

# Environmental Impact Assessment of Land Use Due to the Change of Water Resources Potentialin Urban Watershed: A Review

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# ABSTRACT

Problems of water resources are becoming of a major concern today, it is because there is an imbalance between the potential of water availability to the water needs of the population. The main cause is due to the fast growing population that is reflected in the increased activities of land-use change from forest to agriculture and settlements. This rapid land use change pattern caused a disturbance on the environmental conditions of its watershed (DAS). Erosion and flooding problems are the common results of land use activities that do not fit with the criteria of land suitability. Thus, a comprehensive study is needed to compare impacts that are caused by the land use change activities through a review of several studies. The results of this review showed that all the upstream catchment areas have the same problem, namely un controlled land use result caused by the pull-up and driven factors, each are reflected in the water resources availability and in adaptation activities of its society, respectively.

Keywords: Environmental Impact Assessment, LandUse Change, Water Resources Potential

# **INTRODUCTION**

One of the main problems in sustaining the potential of water availability is the land use changes that lead to the expansion of the settlement area, thus causing an imbalance in the soil water storage [1]. It is further described [2], who explained that the change in land use will have an impact on global climate change that directly results in a decrease in the precipitation percentage and an increase in the potential evapotranspiration.

The direct impact of climate change that causing an imbalance of rainfall distribution and its intensity, is the disturbance of hydrological cycle, which in turn affects the quality and quantity of water resources in the watershed area (DAS) [3]. Disruption of the hydrological cycle processes according to [4], is related to the location of the watershed that is situated in urban areas, or that is dominated by agricultural and settlement activities, which resulted in a negative impact on the function and the role of the basin as a source of water providers and distributors, namely inequity of water balance.

A condition on the water balance of the watershed area is an important indicator to show the environment quality. This is related to population pressure, which is reflected by the pattern of land use that is uncontrolled in the catchment area, therefore it affects the hydrological runoff in the basin's segment [5]. The pressure of population is caused by many factors [6], such as: a) land conversion from forest to agriculture and settlement, b) pollution by domestic and industrial wastes, and c) exploitation of ground water that is not under control. Furthermore, the environmental management of watershed area should be measured by using a systematic and an integrated approach. It means that a proper analysis and exact model are required to solve the problem of the watershed environment [7,8,9].

One example of negative impacts from an uncontrolled land use patterns is a growing runoff, which can lead to an erosion and landslides in areas with the slope of greater than 30%. The more limited ability of the soil infiltration due to the impermeable layers that block the entry of water, the less the ground water volume reserve that leads to the increase in the potential of flooding [10].

The problem of environmental degradation due to the uncontrolled land use change is occurred in all over watershed areas, especially upstream, which systematically affects the river system as a whole. Thus, this paper will compare some of the impacts caused by the change of the land use upon the potential availability of water, which occurs in some watershed areas, particularly at Galala watershed, in Ambon, North Moluccas.

#### 2. Environmental Impact Assessment based on Watershed Management.

Watershed area is the site for various processes of environmental, economic and social activities, including for its wastes disposal, that make it as a pool of complex environmental problems [11]. Thus it needs a comprehensive approach to analyze and to evaluate any impact of these problems so that the availability of water could be sustained.

\*Corresponding Author: Joni Hermana, Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh Nopember, Surabaya. Email: Hermana@its.ac.id Guzman et al. [12], assessed the impact of land conversion activities by using a runoff coefficient, this was done by using the Curve Number method and GIS, taking into account the area of the watershed that was examined based on the result interpretation of Landsat ETM+ satellite image. Furthermore, the region was plotted as a map by using DEM (Digital Elevation Model) so that the characteristics of any land within the area and its slope grades were obtained. From their results, it can be seen that the dominant characteristics of the land was caused by human activities that contributed to more than 20% of the surface runoff, in order to obtain 71% of the total runoff generated.

Another impact of land use change [13] basically leads to the potential for soil erosion and landslides if it takes place in the upstream region of the watershed, and will systematically affect the potential for flooding in the lower reaches. It was stated after analyzing the relationship between land use change impacts of socioeconomic conditions and physical conditions of the Ramian Watershed in Iran, through the vegetation management approach. In this study [13], the quality conditions of the watershed was assessed by using hydrology model, SCS (Soil Conservation Service) and Erosion Model, while the socio-economic analysis using the Cost-Benefit analysis. The analysis yielded the scenario for the decision-making process in determining sub watershed areas that need to be managed through re-vegetation system with plantation. The scenario was then re-analyzed by using the MCDM (Multi Criteria Decision Making) to rank the priority areas to be managed by using that re-forestation method.

Methods of environmental impact assessment conducted previously [12] and [13] can be complementary in considering several aspects, among others: the extensive basin, the dominant land use typology and parameters used. The Landsat ETM+ was able to be used in assessing vegetation density [13], and it will be easier to estimate the priority rank in the determination of a sub-watershed reforestation in such areas. Thus, the watershed management due to the land use changes that used re-forestation which affects the assessment of water resources, can be applied in all watershed areas that have the land use patterns that do not conform to the criteria of the existing land. The used cost-benefit methods play a role in determining the level of water demand in any land use activity, and this is an important factor to determine the potential water availability.

#### 3. Land Use Change on Urban Watershed based on Human Activities

Human activity is a major factor in the land use change, and it is reflected in cultivated lands in the basin region for conducting agricultural activities. In fact, it was stated [14] that the population and their activities always increase proportionally to the increase in the residential area of the city. Because of the limited living space, the growing population will occupy the land space along the river that is reserved for a conservation zone for the watershed area. Similar findings [15] noted that the occupation of the land space along the river could be explained in common due to the presence of driven factors, among others; the availability of natural resource potential that has not been utilized or the high opportunity to conduct agricultural extensification. This leads to a significant relationship between agricultural utilization patterns using the traditional way to rapid environmental degradation and availability of natural resources in the watershed.

The impact of relationship between the increased population with the availability of natural resources is environmental changes that lead to a decrease in the river ability to keep on pressures caused by the human activity, one of which is the high runoff due to land conversion and increased concentrations of pollutants in river water [16]. The same thing stated in [17], by using simulation Distributed Hydrology Soil Vegetation Model (DHVSM), it was found there are linkage factors between the replacement of planting patterns in agricultural areas with the potential of groundwater storage. This suggests that if there is a high rate of cropping patterns in the upstreams region of the watershed, it will reduce the potential for water absorption in the soil. It can be overcome, however, by producing the irrigation system on the farm so that conservation and economic goals can be achieved simultaneously.

#### 4. Land Use Change related to Water Quality: A term for sustainable water resources

By using statistical and spatial methods [18], that was then modeled by using BASINS (Better Assessment Science Integrating Point and Nonpoint Sources), it was stated that a river water quality within a watershed depends on the type of land use within its boundary and the flow patterns in each segment of the river. It was also explained that there is a significant relationship between agricultural activities with the high nutrient concentrations of N (nitrogen) and P (phosphorus) present in the river water. Analysis of the relationship between land use with water quality are also published [19], with the thesis that land use is the main indicator in controlling the level of evapotranspiration and run-off, which is a major cause of the sedimentation and deteriorated water quality.

The slow water flowrate due to the addition of pollutant containing water from surface soil and the runoff sediment could be considered as a contributing factor that reduces water quality, because of these pollutant materials accumulated in particular river segments [16]. Therefore, to determine the river water quality, assessing the river ecosystem can be used as one of the indicator [20]. This theory was proved by using stratified random sampling method, the result showed for the watershed that was dominated by agricultural land, the

nitrogen and phosphorus concentrations of the river water will be high. Where the watershed was dominated by settlements, the river water would content the high concentration of BOD, because it was contributed from disposed domestic wastes.

The temperature and rainfall intensity changes are other important factors that contribute to the erosion and sedimentation. It can be explained that the lack of land cover that can withstand the rate of runoff, and the presence of impermeable layers that reduce the infiltration capacity into the soil, caused the total runoff. If it passes over the land use types, such as agricultural area and settlements, it will bring the pollutants into it [21, 22].

The generated pollutant concentration is determined by the type of land use. For instance, in the dominant agricultural land, the produced pollutant was N and P, which is part of the fertilizer. Hence, the existing pollutant concentration of the river water was determined by the total of its surface runoff [23, 24].

Sustainability of water resources potential is therefore more intended for the surface water, and it was basically defined from three dominant factors: 1) the need for water, 2) the quality, quantity and distribution of water, 3) land use conditions, such as those described in Figure 1 below.



Figure 1. Water management cycle based on urban watershed

The relationship between water quality and the potential of its availability, especially for areas of at the upper Galala watershed, is reflected from the imbalance interaction between water use patterns with the negative impact of the land use activities by the community. Hence, it affects the self-purification of river flows. The rapid change in land use because of agricultural and settlement activities followed by the lowering forest coverage area, affects high sedimentation and BOD concentrations in water bodies, thus giving effect to the reduced water distribution allocation. By considering the level of the water needs of population has reached 17.616 MLD, a continual increase in population growth and its activities could create water scarcity in the region for the future.

The average consuming water is 52% of the total water supply in an area and it depends on climatic conditions, water quality, as well as the regulation applied to each region [25]. The high population growth is the main factor in determining the high water demand, because it is associated with the high generated waste production, as indicated by the high BOD, DO and TDS concentrations[10].

#### 5. Sustainable Water Resources based on Land Use Management

The sustainability of water availability is determined by the land use management. It was reported that the relationship between land use patterns and the climate, in this case is the rain intensity, temperature as well as the soil infiltration as natural factors, affects surface runoff, which in turn the river water quality [27]. Consequently, it limits the water function to meet the community needs, such as the unbalanced percentage between the factors of quality, quantity, and distribution of water [28].

With the limited availability of water levels, it was explained [29], the necessity of comprehensive regulation in addressing these water availability issues, among others, by specifying four factors that must be improved, namely; 1) the river water resource potential itself, 2) the development of irrigation, 3) the reuse of ground water and 4) the improvement of drainage system.

Changes in land use will adversely affect the sustainability of water resource potential, and it is measured based on the quantity and the function of water availability to meet the needs, one of which is located at the Galala watershed, in Ambon. The environmental degradation of Galala watershed is influenced by two main factors that are the push/driving and pull factors as described in Figure 2 below:



Figure 2. Pull up and driving/push factors in land use activities

As it is shown in Figure 2, by minimizing the driving factors, through the realignment of land use patterns in accordance with the criteria of land suitability in each sub-watershed, the potential water availability could be increased.

The assessment process of land use change through spasio temporal assessments uses the time interval of (10-15) years, and one example of the analysis in land use change shown in Table1 below:

Land Use Type	Area in 2001		Area in 2011	
	(Ha)	(%)	(Ha)	(%)
Forest	440	20.41	285	13.22
Bushes Area	1200	55.66	985	45.69
Plantation	382	17.72	485	22.50
Moor	42	1.95	125	5.80
Settlement	92	4.27	276	12.80
	2156	100	2156	100

Table 1. The area of land use changes in the Galala upstream watershed [29]

Hamad et al, [30], has stated that one of the indicators of the potential availability of water in the watershed are determined by the cumulative of natural land cover (forest), which is shown on Table 1, the forest are shrinked from 440 hectares in 2001 to 285 hectares in 2011, and turn into settlement, and agriculture forms. The increasing of settlement and agriculture activities can creates the increasing of run off coefficient on that area, which gave a negative impact on the hydrologic condition of the Galala watershed, particularly the water balance index.

The assessment for the environmental impacts of land use change at the Galala watershed area is more appropriate to use the MCDM and the Vegetation Density Assessment (VDA) made by[13]. So, the management of priority area, the area that experienced an environmental degradation, which needs a reforestation, could be conducted by restoring the landing the water shed sub-region. While the assessment of the impact of land use change in the city of Ambon, especially in the upper reaches of the river area of Galala, can be done by using additional aid interpretation of Lands at ETM+satellite imagery or IKONOS Satellite imagery. It is because of the vast area of the watershed and in the ease of classes delineation of subwatershed areas to be analyzed.

### CONCLUSION

The potential availability of water resources is mainly determined by the quality of the watershed environment, especially the upper region. This is an impact that was produced by the land use change from forest to agriculture and settlements. The increase in population activities of the upstream of watershed area will cause the decrease in the percentage of land coverage vegetation. Thereby it affects groundwater storage and high runoff waters which can lead to erosion and floods. So there are two major factors which related to population in the area that affects the land use change activities rapidly; 1) Pull up factors, which consists by the existing condition of natural resources of Galala watershed, that can be used to fulfil the daily needs of population, such as; water, fertilized soil, and all other of natural resources surrounds that area, 2) Driving/Push up factors, these came as resulted of population activities that has been reflected from adaptation behavior and the growth of population itself. These factors are become the main problem, which happened in all upstream area of watershed, including Galala watershed. There for, re-forestation is became the main solution to minimize or even to avoid the degradation of environment, which causes by the impact of land use activities. The methods of Multi Criteria Decision Making (MCDM) and Vegetation Density Assessments (VDA) which has undertaken by Sadoddin, 2010 [13], are the proper approach to analyzed and evaluated the suitability factors between land

use activities and the quality of physical condition of soil in that area. Also by using remote sensing analyzes based on the interpretation of LANDSAT ETM+ satellite imagery (for Vegetation Density) makes more simple and accurate to calculated and predicted the potential of water availability in the small scale of Galala watershed.

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