# Suroso_2021_Impact of land use changes on the water

*by* Suroso Suroso

# Impact of land use changes on the water availability in Ciwulan watershed, West Java

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**Abstract.** The purpose of this study was to see the impact of land use changes in the Ciwulan watershed on river water populations, especially during the dry season for drying. The physical hydrological model was based on Shetran's physical use by utilizing hydro-climatological data obtained from remote sensing observations from 2001 to 2017. The input data are data on changes in land use and cover, digital elevation models, rainfall data and evaporation as well as land data via HWSD. The most significant land use change occurred in the agricultural land category with an annual increase of 7% from an area of 12 $km^2$ in 2001 to 40.5 $km^2$ in 2017. Land changes with a decreasing trend in area was forest areas with 1% decrease annually, from the initial area of 2001 of 462.5 $km^2$ to 403 $km^2$ in 2017. The smallest change occurs in urban land which tends to be stable in the range of 24 $km^2$. The decline in the water catchment area has an impact on decreasing water availability in the Ciwulan river, especially during the dry season. River discharge during the dry season tends to decrease from over years.

## 1. Introduction

Land use usually includes all types of features and has been linked to human activities in utilizing land, while land cover includes all types of features on the earth's surface that exist in certain land [1]. One of them is the degradation of green forest land into shrubs or agricultural land that occurs in the Ciwulan watershed. In addition, almost all human activities are related to land use. Referring to Regulation Number 41 Article 18 paragraph (2) of 1999 concerning Forestry, the forest area that must be maintained is at least 30% of the area of river basins and islands with a proportional distribution [2]. According to the West Java Provincial Forestry Service, the area of West Java Province is 3,709,528,44 hectares while the forest area in West Java based on the Decree of the Minister of Forestry Number 195/Kpts-II/2003 is 816,603 hectares or 22.01% of the total area of the Province West Java [3]. This uncontrolled land use change can cause rainwater that should seep into the ground to overflow as surface runoff and flow into rivers because the land surface has turned into a plantation, industrial and residential area [4].

One of the disasters that often occurs due to improper land use change is drought. Drought is a natural disaster event caused by a deficit of rainfall in a certain period of time which causes the absence or insufficient water for human and environmental activities [5]. Drought disasters can be a serious problem, causing complex and wide-ranging effects long after the end of the dry season. Based on data on drought

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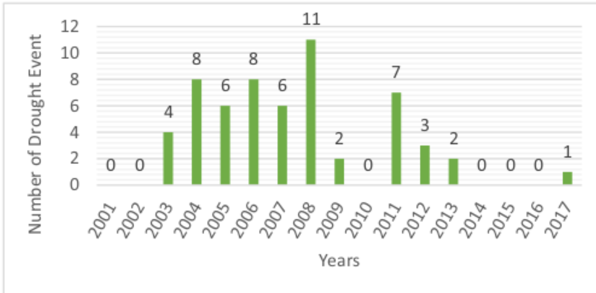
disasters in West Java, in the Ciwulan watershed area, drought occurs almost every year for more than one month, can be seen in the following Figure 1.




(Source: Indonesian Disaster Information Data)
**Figure 1.** Drought case data in Ciwulan Watershed

Some of the effects of drought includes lack of clean water sources. Decreasing clean water sources will have an impact on public health because it reduces clean water for drinking water and interferes with daily activities. Then many plants die because during the dry season a lot of fertile lands are damaged and the plants do not have water source. Also, air pollution will increase due to the reduction in plants which process carbon dioxide gas into oxygen for human life during the dry season.

Based on several explanations regarding the impact of drought, there will be a domino effect that occurs when a drought occurs. Because the reduced availability of clean water will have an impact on people's daily activities, lack of water will also cause many rice fields to die and cannot be planted which will lead to new disasters, one of which is starvation. From an economic point of view, the prices of various necessities will also soar because the supply of goods is running low due to a large amount of land that cannot be planted. Because water is a basic and vital need for all living things that cannot be replaced with other resources.

## 2. Research objectives

This land use analysis is needed to see how much impact land use changes on water availability, especially during the dry season. By using a remote sensing system with the help of satellite technology, hydro-climatological, and land use data can be monitored spatially and temporally, even closer to the actual situation. SHETRAN is a model that is able to take into account the heterogeneity of space in order to obtain broader and more accurate results compared to modeling in previous studies. The analysis carried out is to see the changes in land use and cover that occur in the SHETRAN results for modeling river water availability, especially during the dry season. The object of research was to see the impact of land use changes in the Ciwulan River Basin, West Java because the existence of this watershed is very important to meet the needs of the surrounding community.

## 3. Study location

The research was done in Ciwulan River Basin in West Java, precisely in the Salawu District, Tasikmalaya Regency. The Ciwulan Watershed is one of the largest watersheds in Tasikmalaya Regency. Apart from being used to meet their daily needs, the community also uses it for agricultural needs to irrigate the fields belonging to local residents. The existence of this watershed is very important for the surrounding community, so it is necessary to evaluate the availability of water in the Ciwulan watershed, especially during the dry season. This watershed is located in the coordinate range 108.219° East Longitude and 7.597° South Latitude. The Ciwulan watershed has an area of approximately 236.6 $km^2$, stretches 119.30 $km^2$ and flows through almost three different districts/cities, namely Tasikmalaya Regency, Garut Regency, and Tasikmalaya City. With a maximum width of 80 m and an average slope of 0.02080 m, the Ciwulan watershed has 404 tributaries. The upstream part is located between Mount Cikuray and Mount Kracak, Galunggung, Bungbulang and Balitiganar. While the downstream part is in Karangnunggal District, Cidadap Village and empties directly into the Indian Ocean.

## 4. Data input

### *4.1. Map and DEM (digital elevation model) data*

Map is a depiction of the earth's surface on a flat plane with a certain scale through a projection system. This watershed map with shapefile format (.shp) was obtained through satellite observation. The Digital Elevation Model (DEM) data is in the form of raster layer GIS type data obtained from satellite image data extraction. The DEM data used in this study are the results of observations made by the Shuttle Radar Topography Mission (SRTM) with a resolution of 30 × 30 meters and 90 × 90 m. The following is an image of the Ciwulan watershed topographic map data which will then be processed using ArcGis (Figure 2).

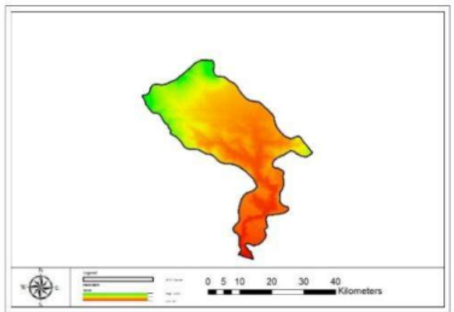



**Figure 2.** Ciwulan watershed DEM data

### *4.2. HWSD (harmonized world soil database) and LULC (land use land cover) data*

The Harmonized World Soil Database (HWSD) is an update on regional and national land information contained in a digital world land map with a scale of 1: 5,000,000 by the Food Agriculture Organization of the United Nations (FAO) and the International Institute for Applied Systems Analysis (IIASA). In this study, HWSD is classified according to the British system with a spatial resolution of 500 × 500 meters from 2001 to 2017 as visualized in Figure 3. Furthermore, land use land cover (LULC) which is the main data to analyze how much land use and cover changes have occurred in the Ciwulan watershed and identify drought through changes in land area and cover. Through the results of remote sensing or GIS, this LULC data provides information on annual land cover types with a spatial resolution of 500 × 500 meters, from 2001 to 2017. Based on MCD12Q1, 17 land cover categories are classified into seven categories for modeling in the SHETRAN program. The seven categories are Arable land, Bare Ground, Grass, Deciduous Forest, Evergreen Forest, Shrub and Urban.

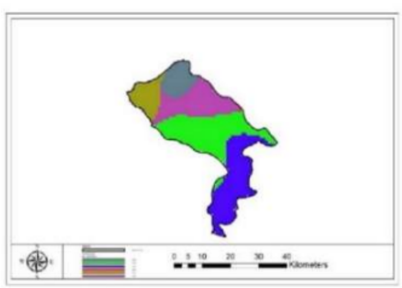


**Figure 3**. Ciwulan watershed HWSD data

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*4.3. Rainfall data and evaporation*
The rainfall data used is daily rainfall and obtained from the TRMM satellite measurements from 2001 to 2017. Meanwhile, evaporation in the process of the hydrological cycle is the movement of water from the surface of the oceans and land to the atmosphere. This evaporation data was obtained from Model Global Land Evaporation Amsterdam (GLEAM). GLEAM is a set of algorithms that separately estimate the various components of soil evaporation, bare soil evaporation, interception loss, open water evaporation and sublimation. The evaporation data used are evaporation data from 2001 - 2017 with a spatial resolution of 500 × 500m.

## 5. Methods

*5.1 ASCII data file processing with ArcGIS*
First, processing LULC data, soil data, DEM data, rainfall data and evaporation data from 2001 to 2017 were carried out using ArcGIS software. All data were entered and processed on the ArcGIS worksheet, then cutting the grid according to the location of the research study. Output was obtained in the form of data files with ASCII format which will form coordinates in the form of points forming rows and columns as a basis for making maps in the SHETRAN modeling application.

*5.2 CSV and XML file data processing Ms. Excell*
The rainfall data and evaporation records were used as input data and processed with Ms. Excell. There are nine rain codes and evaporation data that entering the Ciwulan watershed from the many existing codes, with the output data being a CSV file. If the ASCII and CSV data files have been obtained, the next step is creating an XML output file to be able to run the SHETRAN program. All unnecessary files were deleted and analysis to determine soil types will also be carried out concerning the British Standards [6].

*5.3 Data processing with SHETRAN program and validation*
The SHETRAN Easy Setup version program is used in this study. ASCII, CSV, XML, and other necessary files, then combined in each folder per year from 2001 - 2017. Then after all the folders are ready, the next step is to run the Shetran Easy Setup program. When the process is running it must be finished 100% as shown in Figure 4. Analysis of water availability in the Ciwulan watershed was carried out by making the average minimum discharge value in one month from the daily minimum discharge value. Then validation of the average monthly minimum discharge value and a recap of drought events in a sample that is considered to represent several areas in the Ciwulan watershed in two different years.

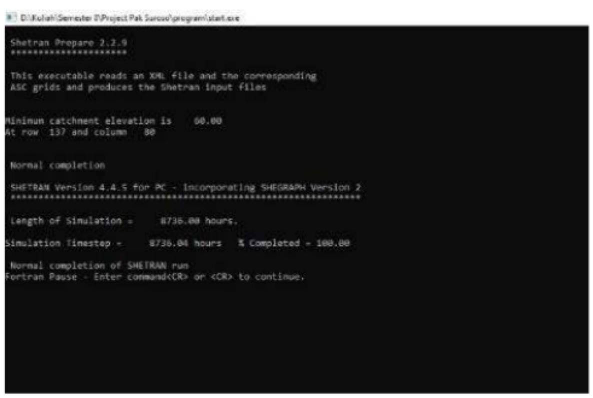


**Figure 4**. Running process SHETRAN

## 6. Results

### *6.1 Analysis of land use change and cover*

The results showed that the largest land-use change occurs in the Garapan category with an annual average increase of 7% with an initial land area of 12 km$^2$ in 2001 to 40.5 km$^2$ in 2017. While land changes that tend to decline in the area from year to year are Pine Forest with an average percentage decline of 1% from the initial area of 2001 462.5 Km$^2$ to 403 Km$^2$ in 2017. The smallest change occurs in the category of residential land which tends to be stable in the range of 24 km$^2$. The difference in land use change can be seen more clearly in Figure 5.

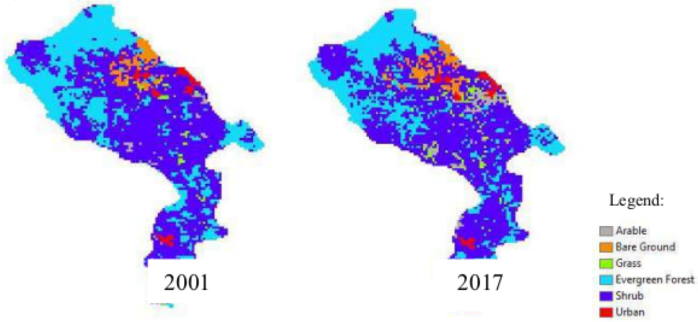


**Figure 5.** Map of change in LULC in 2001 and 2017

### *6.2. Validation of debit value and drought disaster events*

Table 1 and 2 showed validation between the average value of the minimum monthly discharge and the recap of drought events to see more clearly the comparison of the average monthly minimum discharge value with drought events. Based on the validation, it can be seen that in dry areas, the flow rate shown by the Shetran model has a smaller number than when there is no drought.

**Table 1.** Validation of debit value and drought disaster events in 2006

| Month | Garut regency | Time of the drought | Tasikmalaya city | Time of the drought | Tasikmalaya regency | Time of the drought |
|---|---|---|---|---|---|---|
| January | 1.160 | no drought | 0.353 | no drought | 131.761 | no drought |
| February | 0.899 | no drought | 0.331 | no drought | 117.523 | no drought |
| Mach | 0.680 | no drought | 0.212 | no drought | 81.062 | no drought |
| April | 1.179 | no drought | 0.411 | no drought | 146.466 | no drought |
| May | 0.478 | no drought | 0.177 | no drought | 65.330 | no drought |
| June | 0.156 | no drought | 0.034 | no drought | 14.659 | no drought |
| July | 0.002 | drought | 0.022 | drought | 0.017 | drought |
| August | 0.015 | drought | 0.021 | no drought | 0.039 | drought |
| Sept | 0.046 | no drought | 0.044 | no drought | 0.007 | no drought |
| October | 0.064 | no drought | 0.098 | no drought | 0.003 | drought |
| November | 0.121 | drought | 0.110 | no drought | 27.688 | drought |
| December | 1.231 | no drought | 0.339 | no drought | 125.939 | no drought |

## 7. Conclusion

The results of the LULC analysis show that of the six categories of land types in Ciwulan, five categories of land area have increased, including arable land, bare ground, grass, shrub, and urban land. Meanwhile, another category that has decreased in the area is a forest. Arable is the most dominant area, while urban is the minor. Changes in land use and covers, such as degradation of green forest lands replaced by arable land and settlements, causes a decrease in the value of groundwater availability. The type of land cover in

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an area will affect the ability of land in that area to absorb and store water reserves. The dry area will have a lower discharge value than when there was no drought.

**Table 2.** Validation of debit value and drought disaster events in 2009

| Month | Garut | Time of the drought | Tasikmalaya city | Time of the drought | Tasikmalaya regency | Time of the drought |
|---|---|---|---|---|---|---|
| January | 1.319 | no drought | 0.432 | no drought | 159.445 | no drought |
| February | 0.776 | no drought | 0.313 | no drought | 110.852 | no drought |
| Mach | 0.846 | no drought | 0.286 | no drought | 106.809 | no drought |
| April | 1.050 | no drought | 0.371 | no drought | 133.601 | no drought |
| May | 0.476 | no drought | 0.126 | no drought | 51.326 | no drought |
| June | 0.234 | no drought | 0.062 | no drought | 36.209 | no drought |
| July | 0.129 | no drought | 0.040 | no drought | 24.695 | no drought |
| August | 0.169 | no drought | 0.039 | no drought | 15.387 | no drought |
| Sept | 0.151 | no drought | 0.106 | no drought | 14.167 | drought |
| October | 0.160 | drought | 0.069 | no drought | 25.772 | no drought |
| November | 0.325 | no drought | 0.153 | no drought | 51.038 | no drought |
| December | 1.198 | no drought | 0.365 | no drought | 136.550 | no drought |

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