Projection of changes in land-use and impacts on the peak flow and discharge volume of the Upper Ciliwung watershed

S Robo1*, H Pawitan2, S D Tarigan3, B D Dasanto2

1Graduate School, Watershed Management Division, Bogor Agricultural University Campus IPB Darmaga, Bogor 16680, Indonesia
2Department of Geophysics and Meteorology, Faculty of Mathematics and Natural Science, Bogor Agricultural University. Kampus IPB Darmaga, Bogor 16680, Indonesia
3Department of Soil Science and Land Resources, Faculty of Agriculture, Bogor Agricultural University Kampus IPB Darmaga, Bogor 16680, Indonesia
*corresponding author: sarifrobo5@gmail.com

Abstract. The development of land-use in the upper Ciliwung watershed can be converted every year, which has an impact on surface flow, peak discharge and runoff volume. This study aims to look at projections of changes in land-use and their impact on changes in peak discharge and volume of river flows in the Ciliwung Hulu watershed. The tool used in this study consisted of a tool for analyzing land-use changes and projections, namely the CLUE-S model, while for hydrological responses using the HEC-GeoHMS tool combined with a GIS tool. The results of the analysis of land-use change found a pattern of changes in land-use in the Upper Ciliwung watershed in the period 1996-2013 there were 5 patterns of changes in land-use. Projected land-use change in 2030 with two scenarios. Scenario 2 which is able to hold the rate of change of forest to more than 30%. Scenario 1 HEC-HMS produces peak discharge 114.1 m³/second and runoff volume reaches 5.85 x 10⁶m³ while in scenario 2 with peak discharge 107.0 m³/second and runoff volume 5.70 x 10⁶m³.

Keywords: ciliwung watershed, clue-s, hec-hms, landuse, model.

1. Introduction

The increase of population, income ratio and demand for land for commercial use greatly affect changes in land-use. Changes in land-use are synonymous with an increase in population. Ciliwung Upper watershed is one of the regions included in the administrative region of Bogor Regency and Bogor City with a high population pressure because it is located in the buffer zone of the National Capital. The increasing population has an impact on changes in land-use around the upstream area so that the watershed conditions are degraded. In 2014 there was a change in land-use with good vegetation with a rate of change of 1.95% per year and an increase in residential area of 13.34% per year. Changes in land-use are associated with the dynamics of changes in land-use that occur over a period of time. Changes in land-use in the watershed area will result in increased surface flow, peak flow and discharge volume. These changes have resulted in the hydrological conditions of the Ciliwung watershed becoming increasingly degraded. Increased discharge at Katulampa outlets increased by 68% and volume by 59% from the conditions in 1981-1999 [1].

Many land-use change studies are conducted to see the impact on the hydrological aspects. To see the impact, a land-use change prediction is carried out using a model based on GIS Based Allocation to see the dynamics of changes in future land-use and then to estimate the peak discharge, flow volume and surface flow. to estimate changes in land-use and see the impact of the model is limited by the size of the watershed and the climatic and hydrological conditions in which the model
was developed. The hydrological model has now been developed spatially based and involves more parameters, so that the accuracy in modeling results is more accurate and reliable, with conditions, the method used must be in accordance with the specified standards.

Projections of land-use have been widely simulated in various urban areas but not much has been linked to predictions of the extent of surface flow resulting from changes in land-use that occur. To be able to see this, in this study simulated the projection of land-use with surface flow so that optimization in watershed planning can be done. The purpose of this study is to project changes in land-use in 2030 to see the surface flow volume, and peak discharge of the Upper Ciliwung watershed due to changes in land-use.

2. Methods

2.1. Study site

Upper Ciliwung watershed is astronomically located at coordinates 6° 36' 45" to 6° 46' 30" LS and 106° 48' 45" to 107° 00' 30" BT. Upper Ciliwung watershed covers Bogor Municipality and Bogor Regency. The total area of the Upper Ciliwung watershed is 15117 ha (the delineation of the DEM-GeoHMS DEM model is 12.5m). The tool used in this study is a computer set with ArcGIS 10.1, Dyna CLUE, CLUE-S Converter software, HEC-GeoHMS, HEC-HMS, Digital Camera, GPS and Microsoft Office. The materials used in this study include 12.5 m DEM (Digital Elevation Model), 1: 50,000 land map, 1996 and 2013 land-use maps sourced from the Ministry of Forestry's Planology Agency [2], rainfall data and 1996-2013 discharge. The linkages between research objectives, data, analytical methods, and expected results are presented in Table 1.

![Figure 1. Location of the study area.](image)

2.2. Landuse change using CLUE-S Model

Analysis of changes in land-use and land-use dynamics simulations, data needed includes distribution of land-use at some time. Comparison between the two land-use data will be used to observe changes in each pixel / grid [3]. Cross tabulation was carried out on the land-use series in 1996 and 2013 land-use maps sourced from the Ministry of Forestry's Planology Agency [2], rainfall data and 1996-2013 discharge. The linkages between research objectives, data, analytical methods, and expected results are presented in Table 1.

The CLUE-S model is used in order to project changes in spatial allocation of land-use to determine the extent of the impacts arising from the scenarios applied in the simulation. This model is built on the framework of thinking that there is a relationship between the emergence of certain land-uses and driving factors in terms of socio-economic aspects as well as biophysical factors in the region.
Figure 2. Flow chart of prediction land-use change using CLUE-S

| Table 1. Relationship matrix between objectives, types of data, and results |
|-------------------------------------------------|-------------------------------|-------------------------------------------------|
| **Aim**                                         | **Data analysis method**       | **Result**                                      |
| a Analysis of the driving factors of socio-economic, biophysical and the accessibility of the area that affect land-use change | Statistical regression analysis, combine raster, rasterization, raster to ASCII | Factors that affect the chances of the opportunity of landuse |
| b Prediction of land-use change                  | - Comprehensive tabulation changes per year, rasterization, raster to ASCII | - Land-use In 2030 Scenario 1                     |
| c Develop meteorological model parameters       | - Model HEC-GeoHMS             | Data rainfall each period of the year            |
| d Preparation of the model basin                | Terrain analysis               | Model Basin                                      |
| e Determining the value of KHT and curve number  | SCS method - Curve Number with HEC-GeoHMS | Value curve number                               |
| f Rain-flow simulation                           | Hydrologic modeling with HEC-HMS models | Rain-discharge hydrograph model simulation results |
| g Analysis of peak discharge and runoff volume   | The combination of hydrological modeling to forecast the results of landuse | The volume of runoff and peak discharge          |

2.3. **HEC-HMS hydrological model**

The Basin model in this study used DEM data with a spatial resolution of 12.5 x 12.5. The compilation of the basin model uses four main methods, namely the loss, transform, baseflow and routing methods. The basin model preparation process is divided into several main processes, namely: (a) watershed boundary delineation and watershed components (b) preparation of method loss parameters (c) preparation of transform method parameters (d) preparation of baseflow (d) method compilation
parameters routing method parameters. Meteorological models are related to the precipitation method used in model simulations. In this study the precipitation method used was the specified heterograph method by determining the climatology station used on each sub-section. Model simulation begins with the preparation of control specifications and time-series data.

The specification control is an arrangement of the implementation period of the model simulation which includes date information and time intervals (hours) used in the simulation model. The time and time intervals used in this model simulation are adjusted to the rainfall events selected as input data in the meteorological model. Time-series data aims to enter the input of rainfall and discharge data manually for the manufacture of flow hydrograph in the HEC-HMS model. The hydrological model HEC-HMS simulation is run on HEC-HMS version 4.1. Hydrological simulations in this study were carried out based on the HEC-HMS components that have been compiled, namely: basin model, meteorological model, specification control and time-series. Model simulation is carried out to obtain daily debits of the Upper Ciliwung watershed for a certain year period.

The model calibration aims to obtain optimum values on rain-flow parameters using the HEC-HMS model so that the output in the form of a hydrograph from the model count approaches the measured daily hydrograph for one year. The calibration process is needed to determine the value of each watershed parameter used as the basis for conducting rain-discharge simulations. In this study, the validation of the results of model simulations was carried out based on the efficiency coefficient index of Nash and Sutcliffe tests. Efficiency coefficient emphasizes the ratio between the amount of surface flow volume based on the results of direct measurements and the volume of surface flow from the model simulation [4].

3. Result and discussion

3.1. Dynamics of land-use change

The area of primary forest from 1996 to 2013 has a relatively fixed area of 461 ha or around 3.1%. Secondary forests in 1996 to 2013 have a relatively similar area of 1558 ha or around 10.3% [5]. Plantations in 1996 were 3597 ha or around 23.8%, and continued to increase until 2013 amounting to 5678 ha or 37.6% of the total watershed area. The shrubs in 1996 had an area of 854 ha or around 5.6% and decreased in 2013 to 623 ha or around 4.1% of the total watershed area. The plantations found in the Upper Ciliwung watershed experience relatively small changes.

| Landuse          | 1996 | %   | 2013 | %   |
|------------------|------|-----|------|-----|
| Primary Forest   | 461  | 3.1 | 461  | 3.1 |
| Secondary Forest | 1558 | 10.3| 1558 | 10.3|
| Planted Forest   | 3597 | 23.8| 5678 | 37.6|
| Open Land        | 20   | 0.1 | 20   | 0.1 |
| Settlement       | 1299 | 8.6 | 2229 | 14.7|
| Planted          | 1014 | 6.7 | 1007 | 6.7 |
| Dryland Agriculture | 5867 | 38.8| 3211 | 21.2|
| Paddy Field      | 447  | 3.0 | 330  | 2.2 |
| Shrub            | 854  | 5.6 | 623  | 4.1 |
| Total            | 15117| 100.0| 15117| 100.0|

The area of plantations in 1996 had an area of 1015 ha or around 6.7% and experienced a widespread decline in 2013 to 1006 ha, or around 6.6% of the total watershed area. Settlements in 1996 had an area of 1299 ha or around 8.6% and in 2013 the area of settlements increased very rapidly to amount to 2229 ha or around 14.7% of the total area of the Upper Ciliwung watershed. The increase in population continues to occur, especially those domiciled in the Upper Ciliwung watershed, where the Upper Ciliwung watershed is included in the administration of Bogor Regency and Bogor City so
that many settlements are built in this area. This increase in population needs to be controlled so that the use of productive land for agriculture does not change into residential land.

The extent of land-use change and the land-use change matrix in 1996 and 2013 are presented in Table 2 and Table 3. Table 2 describes changes in land-use for the period 1996–2013. Table 3 illustrates changes in land-use in 2006–2013.

| Land Cover 1996 | Land Cover 2013 | Total |
|----------------|----------------|-------|
|                | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   |       |
| 1. Primary Forest | 461 | -   | -   | -   | -   | -   | -   | -   | -   | 461   |
| 2. Secondary Forest | -   | 1558| -   | -   | -   | -   | -   | -   | -   | 1558  |
| 3. Planted Forest  | -   | -   | 3597| -   | -   | -   | -   | -   | -   | 3597  |
| 4. Open Land       | -   | -   | -   | 20  | -   | -   | -   | -   | -   | 20    |
| 5. Settlement      | -   | -   | -   | 3   | 1296| -   | -   | -   | -   | 1299  |
| 6. Planted         | -   | -   | -   | -   | 9   | 1006| -   | -   | -   | 1015  |
| 7. Dryland Agriculture | -   | -   | 1901| -   | 754 | -   | 3211| -   | -   | 5867  |
| 8. Paddy Field     | -   | -   | -   | 117 | -   | -   | 330 | -   | -   | 447   |
| 9. Shrubs          | -   | -   | 177 | -   | 53  | -   | -   | -   | 623 | 854   |
| Total              | 461 | 1558| 5678| 20  | 2229| 1006| 3211| 330 | 623 | 15117 |

Open land, in 1996 had an area of 20 ha or around 0.1% and in 2013 the area was still relatively the same. Dryland agriculture in 1996 dry land agriculture had an area of 5867 ha or around 38.8%, and in 2013 it continued to decline to 3211 ha or around 21.2% of the total Upper Ciliwung watershed area. The decrease in the area of dryland agriculture needs special attention because dryland agriculture is generally a transitional land before an agricultural land becomes non-agricultural land [6]. Paddy Fields in 1996 had an area of 447 ha or around 3.0% and in 2013 it continued to decline to 330 ha or around 2.2% of the total Upper Ciliwung watershed area.

![Figure 3. Map of land cover 1996 and 2013 the Upper Ciliwung watershed](image1)

### 3.1.1. Spatial model of landuse change with CLUE-S

Model simulations carried out using CLUE-S in the Upper Ciliwung watershed uses a raster size (30 x 30) m. The results of vector to raster transformation are obtained by the number of rasters consisting of 617 rows, and 513 columns. The area for each cell is 900 m2 or 0.09 hectares. Simulation using CLUE-S requires data on land-use requirements or changes in land-use per year. Data on land-use requirements based on the rate of change in land-use for the period 1996-2013 are presented in Table 26. Data on land-use needs are stored in a file with the name demand.in.0 used during simulation.

The CLUE-S spatial model was built by combining 4 variables as a condition in analyzing land-use change, namely land-use requirements (demand), land-use opportunity values to change...
(elasticity), location characteristics, and spatial policy [7]. Model simulations carried out using CLUE-S in the Upper Ciliwung watershed uses a raster size (30 x 30) m. The results of vector to raster transformation are obtained by the number of rasters consisting of 617 rows, and 513 columns. The area for each cell is 900 m2 or 0.09 ha. Simulation using CLUE-S requires data on land-use requirements or changes in land-use per year. Data on land-use needs based on the rate of change in land-use for the period 1996-2013 are presented in Table 5. Data on land-use requirements are stored in a file with the name demand.in.0 used during simulation. Data on land-use requirements in 1996 and 2013 were obtained from the area of each type of land-use in each year. Conversion arrangements for land-use are divided into two types, namely: conversion elasticity and conversion matrix. The elasticity value is adjusted to the condition of the Upper Ciliwung watershed research area.

Data on land-use requirements in 1996 and 2013 were obtained from the area of each type of land-use in each year. Conversion arrangements for land-use are divided into two types, namely: conversion elasticity and conversion matrix. The elasticity value is adjusted to the condition of the Upper Ciliwung watershed research area. The elasticity value is the result of a successful try and error simulation model and the highest accuracy rate of comparison between the predicted 2013 land-use and actual land-use in 2013. The elasticity value of 1.0 is in residential land-use, primary forest and plantations, meaning that these three types of land-use are difficult to be replaced by other land-uses. Furthermore, the use of plantation land has an elasticity value of 0.7. The smallest elasticity value, which is 0.4, is in dryland agricultural land-use, and Paddy Fields means that land-use is easily replaced by other land-uses.

| Landuse                  | Elasticity Value |
|--------------------------|------------------|
| Primary Forest           | 1                |
| Secondary Forest         | 0.7              |
| Planted Forest           | 0.8              |
| Shrub                   | 0.4              |
| Planted                 | 1                |
| Settlement              | 1                |
| Open Land               | 0.5              |
| Dryland Agriculture      | 0.4              |
| Paddy Field             | 0.4              |

Conversion elasticity (main.1) as presented in Table 4 is based on a subjective assessment of the ease of use of a land to experience conversion and changes back to its original nature. Conversion elasticity illustrates the competitive strength of each land-use to be formed in a space [8]. Certain types of land-use will be easily converted if there are other land-uses that are more in line with the characteristics of the location. Primary forests and plantations are types of land that are difficult to convert. The value of elasticity is in the range of 0 and 1. Approaching 1 means that the type of land-use is not easily changed while the value of elasticity 0 indicates that the land-use is easily converted. The elasticity values of each type of land-use are presented in Table 4. The conversion matrix is obtained from the land-use change matrix in 1996 - 2013. The conversion matrix for each type of land-use is presented in Table 5.

Elasticity value 1 is given to the type of land-use of primary forest, settlements, and plantations due to their nature which is difficult to change and irreversible. The use of plantation forest with an elasticity value of 0.8 is based on the consideration of the existing condition of Paddy Fields in the Upper Ciliwung watershed which is relatively difficult to convert and tends to increase in the period of change from 1996 to 2013. Secondary forests with an elasticity value of 0.7 indicate relatively difficult conditions to change associated with more costs issued to convert forests, but changes to other forms are permitted as in the conversion matrix. Dryland agriculture experiences a more diverse transition of change into other forms of use so the elasticity value is given at 0.4. Value of elasticity is considered to be 0.4, this is related to the nature of shrubs which are relatively easy to convert. Converted Paddy

Table 4, Value of elasticity of each type of land-use (main.in1)
Field is almost half the initial use area in the period 1996-2013 so that its elasticity is valued at 0.4. Open land has the lowest elasticity value related to its dynamic nature and has the opportunity to appear in various locations. The parameters of the suitability of the location / characteristics of the location (alloc.reg) are the constant values and beta coefficients (β) of the results of binary logistic regression for each type of land-use against the influence of various driving factors. Opportunities for the emergence of a land-use are determined based on the quantification of the relationship with the driving factors.

Setting the conversion matrix parameters (allow.txt) as shown in Table 5 is based on the transition of land-use type changes in the period 1996-2013. The conversion matrix describes a series of changes in each land-use class.

| Landuse          | PF | SF | PL | OL | STT | DR | RF | Shr |
|------------------|----|----|----|----|-----|----|----|-----|
| Primary Forest   | 1  | 0  | 0  | 0  | 0   | 0  | 0  | 0   |
| Secondary Forest | 0  | 1  | 1  | 0  | 0   | 0  | 0  | 0   |
| Planted Forest   | 0  | 0  | 0  | 0  | 0   | 0  | 0  | 0   |
| Open Land        | 0  | 0  | 0  | 1  | 1   | 0  | 0  | 0   |
| Settlement       | 0  | 0  | 0  | 0  | 1   | 0  | 0  | 0   |
| Planted          | 0  | 0  | 0  | 0  | 1   | 0  | 0  | 0   |
| Dryland Agriculture | 0  | 0  | 0  | 0  | 0   | 1  | 0  | 0   |
| Paddy Field      | 0  | 0  | 0  | 0  | 1   | 0  | 0  | 1   |
| Shrubs           | 0  | 0  | 0  | 0  | 0   | 1  | 0  | 1   |

Information:
PF (Primary Forest), SF (Secondary Forest), PL (Planted Forest), STT (Settlement), OL (Open Land), DR (Dryland Agriculture), RF (Paddy Field), Shr (Shrubs)

CLUE-S model confirms one type of land-use may change to another type of use if given a value of 1 and conversely the type of land-use cannot change to another land-use if given a value of 0. The use of primary forest land will not change. Secondary forests will only turn into plantations. Plantation will not change. Open land will turn into a settlement. Settlements will not change. Plantations will change into settlements and plantations. Dryland agriculture will change into settlements and plantations. The Paddy Fields will turn into settlements. Shrubs will change into settlements and plantations.

The allocation of land-use per cell is the opportunity value of changes in land-use in each cell based on the factors that influence the existence of each land-use. The value is obtained from the results of binary logistic regression for each type of land-use. The logistic regression coefficient values are stored in alloc0.reg. This value will be competitive in determining whether the existence of the land-use remains, or changes to other land-uses. The binary regression results are presented in Table 6.

3.1.2. Driving factors that affect changes in landuse
Changes in land-use and land cover are the result of various interaction processes. Each process goes through a range of scales in space and time. This process is triggered by one or more factors that are influenced by the involvement of agent actions in land-use change and land cover. Driving factors include demographics (population pressure), economic actors, technology actors, institutional actors, cultural actors and biophysical actors. All of these actors influence changes in land-use in different ways.

In this regression process, the driving factor acts as an independent variable while land-use is the dependent variable. The relationship of the driving factors with the opportunities for the emergence of certain types of land-use illustrates the suitability of the land-use location. Analysis is carried out on the driving factors that influence changes or opportunities for the emergence of certain types of land-use. The relationship of the driving factors with the opportunity for emergence of land-use illustrates the suitability of land-use locations.
In Table 6 above, it can be seen that primary forest based on logistic regression results is influenced by five driving factors, namely elevation, distance from the main road, and distance from the center of the sub-district, rainfall and distance from the river. The highest coefficient value, namely rainfall of 8.57 positive values of rainfall, shows the influence that the existence of primary forests will continue to exist or continue to grow, if rainfall is high. The lowest value or the smallest influence is at the distance from the river, which is 0.29, indicating that the influence of the river will be very small on the existence of the primary forest itself.

Secondary forests are influenced by six driving factors, namely population density, distance from the main road, distance from the center of the sub-district, rainfall, and elevation. The highest coefficient value is population density which is -13.92. The minus value on the drivers of population density shows the effect with inverse suitability. Increasing population population will make a land easily convertible, because the need for land is increasing. The population will greatly influence changes in secondary forest land-use, because land needs for housing and agriculture will increase.

Plantations are influenced by seven driving factors, namely population density, distance from the main road, distance from the river, slope, distance from the center of the sub-district, rainfall and elevation. Seven of these driving factors, population density also still has a big contribution in influencing conversion or the existence of this plantation land-use. The lowest coefficient is at a distance from the main road.

Open land is influenced by five driving factors, namely, population density, distance from the river, distance from the center of the sub-district, rainfall and elevation. The five driving factors of population density have a considerable contribution in influencing changes in land-use, the coefficient of population density is -15.56 indicating that suitability is reversed, where the greater the chance for loss of open land.

Settlements are influenced by four driving factors, namely, distance from the main road, slope, distance from the sub-district center, and rainfall. The highest coefficient value for the factors that influence the chances of the emergence of residential land-use is the distance from the main road which is equal to 0.56. The positive coefficient value indicates that residential land-use is affected by the distance from the main road that is getting higher. Plantation, influenced by distance from the main road, distance from the river, and slope. The distance factor from the river has the highest coefficient value that is equal to 4.29. Positive values of the coefficients at the distance of the river indicate that the closer the distance from the river, the more likely the plantations are to convert or increase in number.

Dryland agriculture, is influenced by the distance from the river, distance from the center of the sub-district, rainfall and elevation. The biggest coefficient of the factors that influence dryland

| Driving Factor          | PF (Primary Forest) | SF (Secondary Forest) | PF (Primary Forest) | OL (Open Land) | STT (Settlement) | PL (Planted Forest) | DrA (Dryland Agriculture) | RF (Paddy Field) | Shr (Shrubs) |
|-------------------------|---------------------|-----------------------|---------------------|----------------|-----------------|---------------------|--------------------------|------------------|--------------|
| Pop_Den                 | -13.92              | -2.65                 | -15.56              |                |                 |                     |                          | 0.42             | -17.44       |
| Dis_Road                | 0.46                | 0.76                  | -0.09               | 0.56           | -2.88           | -1.13               | -0.64                    | 0.32             | 0.34         |
| Dis_Riv                 | 0.29                | -0.16                 | 0.78                | 4.29           | -0.63           | 0.32                | 0.34                     | 0.46             | 0.76         |
| Slope                   | 0.56                | 1.09                  | -0.14               | -1.08          | -0.09           | -0.50               |                          | 0.71             | -0.71        |
| Dis_Dist                | 1.02                | 0.58                  | 0.79                | -0.26          | 0.71            | 0.34                |                          | 0.34             | 0.34         |
| Rainfall                | 8.57                | 0.18                  | 0.25                | 0.81           | -0.24           | -2.26               | -2.19                    |                  |              |
| Elevation               | 2.38                | 0.81                  | 0.47                | -2.39          | -2.07           |                      |                          |                  |              |
| Konstanta               | -76.92              | -10.34                | -5.42               | -13.14         | -22.00          | -14.45              | 6.99                     | -19.69           |              |
| **ROC**                 | **0.994**           | **0.955**             | **0.814**           | **0.932**      | **0.838**       | **0.995**           | **0.998**                | **0.959**        | **0.913**    |

Information:
Pop_Den (Population Density), Dis_Road(Road Distance), Dis_Riv(River Distance), Dis_Dist (District Distance), Rainfall, Elevation – PF (Primary Forest), SF (Secondary Forest), PL (Planted Forest), STT (Settlement), PL (Planted), OL (Open Land), DrA (Dryland Agriculture), RF (Paddy Field), Shr (Shrubs)
agriculture is rainfall, which is -2.26. The negative value of this coefficient indicates that the smaller the rainfall, the more likely it is that dryland agriculture will be converted into other land.

Paddy Fields, influenced by population density, distance from the main road, distance from the river, slope, distance from the center of the district, and rainfall. The highest coefficient on the influencing factor is rainfall with the coefficient value is -2.19. the negative value of this coefficient indicates that the smaller the rainfall, the greater the chance for the fields to be converted to other land.

Thicket, influenced by five driving factors, namely population density, distance from the river, distance from the center of the sub-district, rainfall and elevation. The driving factor that has the greatest coefficient value is population density with a coefficient value of -15.56, this indicates that the suitability is reversed or it can be ascertained that the thicket will experience a reduction.

The results of the logistic regression analysis were tested for accuracy using the ROC (relative operating characteristic) method. This accuracy value is usually located in the ROC between 0.5 to 1.0. A value of 1.0 indicates that the exact calculation results are perfect, while the value of 0.5 indicates that the results are due to random effects only [9]. The average ROC value produced ranges from 0.814 - 0.998, this indicates that the results of the logistic regression test have a high accuracy value.

3.2. Land-use prediction simulation results in 2030

Simulation of land-use changes in the Year 2030 projection is carried out in two scenario conditions, namely growth slowdown (Scenario 1) and limited area policy and rehabilitation of forest land, paddy fields and open land (Scenario 2). Comparison of the area of land-use change predicted by 2030 is presented in table 7.

![Figure 4. Map of the results of the CLUE-S scenario 1 and scenario 2](image)

| Landuse             | Existing 2013 | 2030 Scenario 1 | 2030 Scenario 2 |
|---------------------|---------------|-----------------|-----------------|
|                     | Hectare       | %               | Hectare         | %               | Hectare         | %               |
| Primary Forest      | 461           | 3.0             | 461             | 3.0             | 461             | 3.05            |
| Secondary Forest    | 1558          | 10.3            | 1184            | 7.8             | 1558            | 10.31           |
| Planted Forest      | 5678          | 37.6            | 6987            | 46.2            | 5678            | 37.56           |
| Open Land           | 20            | 0.1             | 20              | 0.1             | 20              | 0.13            |
| Settlement          | 2230          | 14.8            | 2944            | 19.5            | 3548            | 23.47           |
| Planted             | 1006          | 6.7             | 989             | 6.5             | 1627            | 10.76           |
| Dryland Agriculture | 3211          | 21.2            | 1834            | 12.1            | 840             | 5.55            |
| Paddy Field         | 330           | 2.2             | 194             | 1.3             | 330             | 2.18            |
| Shrub               | 623           | 4.1             | 504             | 3.3             | 1057            | 6.99            |
| **Total**           | **15117**     | **100**         | **15117**       | **100**         | **15117**       | **100**         |
Table 8. Comparison of the area of land-use change in 2030

| Landuse          | Scenario 1 Hectare | (%) | Scenario 2 Hectare | (%) |
|------------------|--------------------|-----|--------------------|-----|
| Primary Forest   | 461                | 3.0 | 461                | 3.0 |
| Secondary Forest | 1184               | 7.8 | 1558               | 10.3|
| Planted Forest   | 6987               | 46.2| 5678               | 37.6|
| Open Land        | 20                 | 0.1 | 544                | 3.6 |
| Settlement       | 2944               | 19.5| 3417               | 22.6|
| Planted          | 989                | 6.5 | 1496               | 9.9 |
| Dryland Agriculture | 1834            | 12.1| 709                | 4.7 |
| Paddy Field      | 194                | 1.3 | 330                | 2.2 |
| Shrubs           | 504                | 3.3 | 926                | 6.1 |
| **Total**        | **15117**          | **100** | **15117**          | **100** |

Scenario 1 is the policy of changing land-use at half the rate of scenario 0. In this scenario primary land is still 461 ha, secondary forest has an area of 1184 ha, plantations have increased by 6988 ha, open land remains at 20 ha, the settlements were suppressed so that they did not experience a significant increase of 2944 ha, the plantations experienced a significant decrease as well namely 989 ha, the dryland agriculture was reduced to 1834 ha, the paddy fields were reduced to 194 ha, and shrubs reduced to 504 ha from the total area Existing watershed. Land-use scenario 2 is a policy of limiting the conversion of forest land and Paddy Fields. In this scenario forest land consists of three forest lands, namely primary, secondary and plantation forests. Primary forest land remains in its area of 461 ha, secondary forest 1558 ha, plantation forest 5678 ha, while open land is still the same namely 20 ha, settlements have increased dramatically which is 3548 ha, plantations have increased broadly 1627 ha, dryland agriculture has experienced a drastic decline of 840 ha, for Paddy Fields due to policy restrictions, the area of permanent Paddy Fields, namely 330 ha, and shrubs increased broadly, namely 1057 ha from the total area of the existing watershed.

3.3. Build basin model

Building a basin model is an important step in analyzing the hydrological system with HEC-HMS. The threshold value used will determine the formation of the main river and tributary networks. The river network formed will determine the number of sub-basins formed in the watershed [10]. Delineation of the Upper Ciliwung Watershed subbasin model is presented in Figure 5.
The number of Subbasin formed can affect the output of the model [11]. In this research scale the threshold used is 200 km² / or 20000 hectare. Subbasin formed is Subbasin W130 (Ciseuseupan), Subbasin W140 (Cisek), Subbasin W170 (Cibalok), Subbasin W190 (Cilisung Hulu), Subbasin W200 (Cisarua), Subbasin W210 (Cisukabirus), Subbasin W240 (Cisuren). The point of the discharge observation outlet is located on Subbasin W130.

3.4. Calibration and Validation of the HEC-HMS Model

Model calibration is done to get the model results that are close to the conditions in the field or the results of observations by adjusting parameter parameters in the model. The method used for calibration is a combination of trial and error methods to determine optimal combination details. The hydrograph from the comparison of calibration discharge simulation and validation of the HEC-HMS model is presented in Figure 6.

![Figure 6 Hydrograph comparison of discharge data from model and discharge simulation results observation of calibration results (a) and validation results (b).](image)

This is because the usage process is quite simple, fast and requires little experience for modelers [12]. The optimum value is then entered into the input value of the simulation parameters for further simulation until a good model statistic is obtained by looking at the NSE (Nash-Sutcliffe Efficiency) value, Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). The model calibration results in the form of peak discharge and runoff volume are good enough if the NSE is high while the RMSE and MAE values are low. Statistical tests for calibration and validation of the HEC-HMS model are presented in table 9.

| Year  | Validation | NSE   | Statistics MAE (m³/det) | RMSE (m³/det) | Peak Flow (m³/det) | Volume Discharge (x10⁶ m³) | Time of Peak          |
|-------|------------|-------|-------------------------|---------------|--------------------|-----------------------------|-----------------------|
| 1996  | Observed   | 0.700 | 6.3                     | 8.7           | 108.5              | 4.79                        | 27Jan1996, 00:00     |
|       | Simulation | 0.621 | 7.5                     | 9.8           | 115.3              | 6.69                        | 20Jan2013,00:00      |

Table 9 Statistics of HEC-HMS model validation and calibration tests
Determination of the appropriate calibration value for the Upper Ciliwung watershed can be done by looking at the parameters that are sensitive to flow discharge in the Upper Ciliwung watershed. These parameters can include curve number, initial baseflow, recession constant, and ratio to peak.

After calibration, the HEC-HMS model shows an NSE value of 0.700, MAE of 6.3 (m³/sec) RMSE 8.7 (m³/sec) of 105.4 (m³/sec) and volume of 3.73 x 10⁶ m³, peak discharge or highest discharge occurs at January 26, 1996 at 00:00. Calibration results show that there is a 1 day slowdown in the increase in peak discharge, and a decrease in high peak discharge becomes lower. Model validation is done to see the consistency of the simulation model if the input data in this case the rainfall changes with the value of each model parameter the calibration results do not change. Model validation aims to test the consistency of the results of a process in accordance with the specifications specified. In general, validation is done using data after a period of data that has been used for calibration (Indarto 2010) [12].

The calibration and validation values of the HEC-HMS model indicate an NSE of 0.700, for calibration while the validation shows an NSE value of 0.621. NSE from the calibration and validation results show that the HEC-HMS model has a high level of accuracy. This shows that the HEC-HMS model is very good for simulating the hydrological response of the Upper Ciliwung watershed. [4] stated that the NSE value is the accuracy of the model, where the NSE value <0.5 is a low level of accuracy, 0.5 <NSE <0.7 is a high level of accuracy and NSE> 0.88 is very high accuracy.

3.5. Simulation of Changes in Land-use Against Hydrological Response in 2030

The simulation results of the HEC-HMS model in two scenarios, with land-use in 2030 as a result of the CLUE-S model simulation, show that peak discharge occurs between January 18-19. From the two scenarios built, scenario 1 has the highest peak discharge compared to scenario 2. The highest water volume is in scenario 1 while the smallest discharge is in scenario 2, as well as the peak time in the scenario faster than scenario 1 compared to scenario 2.

The results of the research [13] showed that an increase in forest area was able to reduce runoff volume by 18% in the Hei River watershed. According to [14] states that the physical factors that influence the hydrograph include the area and shape of the watershed, the density of river networks, slope, land factors and land-use.

Land-use conditions scenarios from all scenarios show that scenario 2 on land-use is the best scenario with the lowest peak discharge and not too large flow volumes, this is due to land-use resulting from the 2030 scenario in the CLUE-S model that limits forest land, Paddy Fields and open land were not converted so the hydrological response for this scenario looked good. The results of applying the simulation of the hydrological response scenario are presented in Table 10.

| Simulation       | Peak Flow (m³/sec) | Volume Discharge (10⁶ m³) | Time of Peak       |
|------------------|--------------------|---------------------------|--------------------|
| Actual Conditions| 111.3              | 5.80                      | 19Jan2013,00:00    |
| Scenario 1       | 114.1              | 5.85                      | 19Jan2030, 00:00   |
| Scenario 2       | 107.0              | 5.70                      | 19Jan2030, 00:00   |

4. Conclusion

(1) predicted results of land-use in 2030 from two residential scenarios grow rapidly while those that are able to survive are only primary forests because there are restrictions area. (2) the volume of surface flow in the CLUE-S scenario shows that scenario 1 has a flow volume of 5.85 x 10⁶ m³ with peak discharge of 114.1 m³/sec while in scenario 2 has a flow volume of 5.70 x 10⁶ m³ with a peak discharge of 107 m³/sec. The application of 2 land-use simulations in 2030 for the response of flow
volume and peak discharge, scenario 2 (limitation of conversion of forest land, paddy fields and open land) is the best simulation because the peak discharge time is slower and the peak discharge is not too high compared to scenario 1.

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