Analysis of the Impact of Land Use Change on Tidal Flood in Kendari City

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Abstract

This study used a survey method and plot trial method. The biophysical data of land consisted of land use, climate, topography, and land quality. The hydrological data of land comprised erosion, sedimentation, run-off, and run-off coefficient. The hydrological data of watershed (DAS) included the ratio of the maximum and minimum discharge. The objectives of the study were: 1) to analyze the impact of land use changes in the Wanggu watershed on the decrease in the forested area, land quality and the hydrological condition of the watershed; 2) to find out agro-technology applied by farmers in the upstream part of the Wanggu watershed and drainage system in the city of Kendari; and 3) to formulate land use to prevent floods in the city of Kendari. The research was conducted from January 2014 to July 2014. The results of this study showed that: 1) there was a decrease in the forested area by 10,908.7 ha (24.0%) of the watershed, so that the remaining forested area was 19.1 <30% of the Wanggu watershed; 2)there was a decline in land quality such as the weight of soil volume, porosity and soil organic matter, land cover and potential interception; 3) there was a decrease in infiltration capacity, soil permeability; 4) there was an increase in run-off by 499.5 mm / yr, run-off coefficient 25.6%, erosion 23.1 tonnes / ha / year, and the ratio of the maximum and minimum discharge from 49.1 to 75.9> 30, indicating that the Wanggu watershed was in a critical condition; 5) the implementation of agro-technology by farmers was not in accordance with the ability and suitability of the land; 6) the technology of soil and water conservation was not implemented by farmers as shown by the farm erosion by 48.3 tons / ha / yr > TSL 16.7 tons / ha / yr and residential area by 26.0 tons / ha / yr > TSL 9.1 tonnes / ha / yr, leading to land degradation; 7) the rob flood in the city of Kendari was as high as 2-5 m for 3-6 days due to 24.4% decrease in the forest area of the Wanggu watershed and land degradation affecting the hydrological condition of the Wanggu watershed, residential wastes, drainage systems and poor environmental sanitation, the loss of marshes in Kendari bay area, high rainfall of 2.7391 mm / yr and high tide levels exceeding highway; 8) the study tried to formulate flood prevention in the city of Kendari with land use of a minimum forest size of 30% (13,613.3 ha) and agroforesty 37.3% (16,938.3 ha); 9) there was an efforts to apply the technology of agronomic and vegetative soil conservation; 10) there was an increase in the quantity and quality of the drainage system in the city of Kendari of the Wanggu watershed.

Keywords: degradation, erosion, flood, forest, Land use impact, soil conservation

Introduction

Floods are natural phenomena that occur in many parts of the world, including the city of Kendari in the Wanggu watershed. Floods occur due to the disruption of hydrological cycles on watersheds or the global effects of hydrological cycle imbalances on earth (Biosphere). The disruption of hydrological cycles stems from the imbalance in land cover as a consequence of the development activities in various countries. The development activities are in line with the increase in population of each country and region, causing land use changes from year to year. Changes in land use are less even no longer based on land ability and suitability, especially in the areas of newly created provinces and regencies.

The existence of new districts or towns on watersheds greatly affects the water system in the region. A water system is significantly influenced by forested areas in watersheds since they function as the receiver and keeper of the rain water to regulate the water flow (Chang, 2003).

According to a study conducted by Alwi (2012), the use of forest land resulted in high infiltration capacitance (6.7 cm / h), higher than mixed farm 6.0 cm / h, dry farm land 5.3 cm / hour, scrub 4.0 c / h and rural residential area 4.2 cm / h with a coefficient (C) forest run-off of 14% (86% of rainwater entered and was stored in forest land), Agroforestry 19% (81% of rainwater entered and was stored in the land), shrub (22% of rainwater entered and was stored in the soil), dry farm land (32% rainwater entered and was stored in land), and residential area (42% of rainwater entered the soil of the total annual rainfall of 1933.7 mm / yr). In addition, the run-off result of the lowest forest was 267.6 mm / yr, Agroforestry 364.4 mm / yr, shrub 432.6 mm / yr, dry farm/irrigated rice field 617.4 mm / yr and residential area 814.0 mm / yr.

The decrease in land cover over the years had led to the decrease in soil infiltration capacitance and the coefficient of surface runoff. On the contrary, there was a rise in surface runoff, erosion and sedimentation as well as a wider difference of discharge during the rainy season and the dry season (Alwi et al, 2011). The data showed that there was an increase in the use of forest land for non-forest purposes from year to year in the Wanggu watershed and 8 other micro watersheds that empty into Kendari bay. During the period of 1992-2010 (28 years), the forest area decreased by 9,086.4 ha with an average decline of 324.5 ha / yr (1.1% of the watershed area (Alwi, 2012).

The rob flood that occurred in Kendari in 2013 inundated the city as high as 2-5 meters, causing material losses and casualties. The floods have indicated damage to ecosystem and posed a threat to the preservation of the ecosystem in the Wanggu watershed (forest ecosystem, agriculture, ecosystem of Kendari city) and aquatic ecosystem in Kendari bay. Furthermore, the flood would be a yearly serious threat to the people who live in the city of Kendari. A rob flood is a flood that occurs because the drainage system is not able to accommodate runoff from the rain which coincides with high tide of the seawater.

Based on the above description, there was a number of problems identified such as: 1) a decrease in forest cover in the period 1992-2013 causing decrease in land quality and hydrological condition of the Wanggu watershed, 2) the absence of environmentally friendly agro-technology implementation by farmers in the upstream area of the Wanggu watershed and the poor drainage system in the city of Kendari, and 3) minumum socio-economic institutions.

Some researches indicated that the conversion of forest to non-forest had lowered infiltration capacitance and soil permeability, but in the meantime, there was an increase in run-off, run-off coefficient, erosion, sedimentation and Qmax:Qmin (Alwi, 2012) and (Chang 2003). Furthermore, it is said that the forest conversion can reduce soil quality but will rise again with fallow, proper application of soil conservation or cacao agroforestry system (Marwah, 2008; Hand, 2001; Anas et al., 2005; Multilaksono et al., 2005).

This research aimed to 1) analyze vast forest decline and its impact on land quality and the hydrological condition of watersheds, 2) find out the agrotechnology applied by farmers in the upstream area of the Wanggu watershed and the drainage system in the city of Kendari, 3) study the socio-economic and institutional conditions associated with the management of the Wanggu watershed, and 4) formulate a flood prevention method in the city of Kendari.

Materials and Methods

Place and Time

This research was conducted in the Wanggu watershed and 8 micro watersheds with a total area of 45,377.3 ha. All the watersheds empty into Kendari bay covering an area of 1,084 ha. Southeast Sulawesi province comprises South Konawe regency, Konawe regency and Kendari city. This study was carried out for 6 months (January 2013 - June 2013) and it was the continuation of the previous study which lasted for 12 months (September 2009 - August 2010).

Materials and Tools

The materials needed in this study were in the form of maps obtained from various sources. The data were about rainfall, water discharge, population, land use and soil. The maps included land use, topography, soil type, Bathymetry, paper and plastic bags. The equipment used consisted of clinometer, soil drill, soil profile knife, ring sample, meter roller meter, stop watch, dual-cylindered infiltrometer, premeameter, GPS, AWLR, ARR and bottles for water samples.

Research Methods

This study used a survey method and was a follow-up study of the 2009/2010 study using secondary data from relevant agencies and the results of the previous research. To analyze changes in land use and their impacts on erosion, hydrology and sedimentation, the data of land use changes in 1992, 1995, 2000, 2005, 2010 and 2013 were used. The data of run-off was obtained from the secondary data (BWS of Region IV, 2013) and the results of instantaneous measurements. The data of erosion and sedimentation were predicted based on the secondary data of the previous study. The rainfall data for the last 10 years was obtained from Wolter Monginsidi station in Kendari. To obtain data on changes in land use in 2013 it was predicted based on the equation: $y = 1.071x + 14.85, R^2 = 0.948$ forest, $y = 1.071x + 14.85, R^2 = 0.913$ Agroforestry and $y = 0,412x + 5,995, R^2 = 0,864$, residential area (Alwi, 2012).

Changes in land use examined included changes in forest area, mixed farms, shrubs, dry farm areas / wet rice fields and settlements. The impact of land use changes could be on: 1) the biophysical properties of land such as volume weight (BV), porosity (P), organic matter (BO), using data from the previous studies assuming the same land use with different sizes of areas 2) the hydrologic conditions such as surface run-off (RO), coefficient of surface run-off (CRO), Qmax: Qmin, erosion and sedimentation in Kendari bay. The data is predicted using the equations of the previous research, that is, the equation $y = 60.41x + 445.6$, $R^2 = 0.831$ for RO, $y = 0.261e^{0,019x}$, $R^2 = 0.904$ for CRO, $y = 0.482x - 934.9$, $R^2 = 0.980$ for Qmax: Qmin (Alwi et al, 2011), whereas y = $y = 0.261e^{0,019x}$ $R^2 = 0.935$ for the erosion in the Wanggu watershed and $y = 1,0711x + 657.0$ $R^2 = 0.997$ for sedimentation in Kendari bay (Alwi, 2012).

To determine the suitability of land use, an evaluation was conducted on land capability class, agro-technology suitability, and land degradation (if erosion> Etol and erosion <Etol no degradation occurs). The test of agrotechnology suitability used a plot method with an observation plot of 6 m x 4 m based on randomized block design (RBD). Plot observations were intended to determine the erosion, RO and CRO that occur with each type of the land use for the treatment, symbolized as: T1 (mixed farm), T2 (shrubs), T3 (dry land), T4 (settlement) and T5 (forest) as a control. Each treatment consisted of three slopes as a group: 8% (K1), 15% (K2) and 30% (K3), and there were 15 combined treatments as intensive observation. To find out the effect of land use change, F test, $\alpha_{0.05}$ and the test between treatments using BNT$\alpha_{0.05}$ were conducted.

The impact of land use on watershed erosion was predicted by equation USLE (Universal Soil Loss Equation) A = RKLSCP. RO was calculated by the method of rational q = CIA.

Results and Discussion

Changes in Land Use

The analysis results of changes in land use in the Wanggu watershed and 8 micro watersheds thay empty into Kendari bay showed a decline in the forest area from 19,554.2 ha (43.2%) in 1992 to 7,277.6 ha (16.0%) in 2013, and shrub area from 16,296.4 ha (35.6%) to 8,244.0 ha (18.2%), followed by a settlement increase of 2,600.2 ha (5.7%) in 1992 to 5,996.2 ha (13.2 %) in 2013, a mixed farm of 6,357.5 ha (14.0%) in 1992 to 18,813.7 ha (41.5%) in 2013, and a dry land agricultural area/an irrigated rice field of 569.0 ha (1.3%) to 4,567, 8 ha (10.1%) (Table 1).

Table 1: Changes in Land use in the Wanggu Watershed and 8 Micro Watersheds that Empty into Kendari bay in the Period 1992-2013

Periode	Land Use Type									
	Mexed farm		Shrub		Dry land farm		Settlement		Forest	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
1992	6.357,5	14,0	16.296,4	35,9	569,0	1,3	2.600,2	5,7	19.554,2	43,2
1995	10.366,6	22,8	11.489,8	25,3	.210,2	2,7	3.681,8	8,1	18.628,8	41,1
2000	11.908,4	26,2	6.518,0	14,4	4.308,4	9,5	5.364,3	1,8	17.278,2	38,1
2005	14.832,8	32,7	4.415,4	9,7	5.774,1	12,7	5.761,2	12,7	14.593,8	32,2
2010	15.585,8	34,3	9.342,0	20,6	4.022,4	8,9	5.959,3	13,1	10.467,8	23,1
2013	16.938,2	37,3	6.360,6	13,8	6.652,9	15,2	6.740,0	14,7	8.645,5	19,1
∑ Δ	10.580,7	23,3	-9.935,8	-22,1	6.083,9	13,9	4.140,0	9,0	-10.908,7	-24,1
R Δ/th	503,8	1,1	-473,1	-1,1	289,7	0,7	197	0,4	-519,5	-1,1

Description: Σ = sum, Δ = change of land use, R = mean, th = year
The result of the regression analysis of the decrease in forest area (H) follows the equation 1:
y = - 5.154 x + 50.84 with R2 = 0.954 (Figure 1).

The equation shows that a decline in the forest area of 5.154% per 5 year or 1.1% (519.5 ha) per year and is linear with a coefficient of determination (R^2) = 0.954 for the period 1992-2013

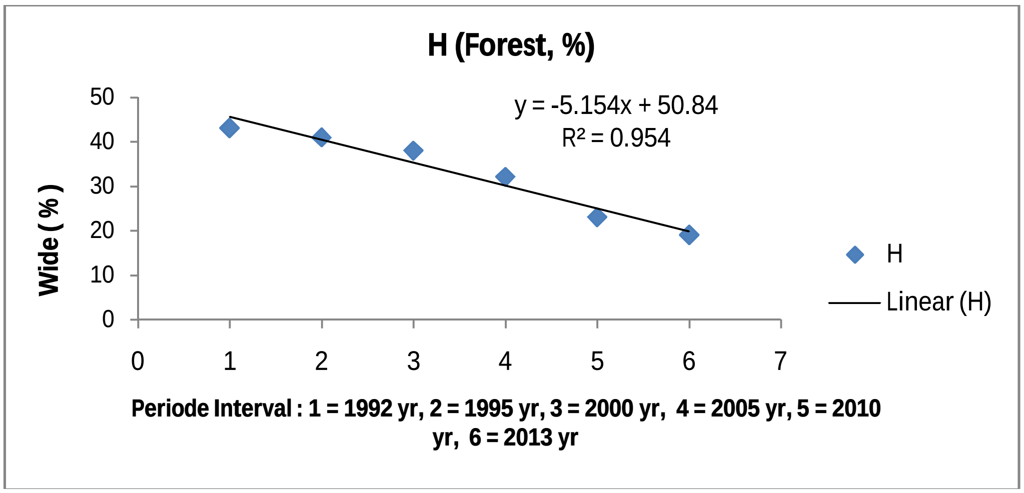

Figure 1: Results of Regression Analysis of the Decrease in Forest area 1992-2013

The results of the regression analysis of the increase in settlement area (P) and mixed farms (Kc) were in inverse ratio to the decrease in forest area which showed an increase from the year 1992 to 2013 (21 years) respectively following this equation:

Settlements (P) with equation 2: y = 1.74x + 4.926, R 2 = 0.945 (Figure 2).

The equation shows that an increase in settlement area of 1.74% per 5 years or 0.4% (197 ha) per year and was linear with determination coefficient (R 2) = 0.911 for the period 1992-2013.

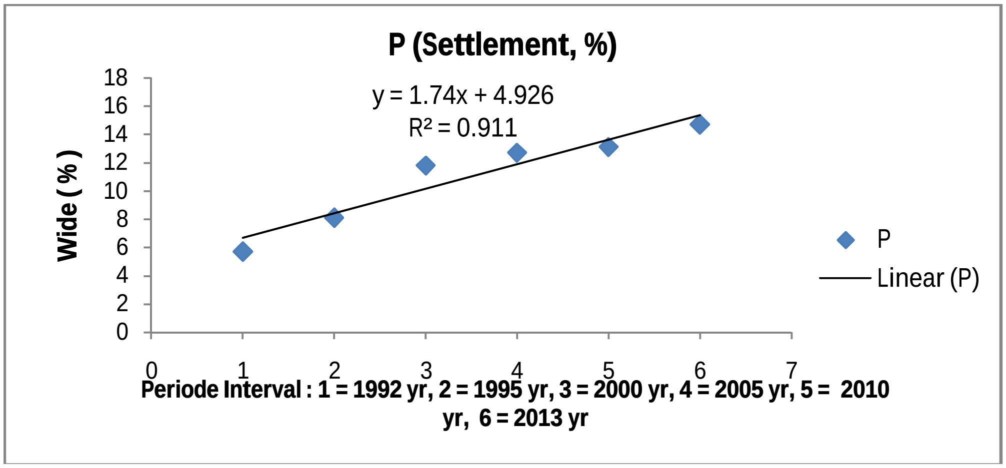

Figure 2: Results of the Regression Analysis of the Increase in Settlement area for the Period 1992-2013

Mixed farms (Kc)) with equation 3: y = 5.1x + 10.73, R 2 = 0.972 (Figure 3).

The equation shows that an increase in mixed farm area of 5.1% per 5 year or 1.1% (503.8 ha) per year to be linear with determination coefficient (R 2) = 0.972 for the period 1992 - 2013. The forest area over the period 1992 - 2013 decreased from 19,554.2 ha (43.2%) of the watershed area to 8,645.5 ha (19.1%) of the watershed area. On the contrary, the settlement area increased from 2,600.2 ha (5.7%) of the watershed area to 6740.0 ha (14.7%) of the watershed area, and the increase in mixed farms from 6,357.5 ha (14.0%) of the watershed area to 16,938.2 ha (37.3%) of the watershed area.

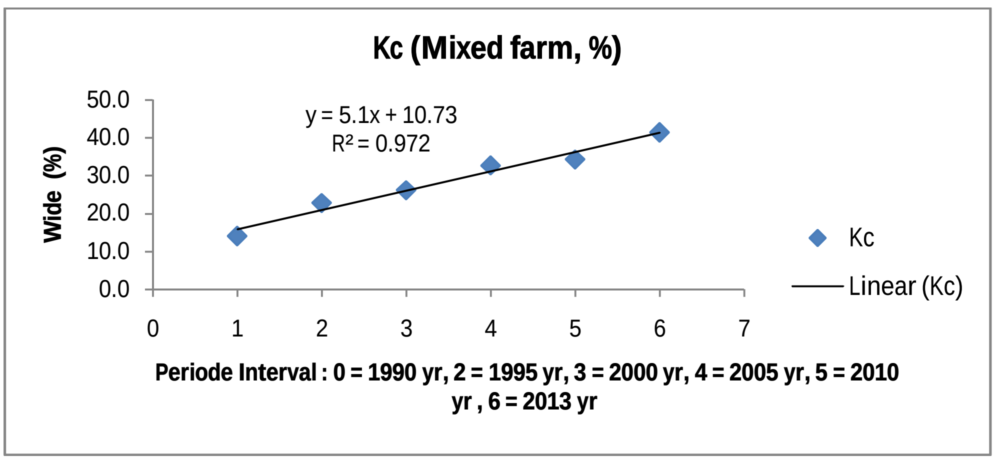

Figure 3: Results of the regression analysis of the increase in Kc area for the period 1992-2013

Thus, the forest area in the Wanggu watershed in 2013 was no longer in accordance with the mandate of Law No.41 / 1999 on the minimum size of forest area 30% of the watershed area. The decrease in forest area affected land cover which consequently minimized rainwater protection against soil surface, potential interception and infiltration capacity; on the contrary, there was an increase in the run-off, coeffcieint of run-off and soil erosion (Calder, 1992, Chang, 2003 and Alwi, 2012). Furthermore, Chang (2003) stated that the forest affected the hydrological system as a regulator of the water system of watershed because forest serves as receiver, hold / store and flow rainwater on the surface of the land. Conversely, residential area, mixed farm and dry agricultural land / irrigated rice field decreased infiltration capacity and potential interception, increasing run-off, run-off coefficient (Calder, 1992, Alwi et al, 2011 and Alwi, 2012).

Impacts of Land Use Change on Land Quality

The results of soil quality analysis due to changes in the existing land use in the Wanggu watershed 2013 showed that the decline in the quality of land such as heavy volume (BV), porosity, organic matter (BO), land cover (PER), potential interception (INT) differed significantly between forest and settlement, dry agricultural land / irrigated rice field and shrubs, except mixed farm which was significantly different from BV and porosity (Table 2).

The impact of land use change on land quality showed that changes in forest land (H) into agricultural area (Pt) increased the weight of soil volume (BV) by 0.22 g / cm^3 but lowered the percentage of soil porosity by -7.83%, material organic soil (BO) -0.81%, the percentage of land cover (PER) -24.51%, and decreased potential interception -150.78% (Table 2). Furthermore, the impact of the use of forest land for residential area on land quality improved BV by 0.39 g / cm3, but it lowered the percentage of soil porosity by -14.7%, BO -3.42% , land PER -47.63% and INT -222.50% (Table 2). This was in line with the opinions of Sinukaban (2007), Asdak (2007) and Black (1996) who stated that the physical properties of soil (texture, structure, weight, volume, prosity, organic matter), the depth of the soil profile, land cover, potential interception, and surface roughness had an effect on infiltration capacity, soil permeability, surface run-off and run-off coefficient.

Table 2: The impact of land use change on land quality in 2013

	BV	Porosity	BO	PER	INT
Land use	(g/cm^3)	(%)	(%)	(%)	(mm/th)
Mixed farm	1.42 bc*	43.7 ab*	3.84 b*	60.87 b*	102.77 b*
Shrubs	1.50 ab	38.7 bc	3.77 b	59.97 b	106.33 b
Dry land farm	1.49 ab	42.0 b	3.66 b	59.53 b	72.07 c
R. Farm **(Pt)**	1,47	41,47	3,76	60,12	93,72
Settlement **(P)**	1.64 a	34.6 c	1.15 c	37.00 c	22.00 d
Forest **(H)**	1.25 c	49.3 a	4.57 a	84.63 a	244.50 a
BNT α .01	0.178	6.122	0.461	6.247	5.785
Impact H > < Pt	**0,22**	**-7,83**	**-0,81**	**-24,51**	**-150,78**
Impact H > < P	**0,39**	**-14,7**	**-3,42**	**-47,63**	**-222,50**

Description: BV = volume weight, BO = soil organic matter, H = forest, P = settlement, INT = potential interception, PER = percentage of land cover, and R = average.
* = The figures in the same column followed by the same letter are not significantly different according to LSD α 0.01

Impacts of Land Use on Hydrological Characteristics of Land

The results of hydrological characteristic analysis of land due to changes in land use in the Wanggu watershed in 2013 showed that forest change (H) to settlement (P), dry land /rice field and shrubs caused a decrease in soil infiltration capacity (Inf) which differed significantly, but the mixed farm was not significantly different and changes in the use of forest land to non-forest (residential area, dry land agriculture/rice field) decreased soil permeability (PP) were significantly different (Table 3).

Table 3: Impacts of land use on the hydrological characteristics of the land in 2013

Land use	Inf (cm/h)	PP (cm/h)	RO (mm/h)	C (% rain)	Erosi (ton/ha/yr)
Mixed farm	8,0 ab**	6,0 b*	485,5 d**	25,3 ab**	11,9 c**
Shrubs	5,3 b	4,5 c	576,0 c	29,3 b	18,5 bc
Dry land farm	7,2 b	4,1 cd	822,1 b	42,6 c	48,3 a
R-Farm **(Pt)**	**6,8**	**4,9**	**627,8**	**32,4**	**26,2**
Settlement **(P)**	5,6 b	3,1 d	1.083,8 a	55,9 d	26,0 b
Forest **(H)**	8,9 a	7,2 a	356,3 c	18,6 a	3,1 d
BNT $_{0,05}$		3,4			
BNT$_{0,01}$	1,1		62,2	0,10	7,6
Impacts H > < Pt	**-2,1**	**-2,4**	**271,5**	**13,8**	**23,2**
Impacts H > < P	**-3,3**	**- 4,1**	**727,5**	**37,3**	**22,9**

Description: infiltration rate (Inf), permeability profile (PP), run-off (RO), run-off coefficients (C) CH effective in 2013 = 2,574.7 mm
** The figures in the same column, followed by the same letter are not significantly different according to the test of BNTα 0.01
* The figures in the same column, followed by the same letter are not significantly different according to the test of BNTα 0.01

Furthermore, changes in the use of the forest land to non-forest increased surface run-off (RO), surface run-off coefficient (C) and erosion were significantly differerent (Table 3). The impact of the land use changes on the hydrological characteristics of the land in the Wanggu watershed indicated that the change of forest land (H) to agriculture land (Pt) decreased soil infiltration rate by -2.1 cm / h and soil permeability -2.4 cm / hour but increased soil RO by 271.5 mm / yr, surface runoff coefficient (C) 13.8% and erosion 23.2 tonnes / ha / year (Table 3). The impact of changes in forest land (H) to residential area(P) on hidological characteristics of the land lowered soil infiltration rate (Inf) by -3.3 cm / h and soil permeability (PP) -4.1 cm / h, but increased RO , C and erosion by 727.5 mm / yr, 37.3% / year and 22.9 tons / ha / yr (Table 3).

Analysis of the Impacts of Land Use Changes on Hydrological Watershed

The analysis result of the impacts of the land use change on the hydrological condition of the watershed which empties into Kendari bay used the research data in 1992 - 2010 and a study in 2013 (Table 4). The table showed that the changes in land use in the period 1992-2010 had an impact on erosion by 12.7 tons / ha / yr (81.9%), surface runoff 262.7 mm / yr (48.8%) and increased surface run-off coefficient by 13. 2 (47.1%) (Alwi, 2010). Further researches in 2010 - 2013 showed an increase in erosion from12.7 tonnes / ha / yr (81.9%) to 30.5 tons / ha / yr (197.0%), runoff (RO) from 262.7 mm / th (48.8%) to 889.5 mm / yr (165.2%) and an increase in surface runoff coefficient (C) from13.2% (47.1%) to 34.3% (122.9%). This is consistent with the result of the research by Handayani (2005) who showed that the decrease in forest cover with an area of 4,897 ha (18.1%) in 1989 to 4,459 ha (16.2%) in 1998 had increased the peak discharge and run-off volume, respectively 18.9% and 18.8% in the Ciliwung watershed. According to La Baco (2011), the decrease in forest area from 55.3% in 1999 to 47.0% in 2008 had increased the value of C from 36.3% to 47.1% in the Konaweha watershed, Southeast Sulawesi.

Table 4: Impacts of Changes in land use in the Wanggu Watershed in the Period 1992-2013 on the Hydrological Condition of the Watershed

Land use*	Erosion (A)	Run-off (RO)	C (%)
Periode	(ton/ha/yr)	(mm/yr)	
1992	15,5	538,6	28,0
1995	20,3	554,2	29,1
2000	23,5	607,3	31,0
2005	26,7	632,9	33,1
2010	28,2	801,3	41,2
∑ impacts 1992-2010	12,7 (81,9%)	262,7 (48,8%)	13,2 (47,1%)
R impacts/yr (yr 18)	**0,71 (4,6%)**	**14,6 (2,7%)**	**0,7 (2,6%)**
2013	46,0	1428,1	62,4
∑ impacts 2010-2013	17,8 (63,1%)	626,8 (78,2%)	21,2 (51,5%)
R-impacts/yr (yr 3)	**5,9 (21,0%)**	**208,9 (26,1%)**	**7,1 (17,2%)**
∑ increasing 1992-2013	30,5 (196,8%)	889,5 (165,2%)	34,4 (122,9%)
R- increasing/yr	1,5 (9,4%)	42,4 (7,9%)	1,6 (5,9%)

Description: * (mixed farm, shrubs, dry land, settlement area and forests with an area as listed in Table 3), RO = runoff and C = coefficient of runoff at CH = 1,933.7 mm/yr.

The impacts of changes in land use in the period 1992 - 2010 (18 years) per year were on an increase in erosion by 0.71 tons/ha/yr (4.6%), runoff (RO) 14.6 mm/yr (2.7 %), and the surface runoff coefficient (C) 0.7 (2.6%) (Table 5). Furthermore, the impacts of changes in land use in the period 2010 - 2013 (3 years) per year were on an erosion increase of 5.9 tons/ha/yr (21.0%), RO 208.9 mm/yr (26.1%) and C 7.1% (17.2%) (Table 4). The comparison of the effects of land use changes in the periods of 1992 - 2010 and 2010 - 2013 was erosion of 0.71 tonnes/ha/yr : 5.9 tons/ha/yr, RO 14.6 mm/yr : 208.9 mm/yr, and C 0.7% : 7.1%.

The average increase in the impact of changes in land use in 1992 – 2013 was erosion of 1.5 tons/ha/yr (9.4%), RO 42.4 mm / yr (7.9%) and 1.6% (5 , 9%) (Table 4).

The curve relationship between time and erosion, RO and C in the period 1992-2013 for 21 years showed an exponential equation, which means that erosion, RO and C increased from year to year exponentially following the following equation: erosion, $Y = 13,08e^{0.187\ x}$, R^2 0,920, run-off (RO) $Y = 390,3\ e^{0,172x}$ and surface run-off coefficient (C) $Y = 21,51e^{0,145x}$, $R^2 = 0,811$ (Figures 1, 2 and 3). Furthermore, the impacts of changes in land use in the Wanggu watershed of the year 1992 - 2013 on the hydrological conditions of the Wanggu watershed increased from year to year due to the decrease in the average forest area -519.5 ha/year (-1.1%) and shrubs -473,1 ha/yr (-1.1%) of the Wanggu watershed area; on the contrery, it was followed by the increase in settlement area by 197.0 ha/yr (0.4%), mixed farm 503.8 ha/yr (1.1%) and the increase in dry land 289.7 ha/yr (0.7%) of the watershed area (Table 1, Figures 1, 2 & 3).

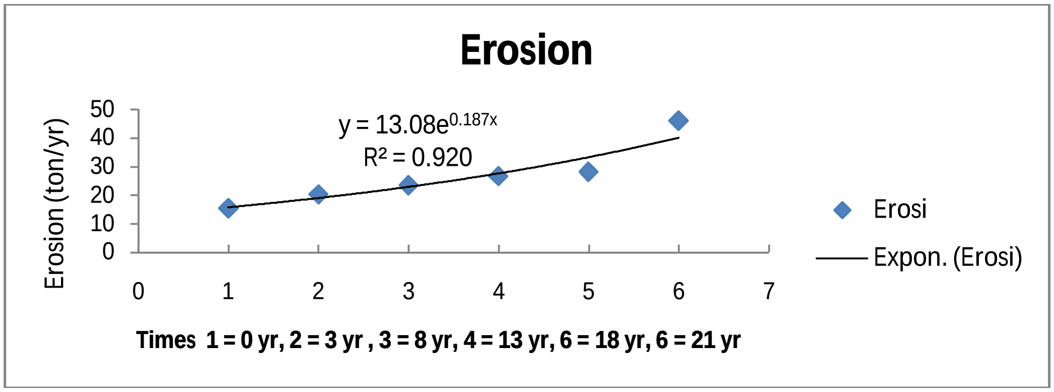

Figure 1: The Curve Relationship between Time (1992- 2013 = Yr 21) and Erosion

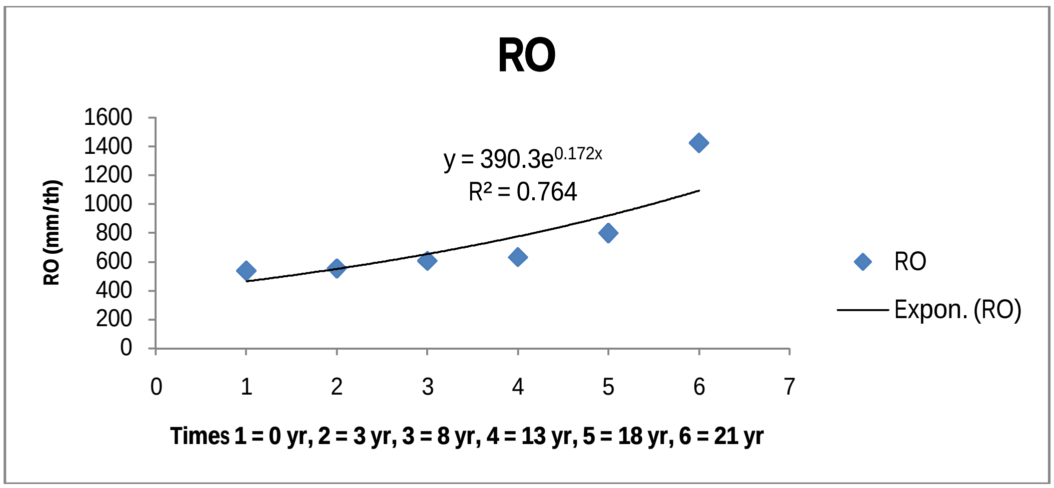

Figure 2: The Curve Relationship between Time (1992- 2013 = 21 th) and RO

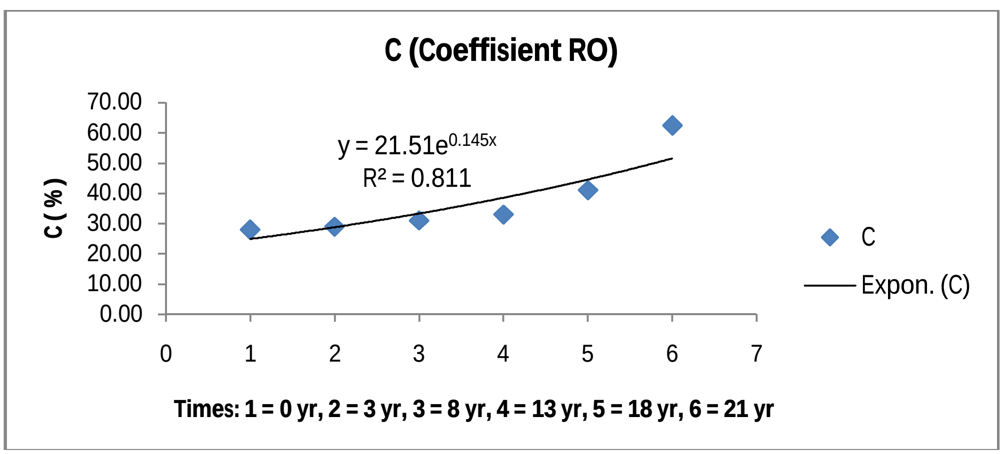

Figure 3: The Curve of the Relationship between Time (1992- 2013 = 21 years) and C

The great impacts of changes in the use of forest land into non-forest in the period 1992 - 2013 had led to a decrease in the average forest area by -519.5 (1.1%), resulting in a decrease in the quality of the land (BV, porosity, BO, the percentage of land cover (PER) and potential interception (INT). The decline in the quality of the land caused a disturbance to the hydrological conditions of soil (infiltration rate, permeability, surface run-off, the surface run-off coefficient and soil erosion and sedimentation which subsequently affected the drainage system of the Wanggu watershed, influencing the hydrological conditions of the Wanggu watershed. This is in line with the researches conducted by by Calder (1992), Chang (2003) and Alwi (2012) that the decline in forest area affected the land cover, consequently minimizing rainwater protection against soil surface, potential interception and infiltration capacity, but increasing run-off, run-off coefficient and soil erosion. Furthermore, Chang (2003) stated that the forest affected the hydrological system as a regulator of the water system of the watershed because forest serves as a receiver, holding / storing and draining the rainwater that falls on the surface of the land. Conversely, residential area, mixed farm and dry land / irrigated rice field decreased the infiltration capacity and potential interception, but increase run-off, run-off coefficient (Calder, 1992, Alwi et al, 2011 and Alwi, 2012).

Table 5: The Maximum Flow Discharge (Qmax) and (Qmin) of Some Rivers Empty into Kendari bay in 2013

No.	River names	length	wide	depth	Qmin	Qmax	Qmax:Qmin
		(m)			(m^3/s)		
1.	Wanggu	38,0	17,0	1,25	3,1	152,1	49,1
2.	Wua-wua	4,5	4,0	0,35	0,4	30,4	75,9
3.	Tipulu	8,6	3,5	0,36	0,5	26,8	53,5
4.	Lahundape	8,7	4,5	0,32	0,4	24,8	61,9
5.	Benu-benua	8,5	4,0	0,35	0,5	27,6	55,1
6.	Kambu	10,9	6,0	0,45	0,9	54,7	60,8

Source: Primary Data Processed in 2013 rainfall = 2,547.7 mm/yr

The measurement results of maximum flow discharge (Qmax) and minimum (Qmin) and Qmax : Qmin in 2013 showed that the six watersheds produced Qmax : Qmin 49.1 - 75.9> 30 (Table 5). This indicated that all six watersheds that flowed into Kendari bay had been categorized as seriously damaged that required a serious handling. Moreover, it also indicated that the minimum and maximum discharges of these rivers in the dry season and the rainy season had a significant difference which also meant water shortages in the dry season and water excess (flooding) in the rainy season.

Evaluation of Agro-technology in the upstream area of the Wanggu watershed

The evaluation results of the suitability of land use and Agrotechnology based on the result of erosion prediction versus erosion which could be tolerated (Etol) in the upstream area of the Wanggu watershed on different types of land use showed that the forest and mixed farms (Agroforestry) indicated a prediction result of successive erosion of 3.1 ton/ha/yr < ETol 15 tons/ha/yr and 11.9 < ETol 17.2 tons/ha/yr, whereas shrubs, dry land and settlement showed an erosion prediction respectively 18.5 tons/ha /yr > ETol 13.6 tons/ha/yr, 48.3 tons/ha/yr > ETol 16.7 tons/ha/yr and 26.0 tons/ha/yr > Etol 9.1 tons/ha/yr (Table 6).

Table 6 shows that forests and mixed farms are vegetation with a protective layer or buffer which effectively eliminates the influence of rainfall and topography on erosion. Parts of the existing vegetation on the ground, such as leaves and stems, absorb rain-destroying energy, thus reducing the impact on soil erosion. Parts of the rooting system in the soil will increase soil mechanical strength, porosity and infiltration capacity, thus minimizing surface run-off and surface run-off coefficient which in turn reduce soil erosion. The opinion was reinforced by Arsyad (2010), Chang (2003), Sinukaban (2007), Asdak (2007) and Black (1996), saying that the physical properties of the soil (texture, structure, porosity, organic matter), soil forofil depth, land cover, potential interception, surface roughness had an effect on infiltration capacity, soil permeability, run-off and run-off coefficient and on minimizing erosion. The amount of erosion will determine the level of soil fertility and land preservation / agricultural production or degradation. Furthermore, Sinukaban (2001) stated that the use of land that does not use agro technology (conservation of soil and water) will accelerate the degradation of land and marginalize between land and farmers.

Table 6: Results of Erosion Prediction in different Land uses in the Wanggu Watershed in 2013

Land use	Erosion	ETol	Erosi > < ETol	Description
	(ton/ha/th)			
Mixed farm	11,9 c*	17,2	<	Erosion < ETol
Shrubs	18,5 bc	13,6	>	Erosion > ETol
Dry land farm	48,3 a	16,7	>	Erosion > ETol
Settlement	26,0 b	9,1	>	Erosion > ETol
Forest	3,1 d	15,0	<	Erosion < ETol
BNT 0,01	7,6			

Source: Primary data of 2013 with an effective rainfall of 2574.7 mm/yr , ETol = Tolerable erosion
Note: * = Figures in the same column followed by the same letter are not significantly different according to the test of BNTα 0.01

Evaluation of the Drainage System in Kendari City in 2013

Observation and evaluation of the drainage system in the city of Kendari showed that the drainage in the region belonged to the category of poor - very poor, not only from the drainage system but also in terms of volume and drainage quality.

A drainage system in a region consists of natural drainage and artificial drainage systems. Natural drainage system (the drainage of watershed system) is a drainage system that is formed naturally in accordance river network in a watershed. Meanwhile, an artificial drainage system is a drainage system that is designed and built by humans in the form of canals, drainage networks on either side of the road and drainage in residential areas. The drainage system of the Wanggu watershed is closely related to drain pattern and the shape of the Wanggu watershed. The flow pattern of the Wanggu watershed is shaped to resemble the pattern of branches or twigs (dendritic pattern) and the Wanggu watershed is circular in form (radial). Such a flow pattern can speed up the movement surface run-off, especially since the upstream condition of the Wanggu watershed has been critical as a result of land occupation by slash-and-burn cultivation and encroachment into cocoa and mixed farms. This resulted in the upstream area of the Wanggu watershed as cathment area is not able to hold rain water during the rainy season. As a result, this has led to excessive surface runoff (overflow), which by natural and artificial drainage systems are not able to accommodate the flow of water in the rainy season, causing floods in many places. The value of drainage density of the Wanggu watershed was Dd <1 km / km^2, which means the Wanggu watershed would experience inundation (Lynsly, 1942). Drainage density is prone to inundation during the rainy season if the watershed the forested area in the upstream region is less than 30% of the watershed area (Alwi 2012). In addition, the drainage system of Kendari city is exacerbated by the poor garbage disposal system by urban population so that in the rainy season the drainage in the city of Kendari both natural and artificial is clogged by agricultural waste and paper waste, paper towels and plastic, triggeringt floods in the streets and neighborhoods in the city of Kendari.

Conclusions and Recommendations

Tidal flood in Kendari city in 2013 was due to:

1. There was a forest decline of 10,908.7 ha (24.04%) during the period 1992-2013, from 19,554.2 ha (43.2%) to 8,645.5 ha (19.1%) or < 30% of the Wanggu watershed area had led to a decrease in the quality of land: soil physical properties (volume weight of 0.3 g/cm3, porosity -1.3% and organic matter -0,2,1%, the percentage of land cover -36.0% and potential interception -186 , 6 mm/yr).
2. The decline in forest area had an impact on a decrease in land hydrological characteristics like the decrease in an infiltration rate of -2.7 cm/h and soil permeability -3.3 cm/hour, increasing run-off by 499.5 mm/yr, run-off coefficient 25.6% of rain, erosion 23.1 tons/ha/yr and the increase in Qmax: Qmin of the Wanggu watershed and 8 micro watersheds, namely: 49.1 to 75.9> 30 others, meaning that the hydrology of the watershed had been critical.

3. Evaluation of the Agrotechnology applied by farmers in the upstream area of the Wangu watershed and 8 other micro watersheds was not suitable with capability class and land use, and they did not apply soil and water conservation technologies as indicated by the erosion in shrubs (18.5 tons/ha/th> ETol 13.6 tons/ha/yr), dry land (48.3 tons/ha/yr > Etol 16.7 tons/ha/yr) and settlement (26.0 tons/ha/yr > 9.1 Etol ton/ha/yr) which had led to land degradation.
4. The drainage system of Kendari city is bad, both in quantity and quality, including environmental sanitation systems. The volume of agricultural waste and household waste is high. The marshes around Kendari bay, which function as water parking area has been filled by soil, transformed into residential area and hotel site, have caused the blockage of the water flow in the drainage system.
5. The cause of tidal flooding as high as 2-5 m for 3-6 days in Kendari city was the decline in the forest area of 10,908.7 ha (24.04%), making the forested area remain 19.1% < 30% of the Wanggu watershed area, land degradation, disturbed hydrological conditions, household waste, poor drainage of Kendari city, the filling of the marshes around Kendari bay, high rainfall of 2739.1 mm/yr, and the highest tide inundating by-pass road.
6. The formulation of the tidal flood prevention in Kendari city was spatial arrangement of the Wanggu watershed with a minimum forest area of 30% (13613.2 ha), mixed farms or Agroforestery, the application of soil and water conservation, arrangement and improvement of natural and artificial drainage systems, both quantity and quality, environmental sanitation, control of household waste disposal and prevention of filling water-collecting marshes around Kendari bay.

Recommendations on tidal flood prevention in the city of Kendari are as follows:

1. There should be a spatial planning of the Wangu watershed and 8 other micro watersheds that empty into Kendari bay, the forest area of 30% (13613.2 ha) of the watershed area, agroforestery, the application of soil and water conservation, repair and improvement of the drainage system in both quantity and quality, environment sanitation, control of household waste disposal and prevention of filling water-collecting marshes around Kendari bay.
2. There should be regional regulation issued by the governor of Southeast Sulawesi province, joint regional regulation between Konawe district, South Konawe and Kendari city, and special regional regulation of the City Government of Kendari regarding the arrangement of Kendari city drainage system.
3. The should be further studies on the impact of the decrease in forest area on flooding and sedimentation in Kendari bay.

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