Land cover change impact on urban flood modeling (case study: *Upper Citarum watershed)*

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Abstract. The upper Citarum River watershed utilizes remote sensing technology in Geographic Information System to provide information on land coverage by interpretation of objects in the image. Rivers that pass through urban areas will cause flooding problems causing disadvantages, and it disrupts community activities in the urban area. Increased development in a city is related to an increase in the number of population growth that added by increasing quality and quantity of life necessities. Improved urban lifestyle changes have an impact on land cover. The impact in over time will be difficult to control. This study aims to analyze the condition of flooding in urban areas caused by upper Citarum watershed land-use change in 2001 with the land cover change in 2010. This modeling analyzes with the help of HEC-RAS to describe flooded inundation urban areas. Land cover change in upper Citarum watershed is not very significant; it based on the results of data processing of land cover has the difference of area that changed is not enormous. Land cover changes for the floods increased dramatically to a flow coefficient for 2001 is 0.65 and in 2010 at 0.69. In 2001, the inundation area about 105,468 hectares and it were about 92,289 hectares in 2010.

1. Introduction

Land cover change is dynamic process-taking place on the biophysical surfaces that have taken over a period and space is of enormous importance in natural resource studies. Land cover change dynamics are substantial elements for monitoring, evaluating, protecting and planning for earth resources. Land cover changes are the major issues and challenges for the eco-friendly and sustainable development for the economic growth of any area.

Land cover change is the conversion of open area to area woke indicated it would decrease catchment areas. Nowadays, the efforts to tackle the incident are still conventional runoff to flow quickly into the body of the river flow through the efforts of normalization techniques. Such shunt and water bodies [1]. Social and economic development drives land use and land cover changes, which have potentially enormous impacts on water resources. Changes in land use and land cover affect the partitioning of precipitation through the vegetation and soil into the main water balance components of interception, infiltration, evapotranspiration; surface runoff and groundwater recharge [2]. Land cover is an important determinant of Eco hydrologic processes in watershed systems. Continued urbanization changes the very nature of Eco hydrological regimes of watersheds and increases their vulnerability to flooding, soil loss, and water pollution [3].

The catchment hydrologic response suspects of having multiple impacts on urbanization and population concentration. The impact of land cover originates from a multiplicity of landscape modifications. This modification may potentially lead to compensations and makes it difficult to synthesize the results from the numerous case studies related to the impact of urbanization on catchments hydrologic response. In some cases, the observed data are not in full agreement with the ideas that urbanization tends to increase flood occurrence and intensity while decreasing base flow [4]. The researcher challenges of assessing the impacts of future climate change are enormous. The institutional involved in using that science for making policy are arguably even greater. The development of region has highlighted the difficulties of reconciling. The supply of climate science with the demand for research is more useful, and the policy makers used it [5].

Flood in an urban area can affect all activity in that place; in the long term, it occurs because of land cover change. This study is a modeling and investigates the effect of land use change on the urban flood in the upper Citarum Watershed using a physically based hydrological simulation model. The objective of this paper is to compare the flow changes and flood inundation area detected by a conceptual modeling approach (the residual approach) on the particular case of urbanized catchments. Urban flood modeling is the land cover change for the years 2001 and 2010 in upper Citarum watershed. Comparative analysis of this two term and conditions between 2001 and 2010 inform some conclusions about the tensions between adaptive and risk-based approaches. The role of institutional is risk in adaptation, and the importance of institutional dynamics in shaping the framing climate uncertainties and policy response to scientific knowledge.

2. Study Area and Materials

2.1. Study Area
Upper Citarum watershed flows through the South of Bandung Regency up to Saguling Reservoir. The upper Citarum watershed spread geographically at 6°43'21.8 "-7°19'38.1" South Latitude and 107°32'2 "-107°53'51.6" East Longitude. Figure 1 shows location map of upper Citarum Watershed that lies in Citarum Watershed in West Java, Indonesia.
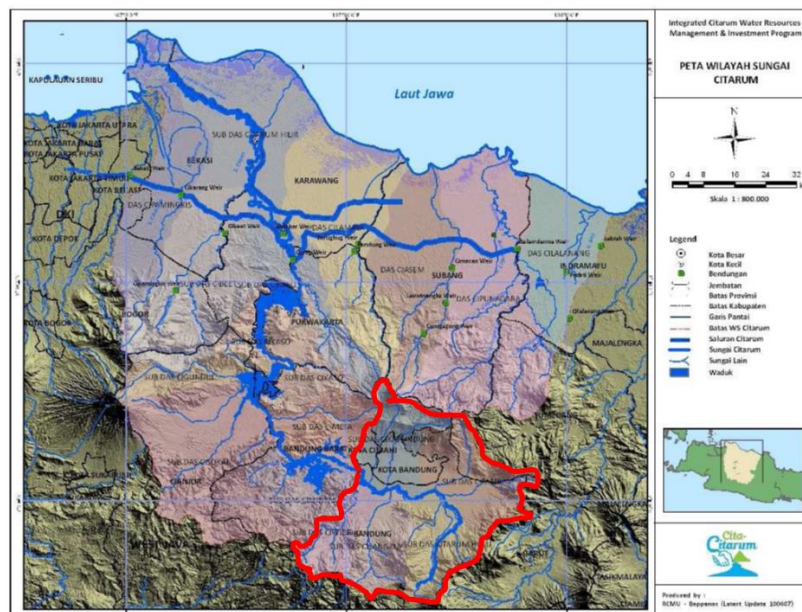

Figure 1. The location map of Citarum Watershed in West Java that shows the location of upper Citarum Watershed as a study area

The upper Citarum watershed consists of thirteen tributaries, where they form a sub-watershed. The upper Citarum watershed looks like a giant basin, better known as the Bandung Basin, with elevations ranging from 625-2.600 m under sea level. The central Citarum basin has morphology between the plains (elevations of 250-400 m under sea level), weak wavy hills (elevations of 200-800 m under sea level), steep hills (elevations 1400-2400 m under sea level), and volcanic body morphology. The flat land dominates in the upper Citarum watershed, weak and steep hilly terrain with variations in elevations of 200-1200 m under sea level. Upper Citarum River originated from Cisanti, located at the foot of Mount Wayang, about 60 kilometers south of Bandung.

Upper Citarum watershed administratively passes several cities and districts, such as Regency Bandung, Sumedang, Bandung, and Cimahi. Upper Citarum watershed defined as one area that serves to accommodate, store and drain the water upstream of Saguling Reservoir (Curug Jompong) with a total area is 1.771 square kilometers.

2.2. Data Sources
The image data products used in this study are land cover data for the years 2001and 2010. In this study, the rainfall data used is the record data from 2001 to 2010. The data of rainfall sourced from the data of Major River Basin Organization of Citarum, Ministry of Public Works. The data of debit recording in this research obtained from Research Centre and Development of Water Resources, Ministry of Public Works. The data of the discharge serves as the calibration and verification reference of the modeling created. The available record data is the measurement data of water level three times a day. Upper Citarum watershed utilizes remote sensing technology to provide information on land coverage by interpretation of objects in the image. The information obtained to show areas that have the most critical and most sensitive land capability.
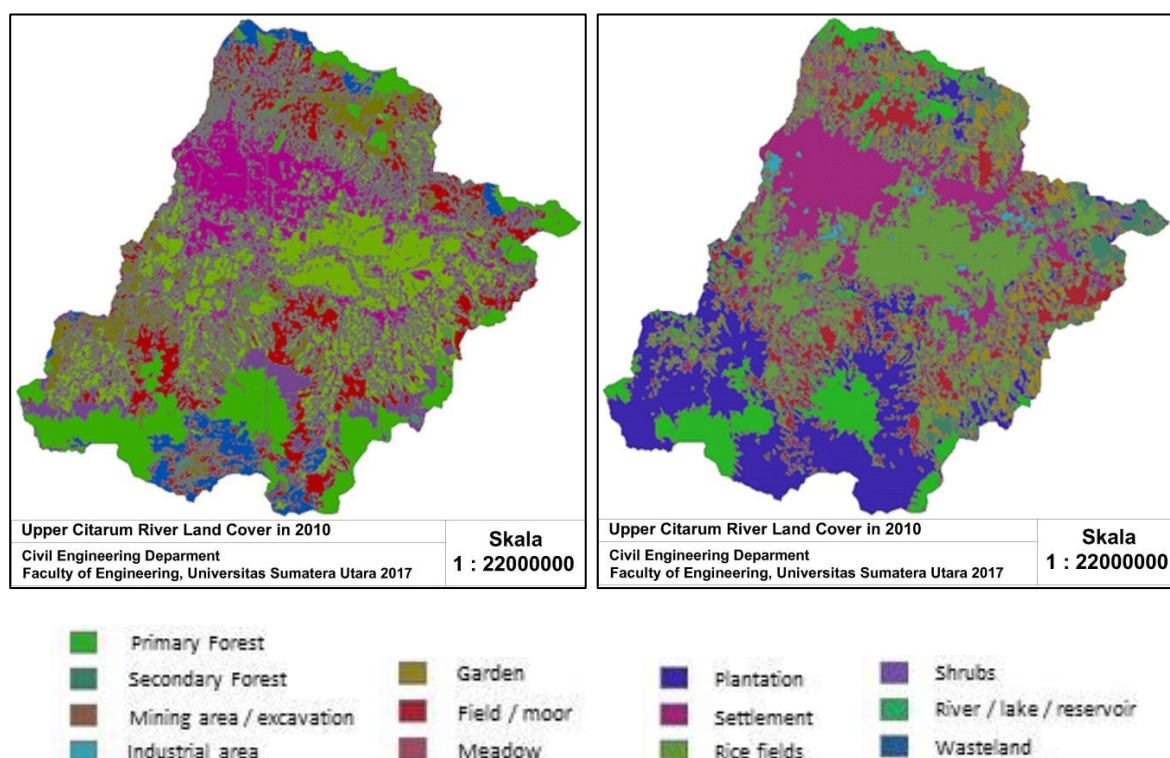

Figure 2. Major land cover in 2001 and 2010 derived from geographic information system data and remote sensing classification of Landsat images by author

Figure 2 shows about land cover in upper Citarum Watershed in years 2001 and 2010, which consists of several types of land cover. There is thirteen classifications of land cover. The land cover of upper Citarum Watershed based on data from Major River Basin Organization of Citarum.

3. Methods

3.1. Land Cover Modeling

Land cover change is dynamic process-taking place on the biophysical surfaces that have taken over a period and space is of enormous importance in natural resource studies. The land cover data derived from two maps of the upper Citarum Watershed corresponding to land cover change for the years 2001 and 2010. The land cover map about coordination of information on the environment in Indonesia describes land cover based on the visual interpretation. The Citarum River Basin Organization, Ministry of Public Works, provides Land Cover data for the area of Citarum Watershed. The nomenclature includes classes of agricultural, urban and natural areas. Land cover change then assessed based on the change in the proportion of these thirteen classes throughout 2001 and 2010 within the catchment.

The data processing of the land cover and its classification system uses the help the geographic information data. Based on the data obtained there is ten classifications of land cover that will be determined the area of each for years 2001 and 2010. Then the data will be compared the amount of change from 2001 to 2010 into the form of bar charts [6].

3.2. Flood Modeling

Forest cover changes can have a great impact on hydrological characteristics of a watershed. Flood discharge can increase as result of a change in land use. Flood peak flow may increase after trees cut down [7]. A simple modeling framework provided based on accessible input data and a freely available and widely used hydrological model (HEC-RAS) to check the possible effect of LULC changes at a particular sub-catchment on the hydrograph at the basin outlet [8].

In this flood modeling, the first analysis of rainfall design and flood discharge design with return period are 5-year, 10-year, 25-year, and 50-year. The flood discharge analysis uses a drainage coefficient based on land cover in 2001 and land cover in 2010. Based on the flood discharge, flood simulation conducted on the upper Citarum watershed for land cover conditions in years 2001 and 2010. Based on the simulation result of the flood condition will be analyzed the impact of the urban area. The problem in this case is the inundation area resulted from some flood discharge design simulations.

HEC-RAS is a widely used hydraulic software tool developed by the U.S Army Corps of Engineers, which combined with the HEC-HMS platform for hydrological simulations. HEC-RAS employs 1d flood routing in both steady and unsteady flow conditions by applying an implicit-forward finite difference scheme between sequent sections of flexible geometry. In all the above models, two boundary conditions required, which usually set at the upstream end of the channel through an imposed inflow as well as the assumption of uniform water depths at the upstream and downstream end (kinematic wave condition). Although an imposed depth would result in more stable solutions than the uniform flow, we choose the latter since, in practice, it is rare to know the temporal evolution of the water depth at a particular location. The models compute the appropriate time step based on the Courant number stability criteria [9].

This method applied the Hydrologic Engineering Center River Analysis System (HEC-RAS) model to estimate the potential catastrophes for different peak outflow scenarios with conclusions and recommendations [10]. After incorporating resampling and vertical errors, all resampled raster datasets used to create a 1D HEC-RAS model. HEC-RAS is the most commonly used flood model tool in Indonesia. The HEC-RAS parameters kept unchanged for different DEMs because the goal is to investigate the sensitivity of inundation maps to topographic errors instead of trying to create newly calibrated model for each topographic dataset [11].

3.3. Calibration and Validation Method

The method compares the observed discharge, and then analyzed the parameters that influence the modeling results. Optimum parameter values in calibration found by statistical measures. The result of comparison then determined the strength in predicting the modeling by Nash-Sutcliffe model of efficiency coefficient (E). The Nash–Sutcliffe efficiency (NI) is the two criteria most widely used for calibration and evaluation of hydrological models with observed data [12]. Nash–Sutcliffe Index can range from -∞ to 1. The value of 1 (NI=1) corresponds to a perfect match of modeled discharge to the observed data. The value of 0 (NI = 0) indicates that the model predictions are as accurate as the mean of the observed data, whereas it is less than 0; it occurs when the observed is the better predictor than the model [13]. The verification process based on the observation flow verified parameter is the runoff.

4. Results and Discussions

4.1. Land Cover Change

In this paper, the model predictions of the land-use areas are accurate and outperform the results of a simple rule based approach for land-uses. The model predicts the highest values due to the presence of the outliers. The model developed by focusing on the mean component of the land-use areas, and there is a need to handle these outliers. The graph show most different of land cover are plantation; it decreased dramatically from 2001 to 2010. It opposites with the settlement that increased nearly doubled. Based on the result of the land cover analysis, in year 2001, obtained by drainage coefficient is 0.65 and in year 2010 is 0.69.
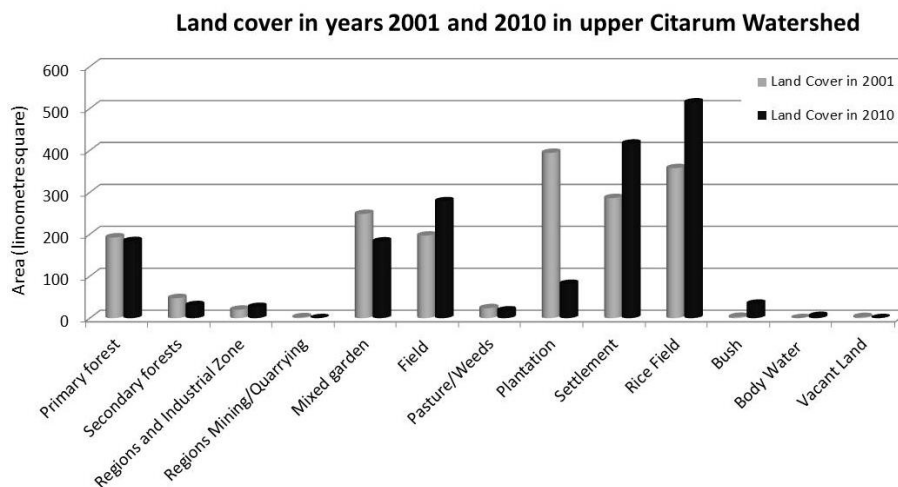

Figure 3. Major land cover in 2001 and 2010 derived from geographic information system data and remote sensing classification of Landsat images by author

Figure 3 shows the comparison between two different years; there are in years 2001 and 2010. The comparison shows not many different areas of land cover. Some classifications decreased dramatically. They are the plantation and mixed garden, but primary and secondary forest did not decrease. Settlement and rice field increased sharply, they almost twice in 2010 than in 2001.

4.2. Flood Modeling

Based on the result of the flood modeling with the help of HEC-RAS and with DEMs obtained flood inundation with Citarum upstream das. Flow coefficient based on changes in land cover in 2001 and 2010. The impacts caused by the flood, for example in 25-year return period seen in the following figure.

Based on the picture shows the review point around Dayeuh Kolot discharge station, changes in flood inundation between in years 2001 and 2010 not significantly changed. It caused by the widening of the cross section of upper Citarum River to accommodate the capacity of the 25-year, so the response from the river of the 25-year return period is not too big. The flow capacity of the river supports the change of land cover that occurs. The result of the flood inundation analysis in the urban area due to land covers change seen in this figure.
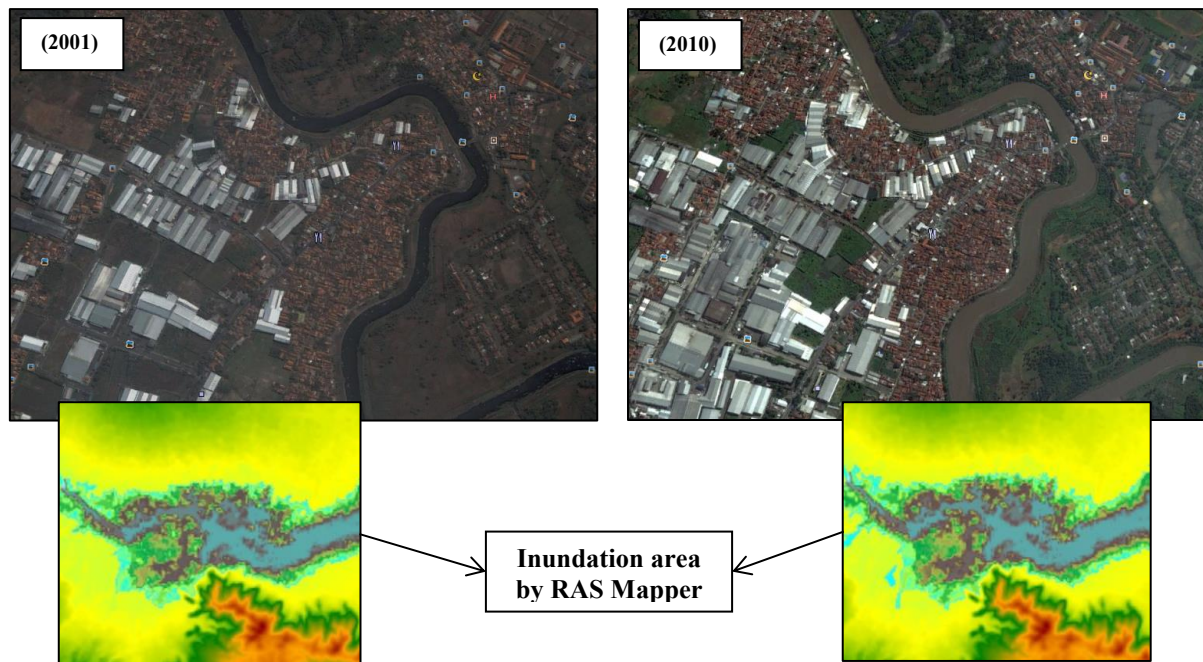

Figure 4. The result of flood inundation analysis in urban area due to land cover change in years 2001 and 2010

Figure 4 shows the comparison between the different of inundation area in years 2001 and 2010. It shows inundation that modeled by HEC-RAS use the tools of RAS Mapper. There are not much different both of them. The result of modeling inundation area that converted from RAS Mapper data. In 2001, the inundation about 105,468 hectares and it were about 92,289 hectares in 2010.

4.3. Calibration and Validation Modeling

The calibrated HEC-HMS model applied for the land cover scenarios to assess the potential land cover impacts on the Snyder and SCS synthesized hydrographs obtained based on the parameters input into the upper Citarum watershed, they analyzed for calibration and verification. The rain that occurs is the total daily rain that distributed evenly in the watershed. Calibration and verification of Citarum watershed carried out at each of the maximum floods in the study sites for three years i.e. 2007, 2008 and 2010, with calibration results as shown below.
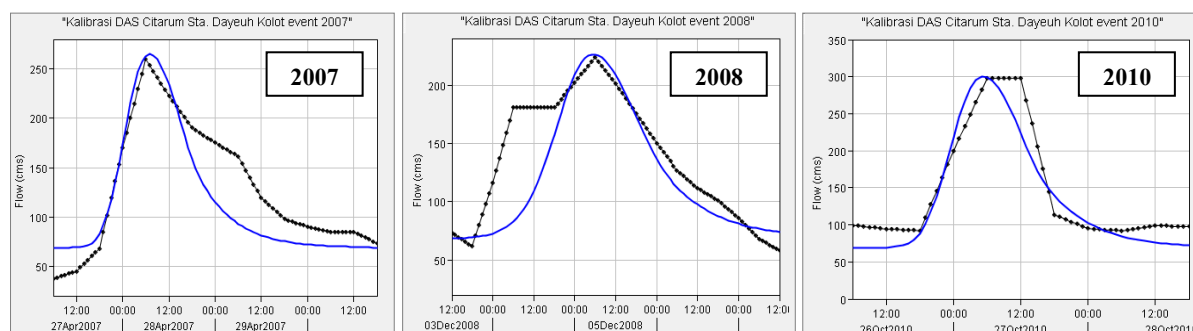
Figure 5. The results of calibration and verification of upper Citarum Watershed against observation of Dayeuh Kolot discharge station

Figure 5 shows the result of calibration and verification in upper Citarum Watershed. The flood modeling was comparable and then determined the strength in predicting the modeling by Nash-Sutcliffe model efficiency coefficient (E). Based on the calibration and verification of Nash Index method (Index E) obtained the result for the year 2007 with index 0,72; In 2008 with index 0.8; and in 2010 with index 0.71. The index values show the flood modeling when compared with the observed discharge value, is close to one, that means the modeling is acceptable.

5. Conclusions

This study and have shown that land cover change in upper Citarum watershed is not very significant. It based on the results of data processing of land cover has the difference of area that changed is not enormous. it increased dramatically to a flow coefficient for 2001 is 0.65 and in 2010 at 0.69. The impacts were not significantly different in 2001 with 2010 especially for the 25-year period based on the results of the inundation impact analysis. In 2001, the inundation about 105,468 hectares and it were about 92,289 hectares in 2010.

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