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USLE Estimation for Potential Erosion at Wae Heru Watershed and Wae Tonahitu Watershed, Ambon Island, Indonesia

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Abstract Calculate the potential erosion at Wae Heru and Wae Tonahitu Watershed aims to map and assess the potential erosion, in order to be a scientific consideration for exploration and development. The method is a field survey to determine the forms of land use and other forms of conservation efforts; secondary data collection, i.e. soil data, rainfall data, slopes data and data interpretation from Geo Eye satellite imagery in 2012. Further data processing used USLE formula with ArcGIS program. The results showed that the potential erosion of Wae Heru Watershed and Wae Tonahitu Watershed are in very light potential class. This is because the conditions in the upstream are still forested largely. However, at the downstream potential for erosion is vary, i.e. light class, moderate class, heavy class and very heavy class. This is because the conditions in the downstream undergo conversion into settlement, moor, garden, open land and sand mining.

Keywords: Erosion, Potential Erosion, USLE, Watershed

Abstrak *Menghitung potensi erosi di Wae Heru dan Wae Tonahitu Daerah Aliran Sungai bertujuan untuk memetakan dan menilai potensi erosi, agar menjadi pertimbangan ilmiah untuk eksplorasi dan pengembangan. Metode ini adalah survei lapangan untuk menentukan bentuk penggunaan lahan dan bentuk lain dari upaya konservasi; pengumpulan data sekunder, data tanah yaitu, data curah hujan, data yang lereng dan interpretasi data dari citra satelit Geo Eye pada tahun 2012. pengolahan data lebih lanjut digunakan rumus USLE program ArcGIS. Hasil penelitian menunjukkan bahwa erosi potensi Wae Heru DAS dan Wae Tonahitu Daerah Aliran Sungai di kelas potensial sangat ringan. Hal ini karena kondisi di hulu masih berhutan sebagian besar. Namun, pada potensi hilir erosi adalah bervariasi, yaitu kelas ringan, kelas menengah, kelas berat dan kelas yang sangat berat. Hal ini karena kondisi di hilir mengalami konversi menjadi pemukiman, tegalan, kebun, lahan terbuka dan penambangan pasir.*

Kata kunci : Erosi, Potensi erosi, USLE, Daerah Aliran Sungai

1. Introduction

Hydrological system is a combination of a complex interaction of several factors namely geomorphology, hydrogeology, biological processes in it and land use practice. Condition of hydrological system can affect redistribution of subsurface water storage in soils and groundwater contribution. An example of one very important hydrological system is watershed. Management and protection of the watersheds is one of the major concern of the 21st century (Walia and Mipun, 2010).

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Geomorphological conditions on Ambon Island, especially in the Ambon City, consists of hilly areas mostly, with steep slopes of ±186,90 km^2 and plain areas with a slope of about 10% has an area of ±55 km^2 of its total land area. Subdistrict of Baguala Ambon Bay which is part of the Ambon city has many watersheds in both large and small, and there are two largest watershed, that is Wae Heru Watershed with a river length of 3.50 Km and Wae Tonahitu Watershed with a river length of 6.00 Km (Asikin, 1999; Ambon City in Numbers, 2012 and Subdistrict of Baguala Ambon Bay in Numbers, 2012). Both of the Watershed ends in Inner Ambon Bay.

Based on that, the potential erosion will be very high and erosion will be happen certainly when the rainy season. Moreover, the pattern of improper land use, often occurs in Ambon (Loppies, 1992; Latupono, 2005). Then, the erosion that occurs all along the watershed also influence the conditions in Inner Ambon Bay, so that the calculation of the potential erosion needs to be done.

In hydrology, watershed conditions that exist in the study area, generally have a kind of dendritic stream-flow patterns with an elongated shape that growth to be parallel patterns (Sahuleka, 1993). Soil drainage is generally good, except in the form of units of plains alluvial coastal freshwater and brackish (Siahaya, 1998). According to Berhitu and Matakupan (2010), rivers that are in the research sites, in general, has undergone a process of silting due to deposition of sand. This is caused by the use of non-agricultural land in the buffer zone and the treatment for a conservation area less attention to the factors that may cause damage to the land. So, therefore water catchment areas are not maintained then the fluctuations of river flow in the dry season and the rainy season is quite large. Frequent droughts in the dry season, while frequent flooding during the rainy season. Tokarczyk (2013) state that drought means a lack of water which normally would be available in a region. During the hydrological drought period, the effects of water scarcity have an impact on almost all economic activities and, although in extreme cases, the supply of fresh water might be limited. Then, managing of water resources needs to be done.

Based on these things then, that will be studied in this research is what are the estimation of potential erosion at Wae Heru Watershed and Wae Tonahitu Watershed? The aims to map and assess the potential erosion that exist in the two watersheds, in order to be a scientific consideration in the future exploration and development in order to face of human population growth which is increasing rapidly. The increase in this growth can be seen in the city of Ambon statistical data in 2015 showing that, since 2000 to 2014, always an increasing number of population and never once occurred a decline in population. With an average population growth rate of 4.7% per year. On the statistical data recorded in 2000 there were 209303 inhabitants and in 2014 there were 395423 inhabitants.

2. The Methods

This research was conducted from May-July 2013, located in the Wae Heru Watershed and the Wae Tonahitu Watershed (Figure 1).

To estimate the potential for erosion, by collecting rainfall data, slope, soil characteristics, land use from the interpretation of satellite imagery and field observations. Then the data is calculated by USLE (Universal Soil Loss Equation) approach (Wischmeier and Smith, 1978), i.e.:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

With, A = soil loss (tons/hectares/year); R = rainfall

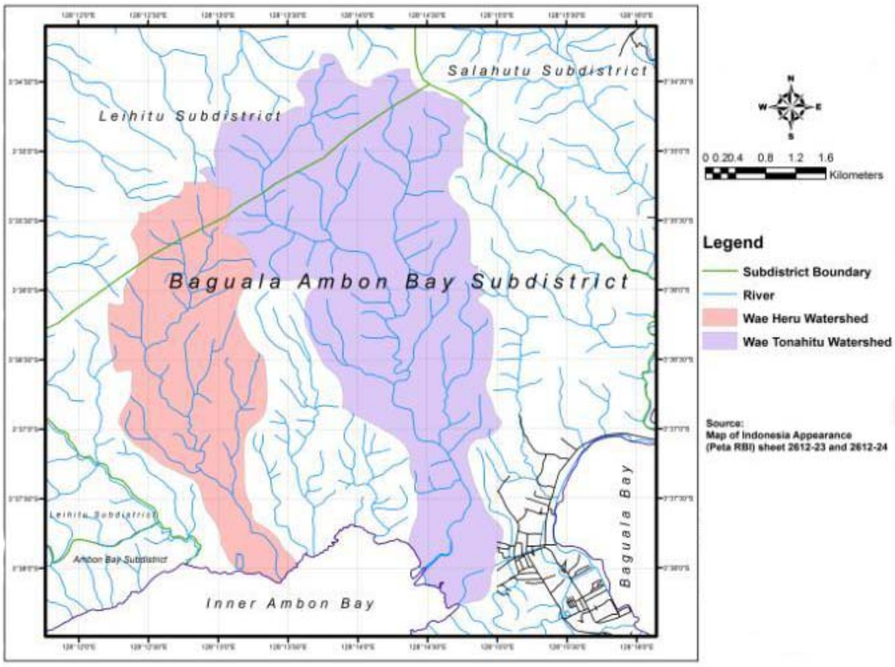

Figure 1. Map of Two Watersheds as Research Area

erosivity index (tons/year); K = soil erodibility index; LS = index of slope and slope length; C = index of vegetation cover (land use); dan P = soil conservation index.

Rainfall erosivity is obtained by using the Lenvain formula (Asdak, 2002), i.e.:

$$R = 2.21 \times P^{1,36}$$

With, R = rainfall erosivity index (tons/year); P = monthly rainfall (cm). Furthermore, to obtain annual rainfall erosivity is obtained by adding up all the monthly rainfall erosivity in one year.

Soil erodibility value obtained by secondary data from Department of Agriculture for soil types in Indonesia. The types of soil in the study area based on research from Siahaya (1998) is alluvial, kambisol, gleisol and podzolic, so that the value of the land erodibilitas can be seen in Table 1.

While the LS index value obtained based on the classification of the Forestry Department which can be seen in Table 2.

Then, the value of C and P are determined based on the classification of Arsyad (2006), which is shown in Tables 3 and 4.

Class of potential erosion is determined by reference to the blend of the lost ground with soil solum levels, as shown in Table 5:

Table 1. Determining the value of soil erodibility for the type of soil in the study area based on secondary data

Soil Types	Value of K	Data Source
Alluvial	0.47	Departement of Agriculture, 2004
Kambisol	0.25	Hammer in Departement of Agriculture, 2004
Gleisol	0.315	Hammer in Departement of Agriculture, 2004
Podzolic	0.16	Hammer, Undang and Suwardjo in Departement of Agriculture, 2004

Source: Departement of Agriculture (2004)

Table 2. Ratings for LS Factors Using Class of Slopes

Class of Slopes (%)	Value of LS
0-8	0.25
8-15	1.4
15-25	3.1
25-40	6.8
>40	9.5

Source: Departement of Forestry (1994)

Table 3. Value of C for different types of crops and land cover and crop management

Sorts of Use	Value of C *
Ground open / no crop	1.000
paddy field	0.010
Moor is not specified	0.700
Cassava	0.800
Corn	0.700
Soy	0.399
Potato	0.400
Peanuts	0.200
Paddy	0.561
Cane	0.200
Banana	0.600
Fragrant roots (lemongrass)	0.400
Grass Bede (the first year)	0.287

Grass Bede (the second year)	0.002
Coffee with poor ground cover	0.200
Taro	0.850
mixed farms	
- High Density	0.100
- Moderate Density	0.200
- Low Density	0.500
Shifting	0.400
natural forest	
- a lot of litter	0.001
- a little of litter	0.005
Production forest	
- Clearfelling	0.500
- Selective logging	0.200
Shrub / grassland	0.300
Cassava + soybean	0.181
Cassava + peanut	0.195
Rice + sorghum	0.345
Rice + soya	0.417
Peanuts + pigeonpea	0.495
Peanuts + cowpea	0.571
Peanuts + straw mulch 4 tons / hectare	0.049
Rice + straw mulch 4 ton / hectare	0.049
Peanuts + corn mulch 4 tons / hectare	0.128
Peanuts + Crotalaria mulch 3 tons / hectare	0.136
Peanuts + cowpea mulch	0.259
Peanuts + straw mulch 2 tons / hectare	0.377
Rice + Croalana mulch 3 tons / hectare	0.387
Cropping patterns overlap shift ** + straw mulch	0.079
Sequential cropping patterns *** + mulch of crop residues	0.357
Imperata pure fertile	0.001

Source : Arsyad (2006)

Note : * = Data from Land Research Center (1973-1981), unpublished

** = Cropping pattern shifts overlap, corn + rice + cassava, after the rice harvest, planted with peanuts

*** = Sequential cropping pattern, rice + maize + peanut

Table 4. The value of P for a variety of special soil conservation acts

Special Measures for Soil Conservation	Value of P
Bench terracing	
- Good Construction	0.040
- Moderate Construction	0.150
- Unfavorable Construction	0.350
- Traditional terrace	0.400
Strip bahia grass plants	0.400
Soil management and cultivation according to the contour lines	
- The slope of 0-8%	0.500
- The slope of 9-20%	0.750
- The slope of >20%	0.900
Without conservation acts on land	1.000

Source: Arsyad (2006)

Table 5. Classes for Erosion Hazard Level

Erosion	Class of Erosion				
	I	II	III	IV	V
Solum levels	Erosion (tons/hectares/year)				
(cm)	<15	15 - 60	60 - 180	180 – 480	>480
Deep	VL	L	M	H	VH
>90	0	I	II	III	IV
Moderate	L	M	H	VH	VH
60 – 90	I	II	III	IV	IV
Shallow	M	H	VH	VH	VH
30 – 60	II	III	IV	IV	IV
Very Shallow	H	VH	VH	VH	VH
<30	III	IV	IV	IV	IV

Source: Directorate General of Reforestation and Land Rehabilitation (1998);
Note: VL = very light, L = light, M = moderate, H = heavy, VH = very heavy

Furthermore, the data calculation results were processed with ArcGIS 9.3 to produce a map of erosion class. The data used are secondary data, that is: slope data sourced from data of Development Planning Agency at Ambon City in 2008, soil type data sourced from Research conduct by Siahaya on 1998, land use data extracted from GeoEye imagery in 2012 as well as data of rainfall during the year 2012 were obtained from the data of Meteorology Climatology and Geophysics Council, Class of 1a, Pattimura Stations, Ambon. Coupled with field observations to ensure the results of image interpretation of GeoEye imagery.

3. Results and Discussion

The calculation can be seen in Table 6. Thus, the value of the rainfall erosivity index (R) of 5312.68 tons/year.

a. Determination of the value of K

Soil erodibility (K) is determined by Table 1. Here are explanations of each type of soil.

The alluvial soil is a kind of undeveloped land with layered deposition. Average soil depth is 79 cm with an effective soil depth is very deep (130 cm). Soil color is dark brown with sandy loam texture, fine granular, friable, fast permeability with pH 5.5-6.0. This soil type is grown from the parent material of young alluvium and spread on land form the old beach and floodplains (Sahuleka, 1993; Siahaya, 1998 and Samalehu, 2013).

Table 6. The Calculation of Rainfall Erosivity Index in 2012

Month	Rainfall (mm)	Rainfall (cm)	$P^{1.36}$	$2.21 \times P^{1.36}$ (tons/year)
January	99.7	9.97	22.81526	50.42172379
February	119.1	11.91	29.05628	64.21437639
March	297.5	29.75	100.9119	223.0152456
April	80.1	8.01	16.94105	37.43971168
May	907.8	90.78	460.1153	1016.854737
June	1252.1	125.21	712.5069	1574.640201
July	1156.8	115.68	639.7809	1413.915757
August	638.7	63.87	285.2357	630.3707885
September	254.1	25.41	81.43411	179.969379
October	136	13.6	34.8027	76.91396301
November	25.6	2.56	3.590925	7.935944584
December	79.4	7.94	16.74002	36.9954366
The annual rainfall erosivity index				5312.687264
Source of rainfall data: Meteorology Climatology and Geophysics Council				

Gleisol is a type of soil that has an effective depth ranging from shallow to very deep (>120 cm). The gleisol color is very dark brown gray and ashy texture silty loam and sandy clay loam, rounded cube and cube structure, very closely (wet) with a pH of 4.8 to 6.7. This soil type is grown from the alluvium material or precipitated and dispersed in the form of brackish coastal alluvial plain land, freshwater and coastal alluvial plain floodplain (Siahaya, 1998).

Kambisol is a type of soil that has shallow to deep soil solum (40-130 cm). Soil color is very dark gray and fawn with sandy loam to dush loam texture, loose, finely granular to blocky, permeability moderate to slow to a pH of 4.8 to 6.0. This type has a parent material of sandstone, granite and periodit-serpentine. Spread on land form the structural origin of loose materials and denudasional growing from andesite parent material and landform fluvial origin-based parent alluvium (Sahuleka, 1993 and Siahaya, 1998).

Podzolic soil has an effective soil depth is very deep (150 cm). Soil color is dark reddish brown to dark brown with yellowish sandy loam texture, rounded cube structure, slow permeability, firm consistency (moist) with a pH of 4.5 to 5.0. This soil type is grown from the parent material loose rocks and andesite. Scattered on the structural origin of landforms and denudasional (Sahuleka, 1993 and Siahaya, 1998).

Here is a map of soil types at Wae Heru and Wae Tonahitu Watershed which can be seen in Figure 2 and 3.

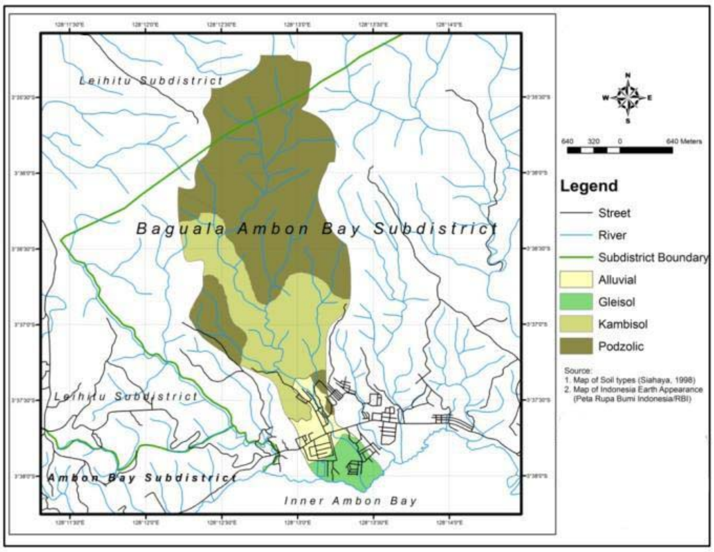

Figure 2. Map of Soil Types at Wae Heru Watershed

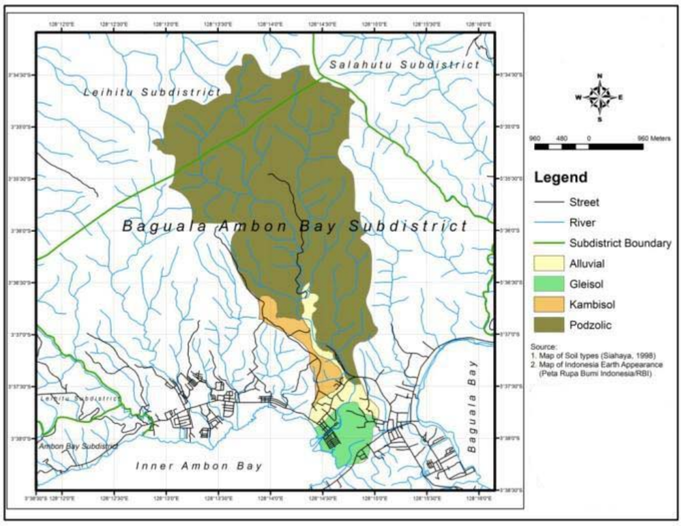

Figure 3. Map of Soil Types at Wae Tonahitu Watershed

b. **Determination of the value of LS**

Ambon City area has a slope that varies, ranging from flat to steep. Flat slope generally be around at the beach

Slope in Ambon city can be seen in Table 7 as well as a map of slope at Wae Heru and Wae Tonahitu Watershed can be seen in Figure 4 and 5.

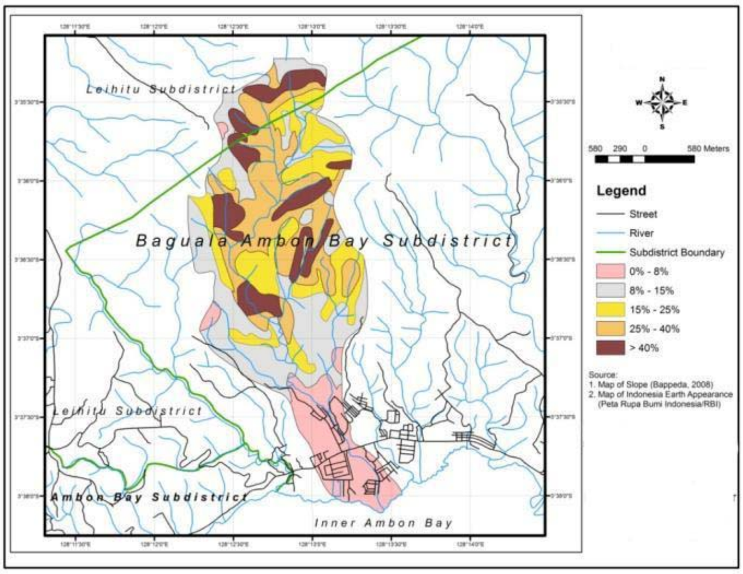

Figure 4. Map of Slope at Wae Heru Watershed

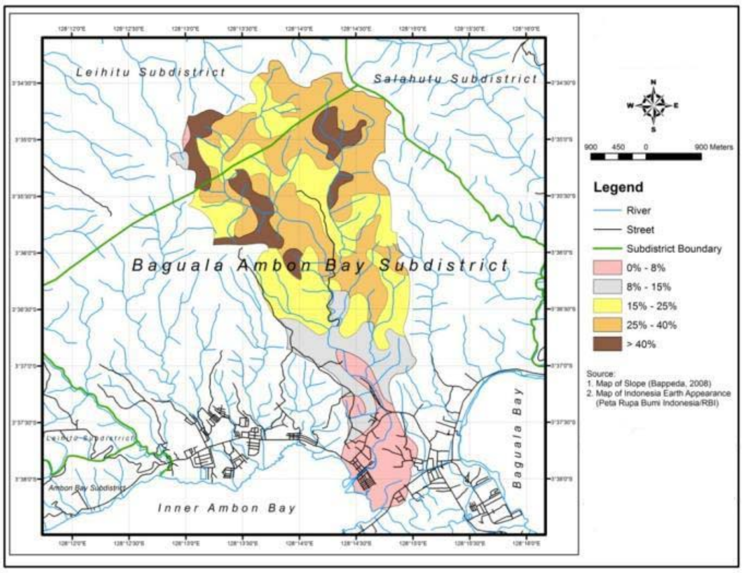

Figure 5. Map of Slope at Wae Tonahitu Watershed

Table 7. Slope at Ambon City

Class of Slope	Category	Large (hectares)	Large (%)
0 – 8 %	Flat	4897.36	13.62
8 – 15 %	Gentle	3580.00	9.96
15 – 40 %	Tilt	8899.97	24.76
> 40 %	Steep	18567.51	51.66
Amount		35944.84	100.00

Source: National Land Agency of Ambon, 1995 in Asikin, 1999.

Conditions varied from flat slopes to steep, resulting in altitude from sea level also varies. Asikin (1999) states that most areas in the city of Ambon is located at an altitude of 100-500 meters above sea level, with an area of 21202.08 hectares or 59% and approximately 9557.73 hectares or 26.59% at an altitude of 25-100 meters. Lowland area with a height of 0-25 meters, the extent of only 13.62%, which are all located on the waterfront. This phenomenon also shows that the area with tilt slope to the area with steep slope directly related to the sea.

c. **Determination of the value of C**

Value of C Referring to Table 3. Meanwhile, based on extracts of GeoEye imagery in 2012 and field observations then acquired some forms of land use on Wae Heru and Wae Tonahitu Watershed, the details are as follows:

1. Land use in the Wae Heru Watershed: forest (large is 533.76 hectares), homogeneous garden (large is 1.30 hectares), mixed garden (large is 24.72 hectares), mangroves (large is 7.40 hectares), settlement (large is 37.85 hectares), sand mining (large is 2.67 hectares), shrubs (large is 0.99 hectares), open land (large is 0.57 hectares) and moor (large is 65.52 hectares).
2. Land use in the Wae Tonahitu Watershed: forest (large is 1265.69 hectares), mixed garden (large is 13.04 hectares), open land (large is 13.25 hectares), mangroves (large is 33.61 hectares), settlement (large is 54.94 hectares), shrubs (large is 0.33 hectares) and moor (large is 40.40 hectares).

Here is a map of land use at Wae Heru and Wae Tonahitu Watershed which can be seen in Figures 6 and 7.

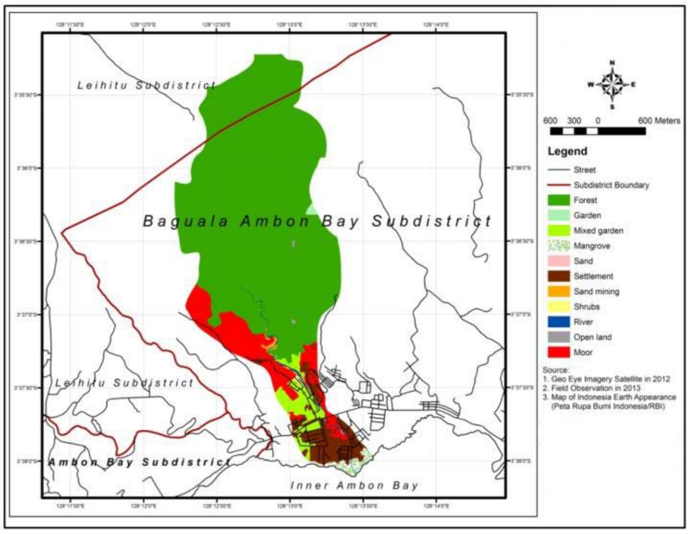

Figure 6. Map of Land Use at Wae Heru Watershed

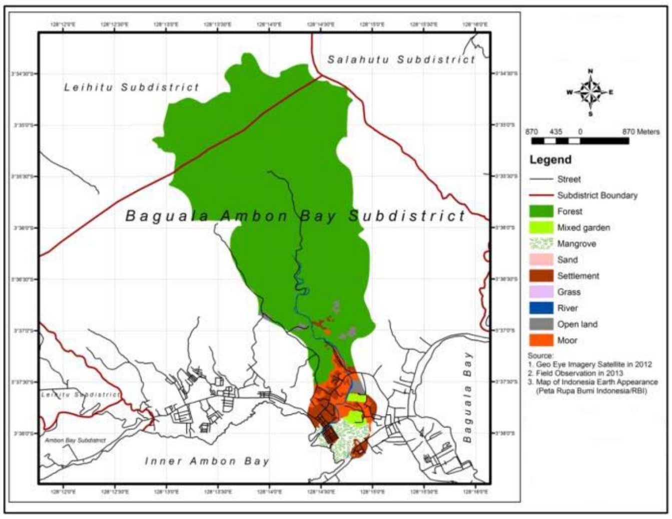

Figure 7. Map of Land Use at Wae Tonahitu Watershed

d. **Determination of the value of P**

Value of P Referring to Table 4.

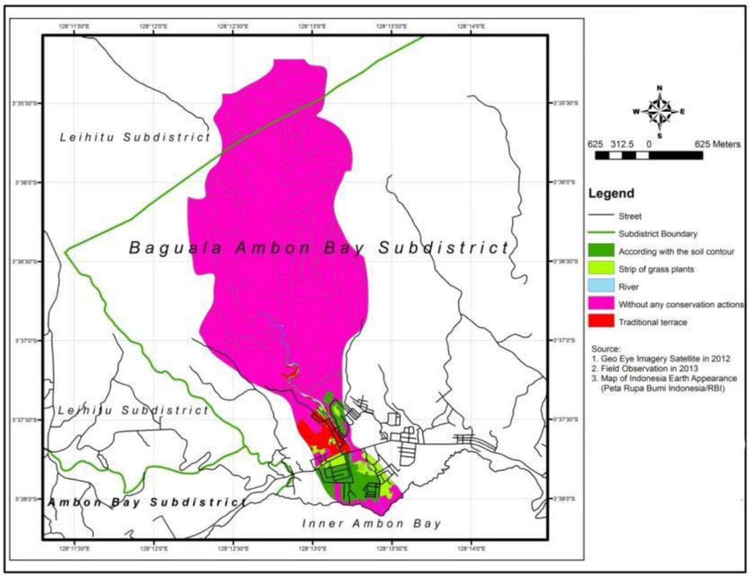

Figure 8. Map of Land Conservation at Wae Heru Watershed

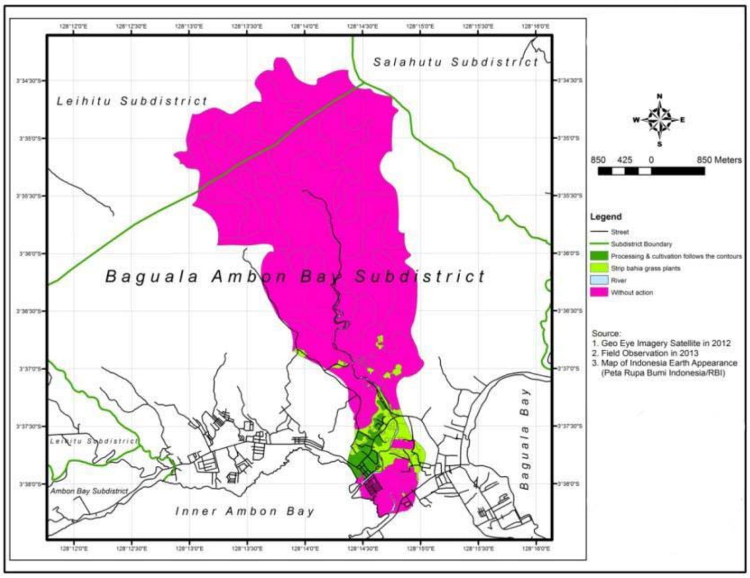

Figure 9. Map of Land Conservation at Wae Tonahitu Watershed

Based on the map (figure 8 and 9), it can be seen that no conservation acts in most areas at Wae Heru Watershed and Wae Tonahitu Watershed (on the map marked with a pink area). This is because most of the areas in the upstream still forested. In addition, there are also some areas that should be conserved, but did not do any conservation acts in the area. For example, sand mining area at Wae Heru Watershed (compare figure 6 and figure 8). In addition, areas with dense settlement also requires conservation acts.

Land management which carried out in accordance with the land contour found in some areas at the downstream (figure 8 and 9, marked with green), whereas in some locations there are land management by using a strip bahia/*Paspalum notatum* grass plants (figure 8 and 9, marked with pale green). In addition, conservation acts using traditional terrace found at several locations at Wae Heru Watershed (figure 8, marked with red).

Conservation acts is important because population growth also increases the demand of fresh water supply. The combined effects will challenge future fresh water availability (Sun et al., 2013), i.e. streamflow, surface runoff and groundwater (Lin et al., 2007). However, surface runoff from urban areas increased and groundwater discharge decreased as replacement of vegetation through development reduces infiltration (Lin et al., 2007). Based on Li et al. (2014) the land use change may result in hydrological process variation because forest, grassland, and agricultural land are of different hydrological responses. Compared with grassland and agricultural land, forest is of higher infiltration rate and canopy interception, so there is more rainfall loss. Besides that, land use changed from grassland and agricultural land to forest, resulting in an increase in soil water storage capacity and infiltration.

e. Potential of Erosion At Wae Heru and Wae Tonahitu Watershed

According Siahaya (1998), land on two watershed area is a land with deep solum, thus determining the grade of erosion potential based on the grade level of erosion on deep soil solum, that is >90 cm (Table 5). Under these conditions, erosion weighing <15 tons/hectare/year is very light (VL) erosion class; 15-60 tons/hectare/year is light (L) erosion class; 60-180 tons/hectare/year is moderate (M) erosion class; 180-480 tons/hectare/year is heavy (H) erosion class; and >480 tons/hectare/year is very heavy (VH) erosion class.

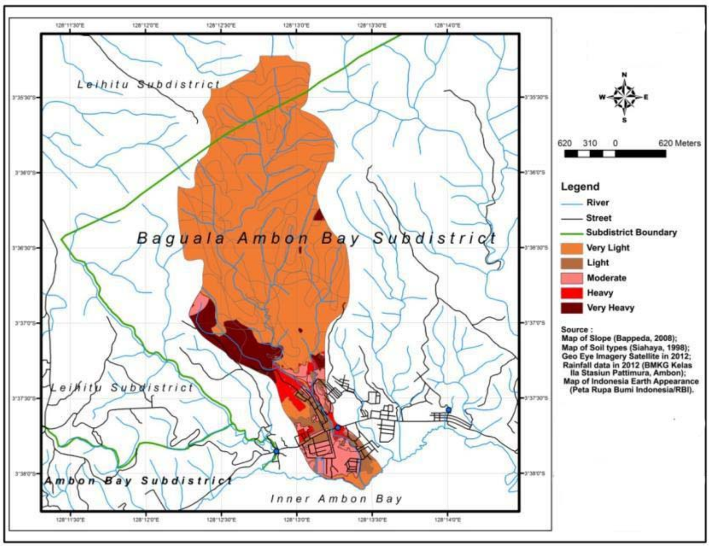

Figure 10. Map of Erosion Class at Wae Heru Watershed

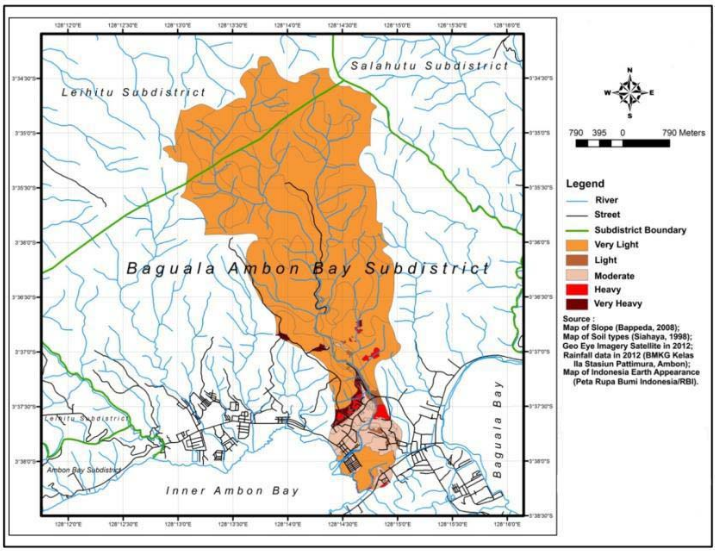

Figure 11. Map of Erosion Class at Wae Tonahitu Watershed

Two main causes of the erosion is due to natural factors and due to human activities. Natural erosion can occur because the process of soil formation and the process to maintain the natural balance of the soil. Erosion due to natural factors still provide adequate media for the ongoing growth of most plants, while erosion due to human activity is largely due to the upper soil layer peeling due to different ways of farming that do not heed the rules of soil conservation or development activities that are destructive in physical (Asdak, 2002). It can be seen in the condition of the watershed area on Wae Heru and Wae Tonahitu, where on the map of land use and land conservation can be seen that many conservation rules are not implemented in the area.

Here is a table of land unit of slope - land use - erosion class in each watershed, accompanied by the wide of each area which has been divided in percentage:

Table 8. Land unit of slope – land use – erosion class in Wae Heru Watershed

Class of slope	Land use	Class of erosion	Wide percentage (%) from the total of watershed area
0-8%	Forest	Very light	1.11
0-8%	Mixed garden	Light	3.3
0-8%	Mixed garden	Very light	1.18
0-8%	Mixed garden	Moderate	0.65
0-8%	Mangrove	Very light	1.56
0-8%	Sand	Heavy	0.15
0-8%	Settlement	Heavy	0.5
0-8%	Settlement	Light	1.72
0-8%	Settlement	Moderate	5.5
0-8%	Sand mining	Heavy	0.2
0-8%	Sand mining	Moderate	0.07
0-8%	Shrubs	Moderate	0.2
0-8%	River	Very light	0.5
0-8%	Open land	Heavy	0.02
0-8%	Moor	Heavy	3.21
0-8%	Moor	Light	0.04
0-8%	Moor	Moderate	2.12
8-15%	Forest	Very light	34.05
8-15%	Mixed garden	Heavy	0.04
8-15%	Garden	Heavy	0.02
8-15%	Settlement	Very heavy	0.2
8-15%	Sand mining	Very heavy	0.25
8-15%	River	Very light	0.1
8-15%	Open land	Very heavy	0.04
8-15%	Moor	Very heavy	7.8
15-25%	Forest	Very light	9.5
15-25%	Sand mining	Very heavy	0.02
15-25%	River	Very light	0.03
15-25%	Moor	Very heavy	0.49
25-40%	Forest	Very light	7.07
25-40%	Garden	Very heavy	0.23
25-40%	River	Very light	0.02
25-40%	Open land	Very heavy	0.05
>40%	Forest	Very light	18.03
>40%	Garden	Very heavy	0.02
>40%	River	Very light	0.01

The greatest percentage is in the condition of the 8-15% slope class with the land use is forest with class of erosion is very light (number 18); followed by land on a slope >40% with the land use is forest and class of erosion is very light (number 34); and the third position is still the same of land use and erosion class, but the slope is 15-25% (number 26). The trio dominated the existing land use in Wae Heru watershed, that is in the form of forest. But in the next extents, land use is moor with class of erosion is very heavy in the slope of 8-15% (number 25) found in this watershed, with a wide percentage is 7.8% from the total of watershed area.

When viewed as a whole, the area with very heavy erosion class covers 9.1% of the total area of the watershed, followed by 4.14% and 8.54% for areas with heavy erosion and moderate erosion respectively. While the area with light erosion class amounted to 5.06% of total area. Thus large area with very light erosion class amounted to 73.16%. Despite wide area with very light erosion class still dominates, but it should be seen that the form of land use in areas with erosion class is moderate to very heavy is garden, open land, moor, sand mining and settlement found in some areas in the central part of the watershed and the whole area of downstream. The forms of land use that is likely to increase in the years ahead due to population growth, the necessities of life, exploration and other development forms. It should be noted that the extent of the area is not increasing, even should be limited. Furthermore, by looking at the table, it can be seen that forest is a form of land use that maintains and protects most of the watershed areas so the erosion class is very light dominate this watershed areas, then for the conversion of forest lands should be limited with very tight, accompanied by conservation acts with high intensity.

For example, in this watershed area there are sand mining activities are located in the slope of 0-8%, 8-15% and 15-25%, with the potential erosion is moderate to very heavy. Then, by looking at a map (Figure 10), sand mining site located in the middle area of the watershed. This is a simple indication of exploitation in watershed areas that propagate toward the upstream area. For that, the ex-mining lands have to do intense conservation efforts so that the potential erosion can be decreased to be light or very light. Moreover, the statistics show that the population growth in Ambon city is increasing every year, then according to Noori et al (2016), it may be a cause of land clearing and can occur continuously.

Table 9. Land unit of slope – land use – erosion class in Wae Tonahitu Watershed

Class of slope	Land use	Class of erosion	Wide percentage (%) from the total of watershed area
0-8%	Forest	Very light	7.3
0-8%	Mixed garden	Moderate	2.85
0-8%	Mangrove	Very light	7.34
0-8%	Sand	Heavy	0.2
0-8%	Settlement	Heavy	0.12
0-8%	Settlement	Light	1.06
0-8%	Settlement	Moderate	9.41
0-8%	Grass	Light	0.07
0-8%	River	Very light	1.06
0-8%	Open land	Heavy	1.07
0-8%	Open land	Moderate	0.1
0-8%	Moor	Light	1.36
0-8%	Moor	Moderate	5.8
8-15%	Forest	Very light	32.56
8-15%	Settlement	Heavy	1.17
8-15%	Settlement	Very heavy	0.24
8-15%	Settlement	Moderate	0.1
8-15%	River	Very light	0.3
8-15%	Open land	Heavy	0.85

8-15%	Open land	Very heavy	0.76
8-15%	Moor	Heavy	0.02
8-15%	Moor	Very heavy	1.7
15-25%	Forest	Very light	10.48
15-25%	River	Very light	0.11
15-25%	Open land	Very heavy	0.12
25-40%	Forest	Very light	10.85
>40%	Forest	Very light	3

Wae Tonahitu Watershed conditions it does not differ much from Wae Heru Watershed conditions. At various slope, most of the land in condition of very light erosion class (73%), with the majority of land use is forest. And approximately 2.82% of the total area is in condition of very heavy erosion class; 3.43% in conditions of heavy erosion class; 18.26% in condition of moderate erosion class and 2.49% in condition of light erosion class, with dominated forms of land use is moor, settlement, open land and mixed garden. This condition is most commonly found in the downstream area of watershed. So as mentioned earlier, that the forms of land use that must be observed, so the extent of that area does not continue to grow in the coming years, otherwise the land use of forest should be maintained in order to preserve the watershed.

The trend of the downstream areas of watershed has the most potential class of moderate to very heavy, because the downstream area has a slope is not steep (0-8% and 8-15%), so that the activity of land conversion and land clearing is going a lot in here. As a solution, then Sun et al. (2013) states that to develop the watershed sustainably, it is necessary to examine these future growth areas carefully in terms of their resources (such as safe drinking water supply), environmental constraints (e.g., mountainous terrain), infrastructures and superstructures (such as transportation networks), and socio-economic conditions (including job opportunities), so that sound planning strategies can be formulated.

4. Conclusion

1. Potential erosion of Wae Heru Watershed and Wae Tonahitu Watershed are in very light potential class, wherein the condition is found mostly in the upstream area with land use is forest. Meanwhile, downstream area dominated by various forms of land use such as settlement, garden, moor, open land and sand mining, so that the land was in light to very heavy condition of erosion.
2. Condition of upstream areas, mostly in the form of forest must be maintained, by limiting the attempted exploitation of land and intense conservation efforts to land that had already been exploited. This is also a form of anticipation to the growth of human population which is increasing rapidly, which may endanger the sustainability of the watershed areas, particularly in the upstream.

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