaliwates. Based on the floodplain area ratio with a sub-watershed can be estimated total floodplains which form the greater percentage of the flat flood plains anyway shape. Conversely the smaller the percentage of the floodplain forms are also increasingly steep.

Analysis of several important soil characteristic at three points on each sub-watershed is at the upland, middle and downland. Important soil characteristic was based on result of Hermiyanto (2007, 2010, and 2011). The division of each region was held by considering the altitude and large area. The results of floodplain laboratory analysis on area study was presented in Table 2. Soil factors that are important include pH, EC, CEC, C-org, and% sand and% silt. Soil depth selected based on the assumption that the plant roots can thrive at depths up to 30 cm. Productivity's data obtained from indepth interviews to illustrate how far the estimated results will be obtained if the floodplain used to support food security.

The results of laboratory analysis showed that the overall soil depth at the upland of each sub-watershed has the smallest value compared to the middle and downland regions. This means that the higher region of the sub-watershed, soil depth would be decreased, and the production of paddy would be decreased too. Such conditions may occur due to average of the soil depth at upland area was 17.7 cm and made the process of puddling inhibited root development not to be optimal. This condition is the opposite of the middle and downland areas that had an average soil depth of 35.0 cm. CEC has the opposite pattern of soil depth where further down the value of CEC smaller floodplain.

Nevertheless, the condition is not a problem because the value of CEC in all areas still above 16 $cmol^{(+)}.kg^{-1}$ and included in the high category.

The interested of C-org level was the fact that the levels of C-org in sub-watershed Kaliwates higher than any other sub-watershed that reaches 5.76%. This may have been due to the presence of some plantation in Kaliwates sub-watershed that were a major contributor to C-org was at 8-15% slope-class that has sedimented almost evenly across the floodplain. The next largest levels of C-org average was on Dinoyo sub-watershed (4.11%) and the Kaliputih sub-watershed (3.26%).

Table 2. Analysis Laboratorium results of floodplain characteristics on Kaliputih, Kaliwates and Dinoyo sub watershed

Sub-Watershed	Position	Altitude (m asl)	pH	Soil depth (cm)	EC ($dS.m^{-1}$)	CEC ($cmol^{(+)}kg^{-1}$)	C-Org (%)	Sand (%)	Silt (%)	Clay (%)	Productivity ($ton.ha^{-1}$)
Kaliputih	Upland	776	7.1	10.5	1.475	52.25	3.25	45	25	30	2.22
	Middle	544	7.3	22.6	1.568	39.50	2.09	47	38	15	2.98
	Downland	302	6.5	35.0	1.595	17.55	4.45	26	35	39	3.47
Kaliwates	Upland	671	6.9	20.7	1.511	18.78	4.18	42	36	22	3.31
	Middle	429	5.4	38.2	1.996	15.45	7.20	22	37	41	4.22
	Downland	331	5.4	39.0	1.985	15.88	5.89	26	34	40	4.47
Dinoyo	Upland	705	6.6	21.8	2.186	25.20	2.79	25	37	38	2.56
	Middle	513	5.3	35.0	2.305	40.70	5.28	21	31	48	4.02
	Downland	255	5.7	40.0	1.790	24.65	4.25	27	36	37	4.15

Productivity in each sub-watershed has no differences significant value. But it is when viewed on an individual basis can be seen that the largest average productivity obtained at Kaliwates sub-watershed that is equal to 4.00 $ton.ha^{-1}$ which was then followed by Dinoyo sub-watershed about 3.58 $ton.ha^{-1}$ and Kaliputih sub-watershed about 2,89 $ton.ha^{-1}$. Then when it sought a total value of production, sub-watershed Kaliputih and Dinoyo yield 70.15 tons and 69.82 tons, while sub-watershed Kaliwates only reached 35.02 tons. This may happen given the extensive floodplains in the sub-watershed Kaliwates only reached 11.98% of the total floodplain in the study area.

One disadvantage of the use of the floodplain was the sudden emergence of flood events in a short time with quite high evel debit and volume. The resultsof depth interviewshowed that crop tolerance to the flood events can be viewed from two things: the current high water flooding and flood duration. Local farmers experience shows that paddy plants could survive and could be harvested when high flood height did not exceed the plants. While tolerance of flooding duration at each location showed different results in which tolerance a flood in the middle region is shorter than the upland and downland regions. The average value for the tolerance of the upland reaches duration about 4.0 hours, the middle region was about 2.5 hours and the downland area of 4.5 hours. The results of the statistical analysis of the perception of farmers and farming in the failure rate of each sub-watershed shows the results of the 67% for Kaliputih sub-watershed, 48% for sub watershed Kaliwates and 35% for Dinoyo sub-watershed.

Conclusion

The largest floodplain that can be utilized for paddy cultivation expansion was in Kaliputih (48.02%), whereas the highest production level achieved by the Dinoyo and Kaliputih (70 tons) and the highest level of productivity achieved by the Kaliwates and Dinoyo (4 ton.ha^{-1}). Level of risk of crop failure due to environmental sensitivity in each sub-watershed was 67% for Kaliputih, 48% for Kaliwates and a 35% for Dinoyo.

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