Land Use Change Projection and Its Impact on Flood Hazard in The Batanghari River Basin

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Introduction

Conversion of forest land into residential areas both upstream and downstream is one of the main contributors to the rise in flood risk in the Batanghari river basin. This is because the forest area has the potential to absorb and store water, thus reducing the risk of flooding. When the forest area is cleared, the risk of flooding increases due to reduced water storage capacity.

The study area is focused on the Batanghari River Basin, which is located in Jambi Province and is the second largest basin in Indonesia with an area of approximately 4.5 million hectares. The basin is divided into several sub-basins, including the Jambi, Muaro Jambi, and Sarolangun sub-basins. The basin is characterized by a tropical monsoon climate with high rainfall from May to September.

Methodology

The study was conducted using a combination of remote sensing and geographic information system (GIS) techniques. Land use change was analyzed using the CLUE (Conversion of Land Use and It's Effect) model, which is a two-dimensional model capable of simulating rainfall-runoff and flood inundation simultaneously.

The RRI model was used to simulate an expansion of inundation area and depth area. Land use changes in the river basin area including urbanization and deforestation continuously can change the water availability and extent of surface and subsurface water interaction. Affecting the flood hazard in the river basin, which is Batanghari, Muaro Jambi, and Jambi City. Several experts said that the cause of this flooding not only comes from high intensity of rainfall, but also caused by anthropogenic factors. Degradation of forests in the upstream basin, as water catchments, and river sedimentation causes most of the rain falls directly into the river. Projected land use had been done by using a dynamic model (CLUE: Conversion of Land Use Effect).

Analysis of land use is divided into two parts: analysis of changes in land use (change detection) and land-use change projection models. Land use classification in 1990, 1997, 2005, and 2015 was derived from satellite imagery (LANDSAT) and then classified using maximum likelihood algorithm. Accuracy assessment in 2015 by using the ground truth data collected using Geographical Positioning System (GPS) in 2015.

Land use projections were used to construct scenarios in the future by using CLUE model. The CLUE model consists of two modules: spatially explicit allocation procedure and non-spatial demand module. Land use demand (demand module) generated from the trend extrapolation of land use change area. In the allocation module it is possible to define which change are allowed based on user defined decision rules (elasticity and conversion matrix).

Both land use classification and projection became an input in the flood inundation modeling. RRI (Run off-Rainfall-Inundation) model was used to simulate an expansion of inundation area and depth area. Finally, how the change in land use will impact the height of the inundation area can be compared.

Result & Discussion

Based on the land use classification in 1990-2015, it can be concluded that the forest area dramatically decreased year by year. While agricultural area continuously increase in 2015. The evaluation result producing the kappa accuracy value of 0.73 in 2015. This value indicates that the model is good enough and can be used for prediction simulation. However, kappa coefficient of 0.61 was categorized as moderate agreement. Given the large river basin area so that this value is acceptable. In summary, the model capable to describe the land use behavior in the future condition.

The results of CLUE model revealed that the number of forest areas decreased over the 51 years of simulation. Nowadays, forest areas with varying slopes of land does not limit commercial parties to planting crops, especially palm oil. Based on the Fig. 4 it is seen that the forest area in the south of Batanghari river basin is in the Merangin and Sarolangun regency will decrease. By 2040, the projected forest area will be reduced by 53% from the actual year of 1990. While the area of agricultural increase as the forest area diminishes. The area increases up to 129% in the year 2040.

According to the land use projection, it is analyzed that the number of changes area are Tebo Regency with 205,400 ha. Follow by Sarolangun, Bungo, Batanghari and Muaro Jambi Regency. Those changes occur from the forest land into residential land.

The impact of land use change on flood inundation depth and area were analyzed by using four scenarios (Table 17). The impact of land use change on inundation area can be obtained by comparing land use 2015 and 2040 with the same rainfall AGCM present data. While to determine the effect of climate change on flood inundation was done by comparing land use 2015 with AGCM present and AGCM future. The area inundation affect from climate change can be obtained about 850 m. Based on the result of the model, it can be said that the effect of land change on flood is 20%, while climate change factor has the biggest influence about 80%.

Conclusions

CLUE can be used well for modeling a land use change in large scale river basin such as Batanghari River Basin. Forest area is predicted to decline continuously until the next 30 years. While agricultural areas always expand along with the increasing of population. Bush and open land area are mostly converted into agricultural land. Currently, Batanghari river basin is dominated by agriculture land use type. Based on the simulation, agriculture land always increase, up until 68% of the beginning areas in year 2040.

RRI model was able to visualize area and depth of flood inundation in current and future situations. Land use 2040, projected that there will be an increase in agricultural area of 266,675 ha and a decrease of forest land of 58,700 ha resulted in the increase of flood area. With the combination of RRI and climate change scenario, the inundation area reaches 2,381 km² and the maximum depth of 7.4 m. The maximum depth is predicted in the area of Tebo Regency.

Acknowledgement

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11. Water level

Data and Tools

1. Satellite imagery of LANDSAT
2. Hydrosheds
3. Stream network
4. Infrastructure map
5. Soil map
6. Regional Spatial Planning (RTRW) map
7. Population density
8. Rainfall Data AGCM-present
9. Rainfall Data AGCM RCP 8.5 - future
10. Water discharge
11. Water level

References