Projecting land use changes and its consequences for hydrological response in the New Capital City of Indonesia

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Abstract. The Indonesian government intends to build a New Capital City in East Kalimantan Province, with a total development area of 56.000 ha located in existing forest and palm oil plantations. This study will look at the fast changes in land use throughout the urbanization process from 2020 to 2045. They will impact surface runoff and increase flood risk in the future. However, this study primarily focuses on modelling to simulate and predict land use changes in the landscape of the primary river basin in the New Capital City. Land use maps for the years 2013 to 2020 were generated using image classification from Landsat images. The CLUE-S semi-empirical model was used for simulations. The modelling effort included a land use/cover change with three scenarios. The simulation revealed that mainland use/cover types will rapidly increase from 2020 to 2045, particularly in converting forest, fishpond, and plantation areas into urban areas and open fields. According to the New Capital scenario model, the built-up area would continue to expand dramatically with a 742.46 % change. In a future study, a surface runoff will be estimated using the HEC-HMS and SCS-CN models.

Keywords: land use/cover changes, CLUE-S, conversion elasticity

1. Introduction

As the capital city of the Republic of Indonesia, Jakarta has experienced various complex urban problems, which cause national economic losses and trigger other problems. On August 26, 2019, President Joko Widodo declared that a New Capital City would be developed in East Kalimantan Province. Where the administrative regions are Penajam Paser Utara Regency and Kutai Kartanegara Regency. The main consideration for relocating the new capital city because the small risk of natural disasters in the region, and the location is in the middle of Indonesia. Furthermore, the location is close to the two big cities of Balikpapan and Samarinda, which have developed, and their infrastructure is relatively complete. However, according to the National Development Planning Agency of Indonesia (Bappenas), the location selection in East Kalimantan has two weaknesses: the potential for flood disasters and the availability of groundwater resources.

In relation to the environmental carrying capacity of the new capital city, investigation of changes in land use resulting from undeveloped land cover, such as forest, palm oil plantation and open fields to
built-up land cover is needed, since it will result in changes in hydrological response, especially the potential for increased runoff discharge. Land use management in urban areas is needed to reduce the rate of surface runoff because the more significant the land is built, the greater the runoff coefficient. In addition, several studies also show a positive correlation between forest loss and surface runoff [1]. From the perspective of regional planning and development, land use is a form of human effort in using natural resources/land, in which there is a business component. In contrast, a land cover is a physical manifestation of planned use or not [2]. However, in simple terms, land use can also be interpreted as a human intervention against certain land areas to meet their daily needs [3]. Land use and land cover (LULC) change is a problem on a global and regional scale. In the national context, regardless of the scale of magnitude, both large and small land use changes often have classic problems in the form of (1) efficiency of resource allocation and distribution from an economic point of view, (2) its relation to issues of equity and equity in control of resources, and (3) its relation to the process of degradation and damage to natural resources and the environment [2]. As a result, the government must include the study of hydrological responses resulting from land use and land cover change in developing a development plan for the New Capital City that does not exceed the environment's carrying capacity.

The land use change model, according to [4] is divided into four main categories, namely: (1) empirical-statistical model; using multivariate analysis of probable external effects that contribute to the causes of change, this model seeks to clearly identify the reasons of land use and land cover change; (2) the stochastic model; in general this model considers land use change to contain a transition probability model using the Markov Chain analysis which describes a process that runs for a moment in one part in a set of conditions; (3) the optimization model; in this model, approach refers to the land rental theory initiated by Von Thunen, where each land parcel is modelled to produce the highest rental value. Consequently, the land use and land cover change trend rely on the landowner's willingness to pick what to lease the property. Finally, (4) dynamic model; according to this principle, the pattern of changes in LULC in space and time is generated by the interaction between biophysical and socio-economic processes. This model was developed to imitate the course of the interaction process and follow the evolution that occurred.

The impact of land use and land cover change on hydrological responses in principle is investigated using models with an empirical equation to calculate peak discharge. However, the development of the reliability’s model is much determined by watershed size, climatic and hydrological conditions. Currently, many spatial-based hydrological models have been developed that involve more parameters. It is expected that the results will be more accurate and reliable. The “Conversion of Land Use and Its Effect Model at Small Regional Extent” (CLUE-S) model is a standard and accurate for predicting land use change. The CLUE-S is a model that illustrates land use and land cover change in a smaller region than the national and provincial scales [5]. In this model, land change opportunities are calculated quantitatively using logistic regression equations. This equation includes physical, social, economic and policy factors to forecast changes in land usage.

The CLUE-S model is a hybrid of empirical, spatial and dynamic approaches that have been applied in the Atlantic Zone (Costa Rica), China, Ecuador, Honduras, and the Island of Java [6]. This model is an integrated, dynamic real spatial model and is based on socio-economic and environmental conditions. In this modelling, land change opportunities are calculated quantitatively using logistic regression equations. This equation includes physical, social, economic and policy factors to predict land use change. Modelling with CLUE consists of two stages. (1) analysis of land use change patterns originating from past and current land use, as the most influential driving factors from the biophysical, socio-economic and policy aspects; (2) use the analysis results to determine possible scenarios to be carried out. The CLUE model is preferred over other land use models because it is most commonly used and has several advantages, including (1) its capacity to model land use allocation using non-spatial parameters as well as spatial parameters, (2) its character is dynamic and also a hybrid, and (3) its capability to simulate in different scale of resolution from coarse to fine [7] [5] [8] [9]. This study aims to simulate and predict land use changes in the landscape of the primary river basin in New Capital City from 2020 to 2045. In future research, the surface runoff will be calculated with the HEC-HMS and
SCS-CN model and expected to be determined the ideal curve number (CN) as a constraint for the development planning of the New Capital City.

2. Methods and materials

2.1. Research area
In this study, the research area is determined in the major watershed (Sepaku river basin) of the New Capital City’s National Capital Territory (KIKN) in East Kalimantan Province's administrative regions of Penajam Paser Utara Regency, Indonesia. The total area of the National Capital Area (KIKN) is around 56,000 ha. In comparison, the New Capital City's Central Government Centre Core Area (KIPP) is 6,596 ha. It borders with Kutai Kartanegara Regency in the north and Balikpapan City in the south. It is located between the southern latitudes of 0°47'48.8” and 1°0’26.3” S and the eastern longitudes of 116°35’20.7” and 116°50’27.7” E (Figure 1). The research area has 29,887 hectares, with an average elevation of 120 m and a maximum elevation of 578 m. East Kalimantan Province has an equatorial type of rain pattern because there are two rainy season peaks in April and January. It also experiences two peaks of the dry season that occur in February and August. The area in the East Kalimantan Province receives a mean annual precipitation of 2,420 mm/year with a monthly average of 117-285 mm/month [10]. There are 12 river basins within the study area. However, the main river basin is the Sepaku river basin. Its river flows through the Central Government Centre Core Area. According to the National Statistical Agency (2010), the regency of Penajam Paser Utara had a total population of 160,912 in 2019, inhabiting this area. Palm oil plantations and forests cover the majority of this regency’s land area.

![Recent Landuse (2020)](image)

**Figure 1.** Map of Sepaku River Basin in The New Capital City Area, Indonesia

As the new capital city, this area will contain clusters of government buildings and consist of other clusters such as media and health research cities, technology cities, education cities, cities of creativity and innovation and sports cities according to their respective designations. New capital’s area contributes 77.17% of the total area of Sepaku watershed or 38.70% of a total area encompassing in Sepaku watershed. Figure 2 shows the entire new capital’s area situated southwest of the Sepaku watershed.
Figure 2. Location of New National Capital’s Area (KIKN) (tentative)

2.2. Investigating changes in land use and land cover
This study examined land use and land cover changes using Landsat 8 data between 2013 and 2020 obtained from the United States Geological Survey (USGS). The original land use data were aggregated into six land use classifications to simplify the analysis: (i) water body, (ii) forest, (iii) built-up area, (iv) open land area, (v) plantation, and (vi) fishpond. The analysis of land use and land cover change was performed using GIS to assess the percentage of change in land use for each category from 2020-2045. The next step is building the different scenarios using this information.

2.3. Land use change modeling
The Dyna-CLUE model was utilized to simulate and forecast land use and land cover changes for several scenarios between 2020 and 2045. Many researchers have been used the Dyna-CLUE model for modelling land-use changes in Southeast Asian Mountain regions with verified results [11] [12] [8]. This model consists of two modules which are the non-spatial module and spatial allocation module. Four inputs are required to build the model, resulting in an optimal solution using iterative calculation of several circumstances and possibilities. The four inputs required are (1) land-use demand, (2) geographical features, (3) policy of spatial planning including constraints, and (4) conversion set up for certain land-use types. The land-use needs and spatial policies differ depending on the scenario. However, the site features and conversion parameters are considered to be the same throughout all scenarios. In this model, the probability of land change is calculated quantitatively using the logistic regression equation. This equation incorporates physical, social, economic and policy factors to predict land use change. The four inputs were utilized to simulate the similarity of each grid cell in each land use type. It is also used to calculate land allocation in each land use type based on the competitive strength to fulfil the total allocation for each scenario [9]. All simulations are performed with a resolution of 120x120 m.

2.3.1. Requirements for land use (demand)
The simulation to forecast land use and land cover change in the CLUE is based on each scenario's parameters. The Landsat images collected between 2013 and 2020 were utilized as land use demand, while the base year for simulation was assumed in 2020. In this research, three scenarios have been evaluated until 2045 for 25 years, which are: (1) Current trend scenario, (2) Spatial plan scenario, and
(3) New capital scenario. The current trend scenario reflected the condition if there were no restrictions (business as usual). In contrast, Spatial plan scenarios were based on the Provincial Spatial Planning Policy (RTRW). Finally, New Capital scenarios were created based on the government's master plan of New Capital City development as described in Table 1.

**Table 1.** Summarizes the characteristics of land demand scenarios for the New Capital City in 2045

| Scenario 1 (Current Trend Scenario) | Scenario 2 (Spatial Plan Scenario) | Scenario 3 (New Capital Scenario) |
|-------------------------------------|-----------------------------------|-----------------------------------|
| Developed Area                      | Adheres to the current trend of land use conversion | Assumed as 5% based on the province's current spatial planning policy (RTRW) | Assumed as 11% of the study area as given in the Master Plan of the New Capital City and the existing spatial planning policy of the province. |
| Rate of conversion (Per year)       | Follows conversion rate based on spatial plan: water body (0.0%), forest (-0.75%), built-up (+15.53%), open land (+3.98%), plantation (-1.21%), fish pond (-1.16%) | Follows conversion rate based on New Capital Master Plan: water body (0.0%), forest (-0.90%), built-up (+20%), open land (+4.94%), plantation (-1.74%), fish pond (-1.16%) |
| Policy in terms of Spatial Planning | Conversion in the protection area is not permitted | Conversion in the protection area is not permitted |

2.3.2. **Policy for Spatial Planning and limitations**

Policy for spatial planning means all policies and regulations where land use conversion is prohibited due to its special status (e.g., protected forest or wildlife reserve). These spatial regulations and limitations serve as the foundation for the land use demand scenarios. In the current trend scenario, it is assumed there is no spatial policies are in place everywhere, even though in the protected area. While in the spatial plan scenario, strict limitations on protected areas are in place based on forest maps published by the Ministry of Environment and Forestry and RTRW. The New Capital scenario includes limitations on future protected areas based on the government plan while accommodating developed areas for the New Capital City (Table 1).

2.3.3. **Conversion parameters based on land use characteristic**

The CLUE model involves characterization for each land use type and formulation of land conversion tabulated in a matrix. The land conversion matrix comprises two groups of parameters: (1) elasticity of the conversion (Table 2) and (2) transition sequence of land use (Table 3). Significantly important land use types cannot be transformed as long as demand is sufficient to incentivize. As a result, estimation must be made by the model with a value ranging from 0 (high possibility of conversion) to 1 (irreversible transformation) that represents conversation elasticity relatively [11]. The conversion elasticity for particular land uses determined by an expert survey and a literature review. In general, aquatic bodies and built-up areas are less likely to be converted. In contrast, agriculture and other areas are more likely to change.

**Table 2.** Conversion elasticity settings

| Land use | Conversion Elasticity |
|----------|-----------------------|
| Water body | 1                    |
| Forest   | 0.2                   |
| Built-up | 1                     |
| Open field | 0.2               |
| Plantation | 0.5                |
| Fishpond | 0.8                   |
### Table 3. Conversion sequence matrix

| Water Body | Forest | Built-up | Open field | Plantation | Fishpond |
|------------|--------|----------|------------|------------|----------|
| Water body | 1      | 0        | 0          | 0          | 0        |
| Forest     | 0      | 1        | 1          | 1          | 0        |
| Built-up   | 0      | 0        | 1          | 0          | 0        |
| Open field | 0      | 0        | 1          | 1          | 0        |
| Plantation | 0      | 0        | 1          | 1          | 0        |
| Fishpond   | 0      | 0        | 1          | 0          | 1        |

### 2.3.4. Geographical characteristics

Location attributes define the most desirable sites of a specific land use category. The CLUE model principle uses binomial logistic regression to estimate location preferences with the determinant’s location factors as a basic parameter based on socio-economic and environmental characteristics in the research location:

\[
\log \frac{p_i}{1-p_i} = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \ldots + \beta_n X_{n,i} \quad (1)
\]

\(p_i\) is described as a grid cell probability on \(i\), while \(X\) is a factor for the location, and \(\beta\) is the coefficient of the dependent variable for the presence of the examined land use type on site \(i\) calculated via regression using the actual land use pattern. The logistic regression equation was used to estimate the coefficients \(n\) using the existing land use in 2015 as the dependent variable.

### Table 4. Significant factor \(\beta\) and \(\beta_0\) values for regression findings

| Variable                | Waterbody (0) | Forest (1) | Built-up (2) | Open field (3) | Plantation (4) | Fishpond (5) |
|-------------------------|---------------|------------|--------------|----------------|----------------|--------------|
| Distance to beach (0)   | -4.649        | -          | 0.910        | 0.793          | -              | -3.667       |
| Population density (1)  | -             | -0.149     | 0.328        | 0.195          | -              | -            |
| Rainfall (2)            | -             | 0.462      | -            | -              | -0.681         | -            |
| Elevation (3)           | -             | 0.906      | -            | -1.106         | -1.125         | -            |
| Slope (4)               | -             | -          | -0.325       | -              | -              | -            |
| Distance to roads (5)   | 2.057         | 0.729      | -            | -              | -1.014         | -14.530      |
| Distance to cities (6)  | -             | -          | -            | -0.771         | -              | 2.598        |
| Distance to rivers (7)  | -             | 0.467      | -1.905       | 0.341          | -0.250         | -            |
| Constant                | -1.640        | -2.061     | -3.632       | -4.473         | 1.645          | -3.350       |
| ROC                     | 0.798         | 0.818      | 0.824        | 0.808          | 0.835          | 0.862        |

A logistic regression model can be used to assess its goodness-of-fit (ROC). The ROC value ranges from 0.5 to 1.0. The value of 0.5 indicating total randomness while 1.0 indicating perfect match [9][11]. The land use prediction for 2045 is simulated by utilizing a basic land use map in 2015. The land use map of LDD with nine aggregated land use classifications detailed in Section 2.2 was utilized here. For the sake of this study, the water body is assumed to be unaltered during the simulation time. Slope, elevation, distance to roads, distance to city, distance to main river, distance to nearest beach, rainfall, and population density were chosen as independent variables as drivers theoretically. Table 4 summarizes the characteristics of the nine location variables utilized in this investigation. Each factor was created in raster map format with a resolution of 120 x 120 m.

### 2.3.5. Model validation

One of Pontius’s three map comparison methods [8] was employed to validate the model. Overlay of three maps has been used for validation, consisting of the reference maps for times 1 and 2 and the
forecast map for time 2. In our case, the 2020 land use map is simulated using the 2013 land use map. The validation approach considers the overlap of the projected 2020 map was then compared to the original 2020 map. The resulting map from the three maps’ overlay divides the forecast into five categories: (1) accurate because an observed change was anticipated as change, (2) incorrect because an observed change was predicted as persistence, (3) incorrect because an observed change was forecasted as the wrong gaining category, and (4) accurate as a result of observed persistence anticipated as persistence, and (5) incorrect because observed persistence was predicted as transformation. Regions from these predictions were utilized to construct three indices of the forecasted map's precision: (1) figure of merit, (2) producer's exactness, and (3) user's exactness. The figure of merit might vary from 0% (no overlapping area between observed and projected transformation) to 100% (comprehensive overlapping area between observed and projected transformation). The correctness of the producer and the accuracy of the user are both conditional accuracies. Considering that the reference maps reflect observed changes, the ratio of pixels that the model correctly forecasts as changes is referred to as the producer's precision. Assuming that the model predicts change, the user's accuracy is the fraction of pixels that the model correctly foresees as changes. These indices' formulations are as follows:

\[
\text{Figure of merit} = \frac{B}{(A + B + C + D)} \quad (2)
\]
\[
\text{Accuracy of the producer} = \frac{B}{(A + B + C)} \quad (3)
\]
\[
\text{Accuracy of the user} = \frac{B}{(B + C + D)} \quad (4)
\]

Which A is indicates errors because of observed transformation projected as persistence. B shows the valid area due to observed changes projected as transformation. Moreover, C points errors because of observed changes forecasted as a false gaining category. In contrast, D shows errors due to observed persistence projected as a change.

2.4. Evaluating the effects of land use and land cover change on hydrological response

Analyzing land use changes from undeveloped land cover is essential, such as forests, palm oil plantations, and fields to built-up land cover to construct the new capital city since they would result in changes in hydrological responses, especially the potential for increased potential runoff discharge. Land use management in urban areas is necessary to reduce the rate of surface runoff because the larger the built-up land, the greater the runoff coefficient. In addition, several studies have also shown a positive correlation between forest loss and runoff [1]. As a result, the study of the hydrological response due to changes in land use must be considered by the government in the development plan for the new capital city region to ensure that the increase in runoff does not create floods.

Runoff can be analyzed based on the characteristics of the flow hydrograph that can be compiled using a hydrological model, including the HEC-HMS (Hydrologic Engineering Center-Hydrology Modeling System) model using the SCS-Curve Number. Furthermore, to estimate direct runoff or infiltration from surplus precipitation, Runoff Number Curve Number (CN) is used as an empirical measure in hydrology. The Curve Number technique was created by the US Department of Agriculture (USDA), originally known as the Soil Conservation Service or SCS. However, it is still referred to as the SCS runoff curve number in certain publications (SCS-CN).

This approach is extensively used and efficient for estimating the quantity of direct runoff from rainfall events in a particular area. Runoff and floods models [13] show that changes in land use will lead to changes in the value of the increasing curve number and increase the maximum flood discharge. The value of the increase in the curve number is linear with changes in the maximum flood discharge. The US Army Corps of Engineers-Institute for Water Resources created the HEC-HMS application model to simulate the rainfall-runoff process in watershed regions [14]. HEC-HMS produces a model flow hydrograph that needs to be compared with the observed flow hydrograph. These results can be used as consideration in the management of watersheds in the new capital city and also as a consideration in planning the New Capital City (IKN) in terms of regional carrying capacity.
3. Result and discussion

3.1. Land use change/cover

In the base year 2020, the region’s primary land uses were intact forest and agricultural (palm oil crops), accounting for approximately 53% and 36% of the total area, consecutively. Forest deterioration has been disturbing in recent years, though not as quick as it was in the 2000s. Between 2013 and 2020, 3722 ha of forest area had reduced in the research region, whereas 3917 ha of plantation land had grown. As a result, the conversion of forest and other land uses to agricultural land has been highly visible in recent years. Table 5 summarizes the region of each land use/land cover from 2013 to 2020. It also summarises that the findings of a binary logistic regression study that used every land use category as a binary dependent variable and eight geographical characteristics as independent variables. It is noticed that the model does not incorporate all of the geographical elements. Each of them has a different contribution depends on the land use types.

| Table 5. Land use change in 2013-2020 (Ha) |
|------------------------------------------|
| 2013 | 2020 |
| Water body | 153.00 | 153.00 |
| Forest | 19689.00 | 15965.00 |
| Built-up | 1701.00 | 1982.00 |
| Open field | 1275.00 | 1794.00 |
| Plantation | 6932.00 | 9805.00 |
| Fishpond | 107.00 | 158.00 |

Distance from cities, distance from major roads, slope, rainfall, elevation, and distance to major rivers were all positively associated with land for agricultural usage (i.e., palm oil crops and trees). Furthermore, built-up was positively linked with distance from road, distance from cities, distance from beach, and population density. As a result, places with these geographical features are more vulnerable to invasion since they are excellent targets for conversion into agricultural land and built-up areas. Slope, elevation, rainfall, and distance from cities, on the other hand, are positively linked with intact forests, implying that regions near these geographical features are more likely to be a forest.

The ROC values for various land use categories varied from 0.798 to 0.862. It shows that the location parameters employed in the regression analysis describe the geographical distribution of land use categories moderately to well. Waterbody (0.798), forest (0.818), built-up (0.824), open field (0.808), plantation (0.835), and fishpond had the highest ROC values (0.862).

Three potential map comparison methods were used for model validation [8], as has detailed in the methodology section. Figure 2 shows the results from the three maps’ overlay enabling for visual examination of the errors. The black pixels indicate where the model anticipated shifting in land use correctly. Meanwhile, the dark grey pixels indicate where the model projected the observed change but assigned to the incorrect land use type. The medium grey pixels represent the inaccuracies where the observed change was anticipated to be persistent. Light grey pixels indicate areas where observed persistence was anticipated to vary as a result of transformation. The white pixels indicate the model accurately anticipated persistence. The model is not as accurate as the null model because the light grey pixels are more than the black ones. This is frequent in high resolution land use models, particularly when the persistence area dominates [8]. The model’s projection’s three accuracy indices (figure of merit, producer’s accuracy, and user’s accuracy) were estimated as 28%, 31%, and 59%, respectively. According to the computation, 28% of the projected transformation properly coincides with the actual change, 31% of the anticipated change is valid because the reference maps reflect the observed change, and 59% of the projected change is also valid since the model forecasts change. This means that the projected map is very close to the reference map.

Table 5 depicts land use/land cover coverage for 2020 and three projected scenarios for 2045, and the maps are depicted in Figure 3. All the scenarios show considerable degradation of forest area ranging
from 7.1% to 13.9% of the total area and the decrease of plantation ranging from 7.9% to 19.3% of total area, while built-up area increases significantly ranging from 11.3% to 24%. Without any change in land use regulation, i.e., in a current trend scenario, the result indicates a potential loss of around 7.1% in forest and 7.9% in a plantation. In comparison, a built-up area may rise by 11.3%. Even if conservation measures such as stricter restrictions on land conversion in protected areas are implemented, the forest and plantation areas are expected to shrink by about 7.5% and 10.3% of the total area, respectively. Meanwhile, the built-up area is anticipated to increase by 13.2%.

![Image](image_url)

**Figure 3.** Predicted land use patterns in 2045 with different scenarios simulated by CLUE model

If the third scenario (new capital scenario) is applied by increasing the built-up and open field demand, the forest and plantation areas are still projected to decline with approximately 13.9% and 19.3%, respectively. In contrast, built-up area is predicted to surge with about a 24% increase. The CLUE data also shows that in all three scenarios, the number of patches grows considerably. However, the average patch size drops significantly.

| Table 6. Projected land use in 3 different scenarios (Ha) in Sepaku River Basin |
|---------------------------------------------------------|------------------|------------------|------------------|------------------|------------------|
| Water body                                             | 151.00           | 151.00           | 0.00             | 151.00           | 0.00             | 151.00           | 0.00             |
| Forest                                                 | 15967.00         | 13817.00         | -13.47           | 13703.00         | -14.18           | 11802.00         | -26.08           |
| Built-up                                                | 968.00           | 4359.00          | +300.31          | 4923.00          | +408.57          | 8155.00          | +742.46          |
| Open field                                              | 1794.00          | 2952.00          | +64.55           | 3228.00          | +79.93           | 4608.00          | +156.86           |
| Plantation                                              | 10849.00         | 8479.00          | -21.85           | 7752.00          | -28.55           | 5057.00          | -53.39           |
| Fishpond                                                | 158.00           | 130.00           | -17.72           | 130.00           | -17.72           | 114.00           | -27.85           |
In the first year, the total forest area was 15,967 ha, which was decreased to 13,817 ha, 13,703 ha, and 11,802 ha under the current trend, spatial plan, and new capital scenarios, respectively. Meanwhile, the plantation area projected will decrease in all scenarios due to the high demand of built-up area with 8479 ha, 7752 ha, and 5057 ha, respectively. As a result, the new capital improves with greater built-up area and open field coverage and rigorous restriction on their management in accordance with the conservation-oriented scenario settings.

3.2. Consequences of land use change/cover on hydrological response

The hydrological response research in this study will go through two stages, namely land use change analysis and flow prediction using the HEC-HMS model. Furthermore, scenarios are created to examine the influence of land change on flow rates in the watershed. The SCS Curve Number unit hydrograph approach converted the effective rainfall hydrograph to the direct runoff hydrograph.

The SCS CN (Soil Conservation Service's Curve Number) technique extensively uses many hydrological models to predict surface runoff. Its parameters were established using long-term experimental data. As a result, the SCS-CN approach predicts direct runoff only roughly. It ignores the impacts of evapotranspiration and infiltration on the watershed [15]. The research related to the hydrological response of the new capital city has not yet been completed. Research related to changes in the value of CN due to land changes which can later be used as a reference in the policy of limiting development in the IKN area, will be carried out later.

4. Conclusion

In the New Capital City region, rapid land use change and deforestation have been seen in recent years using the business-as-usual scenario. There has been an increase in open field areas and deforested regions and a shift from forest to palm oil plants. However, the pace of deforestation is progressively decreasing compared to previous decades (2000-2010) due to vigorous enforcement of regulations prohibiting forest logging.

The land use modelling with 2020 basic data shows that continuing with the current trend for the following 25 years may result in a considerable decrease of the forest by 13.47% and a significant increase of built-up and open areas 300.31% and 64.55%, respectively. In the case of agriculture, the plantation area will decrease around 21.85% of the existing plantation area. This decrease is clearly because of the high land demand on built-up and open areas.

The new capital city has situated southwest of the watershed, which is dominated by oil palm plantations. Moreover, the fishpond will decline throughout the area in all scenarios ranging from 17.72% to 27.85% decline. Besides, the spatial plan scenario reduces forest by 14.18% to built-up and open areas. In this case, the central, southwest, southeast, and northeast parts of the river basin are highly likely to increase in a built-up area. The surge will be around 408.57% for built-up and 79.93% for open field areas. In addition, the increase of open fields will dominate the north side of the watershed.

In contrast, the expanded built-up area will dominate the watershed's south, southeast, and centre. The new capital scenario is used as the final set to project the land use because of the new capital development. In this scenario, built-up and open field areas are planned to have a massive increase throughout the 25-year-period. This is a consequence of the rapid and significant development of the new capital area of Indonesia. Based on the model, the built-up area will continue to increase over the period with a 742.46% change dramatically. Furthermore, the open field also will rise significantly with a 156.86% change from the starting year. Meanwhile, due to the development of the new capital, forest, plantation, and fishpond will decline sharply over the period with 26.08%, 53.39%, and 27.85% decrease, respectively.

As a result, our analysis indicates that land use change, and hence deforestation of forest and plantation, is the primary driver of runoff coefficient in the New Capital City region. In comparison to low land regions, high altitude locations have a higher value of the forested area. A higher likelihood of deforestation happens in the central, northeast, and north parts of the province. Meanwhile, a better chance of retaining their forests happens in the region's west, southwest, and northwest sections.
result, preserving 70-75% of the forest by 2045 may be overly ambitious for this New Capital region because of demand for governmental and residential complexes is still strong and expected to rise over time.

The runoff of each land use change scenario will be examined in the following study based on the features of the flow hydrograph using a hydrological model HEC-HMS and the SCS-Curve Number. Transformation in land use and land cover is predicted to result in changes in the value of the rising curve number and an increase in the maximum flood discharge. Because the value of the increase in the curve number increases linearly with changes in the maximum flood discharge, the optimum value of the Curve Number (CN) or land conversion limitation can be determined as a constraint for the development of the New Capital City (IKN) that considers it carrying capacity in terms of flood prevention.

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