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PREDICTION OF LAND-USE CHANGE IN URBAN GARUT, WEST JAVA: SPATIAL DYNAMICS APPROACH

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ABSTRACT
Landuse is an area on the earth that has characteristics which is biosphere, atmosphere, soil, geological, hydrology, plant. Animal population and various human activities. The city development of course requires the land to support all the activity that will be carried out. The issue of land conversion changes is increasing along with the increase of the community. The development of a city occurs as a result of population growth, social, economic, cultural activities as well as interactions with other cities in the surrounding area. Based on the phenomena, the aim of the research is to predict changes in land use in the Garut Urban area. This research was carried out by system dynamics and spatial dynamics approach. The result showed that the land-use change in Garut Urban Area overall, the most significant change in land use area from 2015 to 2031 was forest area of 753.35 hectares or 47%, while the most significant increase was the settlement/building area of 3,340.49 hectares or 80%.

KEYWORDS
Land use, system dynamics, spatial dynamics, development

Introduction

The problems that occur in every city development currently become quite complex problems to be overcome. Various viewpoints suggest that land use is widely used in urban areas. Urban development, of course, requires land to support all activities that will be carried out. The issue of land conversion changes is increasing along with the increase of the community. Agricultural land has been converted into residential and industrial areas. The issue of decreasing land cover will have a broad impact on the environment, reduce biodiversity, and climate change because it reduces the area of green land cover. The land is an area on the surface of the earth that has certain characteristics which include the biosphere, atmosphere, soil, geological reports, hydrology, plant, animal populations, and various human activities both from the past, the future, and in certain times [1].

The various events regarding land use are always occurring from time to time. Land-use changes are, of course, very much influenced by population growth which has a direct impact on land change, especially in relation to the increasing need for land. According to Chapin and Keizer (1979), to describe the phenomenon of urban land use, it is related to three key systems are activity systems, development systems, and environmental systems [2]. Garut urban area is an area without agricultural main activities, with the arrangement of the functions of the area as a place for settlements, cities, centralization, and distribution of government services, social services, and economic activities. (Local Regulation of Regency of Garut Number 29/2011)

The development of a city occurs as a result of population growth, social, economic, cultural activities as well as interactions with other cities in the surrounding area. A city with all the activities in it will experience development from time to time. Like other cities, Garut Urban has also experienced developments resulting in the emergence of problems with changes in land use and spatial structure According to Lin, Tao (2015) that the city center has a high average population density due to the existence of complete facilities then decreases in the suburban cities so that land conversion that occurs in the city center is greater than in the periphery of the city [3]. With this phenomenon that occurs, this study has the aim of predicting changes in land use in the Garut Urban area which consists of Cilawu District, Tarogong Kaler District, Tarogong Kidul District, Garut Kota District,Banyuresmi District and Karangpawitan District.

Method

In this study, the method used was the spatial dynamics method. The approach was carried out in stages by digitizing the land use map in the Garut urban area [4]. The material used in this study is time-series data consisting of land use maps for 2015 and 2019 as well as population data. The tools used are ArcGIS software, Powersim Studio 10, and Terrset. The interplay between variables in land-use change is shown in Figure 1.

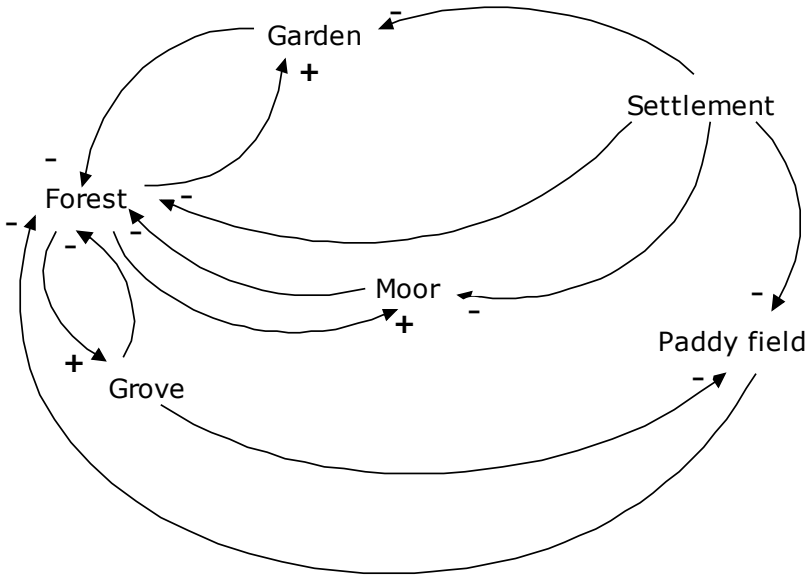

Fig. 1 Causal Loop diagram of Land-use change

In the spatial dynamics model, the results of system dynamics analysis in the form of numerical data and graphics are used as input for spatial dynamics analysis. The result of the analysis is a map of land-use change in the next few years. The land-use changes at two points of the year were analyzed with the help of the Markov Chain model to obtain information on patterns of land-use change. The results of the Markov Chain analysis together with the land suitability and adjacency matrix are then used as input in predicting future land-use changes, which are carried out by predicting future land use models using the Cellular Automata approach.

Markov Chain

The Markov Chain method is a method that processes land-use change at two points in time whose result is a transition probability matrix [5]. The combination of Markov Chain and Geographic Information Systems are through the integration of remote sensing technology has succeeded in analyzing trends, levels,

and spatial patterns of land-use change [6]. This method has limitations in describing the interactions between land-use changes that arise. This method cannot answer why these changes occur, so changes in the existing values are carried out first by using system dynamics analysis to be able to answer changes that occur due to many factors so that it can be explained when and which type of land use will change.

Cellular automata

The cellular automata is a system dynamics whose behavior is influenced by neighborhood relationships [7]. This model has spatial characteristics based on cells whose changes depend on neighboring cells, these cells will live if three or more of the neighboring cells are alive and will die/change if three or more neighboring cells also die/change. By integrating Cellular Automata with the Markov Chain model, its raster-based characteristics can be developed and modeled to model spatial change as a system dynamics. The flow chart for predictive land-use change analysis is presented in Figure 2

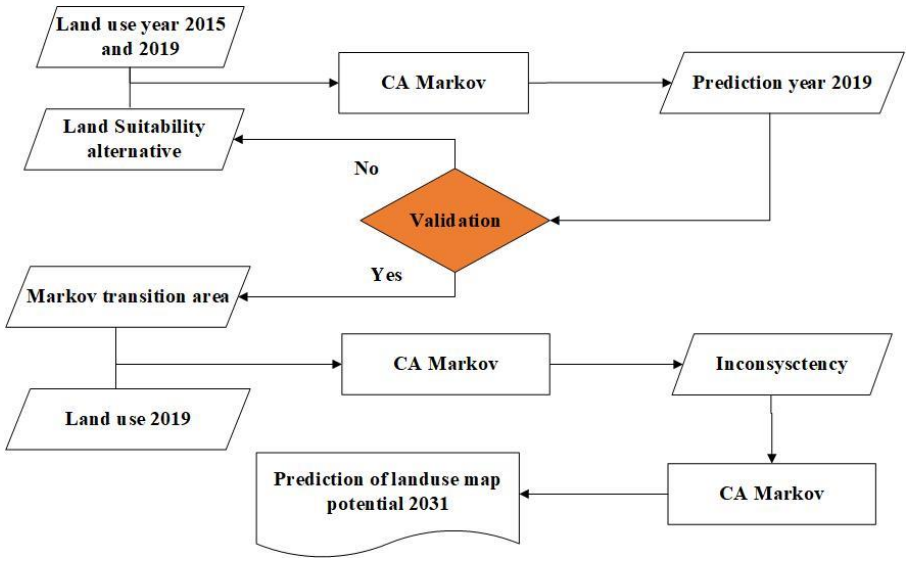

Fig. 2.Flowchart for predicted of land-use chane study

Result and Discussion

The increase in population is one of the reasons for the increased need for land. Because the land cannot be increased, what happens is a change in land use that tends to reduce the proportion of land that was previously agricultural land to non-agricultural land. The land area in the Garut Urban Area is 275.32 km2. The total population in the Garut Urban Area with a total of 697,154 people with population growth in 2019 of 8.97% with a population density of 34.4%. Detail of the population growth in Garut Urban in 2019 is presented in the Table 1.

Tabel 1. Population Growth in 2019

No.	District	Area (km^2)	Amount of population	Population growth (%)	Population Density (%)
1	Cilawu	77,63	107.602	2,53	2,47
2	Tarogong Kidul	19,46	134.818	0,63	12,05
3	Tarogong Kaler	50,57	98.269	1,65	3,56
4	Garut Kota	27,71	130.630	0,9	8,02
5	Karangpawitan	52,07	132.425	1,7	4,58
6	Banyuresmi	47,88	93.410	1,56	3,72
	Total	275,32	697.154	8,97	34,4

Source : DIKPLHD Garut Regency, 2019

The population growth and limited land in urban areas are led to the development of small tenements. The small tenements then develop into dense and slum areas known as slum areas. The development of urban settlements in the Garut Urban Area is closely related to the rapid development and development of the city which leads to trade, hotel, and restaurant activities and the service sector to increase the attractiveness of residents so that housing needs will also increase.

Projection Land-Use

A land-use change was occurred from time to time. Land-use change that occurs is in line with the increasing population growth which directly impacts the increasing need for land. A development plan must know land changes that will occur in the future. Therefore, information regarding the existence of land developments is very important as a reference in making decisions. The graph to see the projections of land use in the Garut Urban Area can be seen in Figure 3.

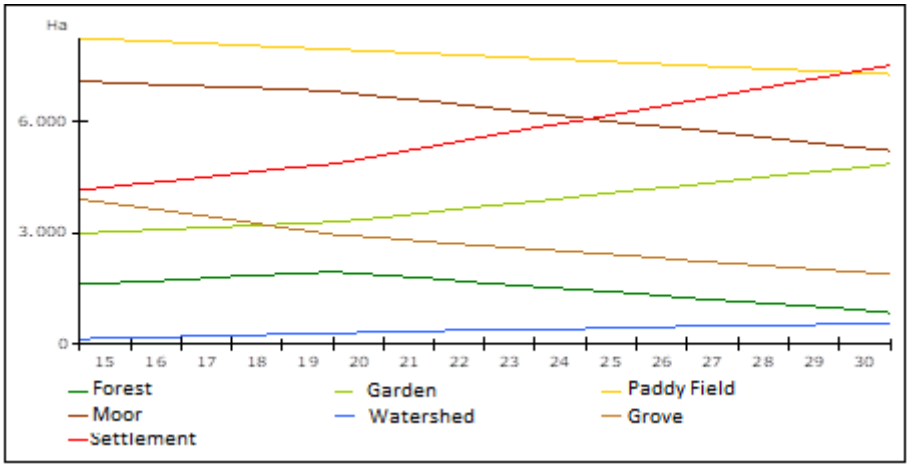

Fig 3. Graph of Land-use changes in the Garut Urban Area

As seen in the graph of land-use change using the system dynamics, it can be seen that land changes until 2031, there has been a reduction in land area for forest land use classes, gardens, rice fields, moor, and vacant land and shrubs, while land use classes for gardens, water bodies, and settlements and buildings have a tendency to increase in land area. The projection map of land-use change in Garut Urban is presented in Figure 4

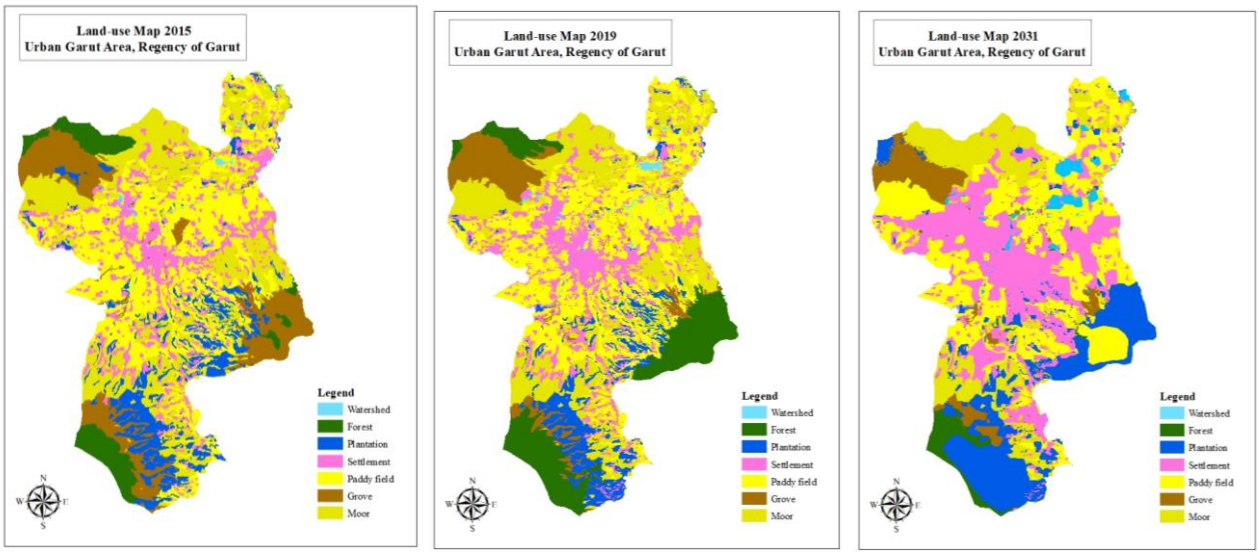

Figure 4. Land-use Map year 2015, 2019 dan 2031 in Urban Garut

Numerically land-use changes in the Garut urban area are presented in full in Table 2 visually the comparison of the percentage of land use in 2015 and 2031 is presented in the pie chart of Figure 5.

Tabel 2. Projection and Land-use change

Land use	Area (ha)		
	2015	2019	2031
Water	159.57	278.16	576.06
Settlement	4163.68	4730.43	7504.17
Forest	1619.23	2522.24	865.88
Garden	2990.43	2414.26	4858.79
Paddy field	8231.65	8036.17	727240
Bush	3926.91	3329.90	1883.77
Moor	7083.93	6864.26	5214.33
Total	28175.41	28175.41	28175.41

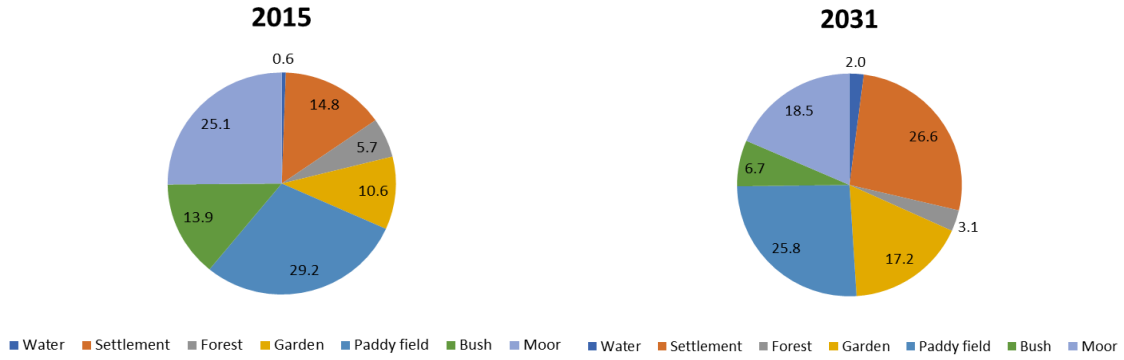

Fig 5. The comparison of the percentage of land use in 2015 and 2031

Land use in the Garut Urban Area with a land area of 28,175.41 hectares. The largest land use in the Garut Urban Area is the use of paddy fields which can be seen from Table 2. The area of rice fields in 2015 was 8,231.65 hectares or 29% of the total land area, while in 2019 the rice fields were 8,036.17 hectares. or an

area of 28%. According to predictions, the largest land use class in 2031 is residential and building land use covering an area of 7,504.17 hectares or an area of 27%. In total, the most significant change in land use area from 2015 to 2031 was forest area of 753.35 Ha or 47%, while the most significant increase was the settlement / building area of 3,340.49 Ha or 80%.

Land use classes that have decreased in area from 2015 to 2019 include: plantations covering an area of 576.17 Ha or 19%, rice fields of 195.48 Ha or 2%, empty land / shrubs covering an area of 597.01 Ha or 15% and moor / fields covering an area of 219.67 Ha or 3%. Land changes from 2019 to 2031 are predicted as follows: water bodies have increased by 107% or an area of 298 hectares, settlements have increased by 59% or an area of 2,774 hectares, forests have decreased by 66% or an area of 1,656 hectares, plantations have increased by 101% or an area of ?? 2,445 Ha, rice fields decreased by 10% or an area of 764 Ha, empty land / shrubs decreased by 43% or an area of 1,446 Ha and moorlands decreased by 24% or an area of 1,650 Ha.

It is feared that uncontrolled changes in land use will further erode agricultural lands that are earmarked for food needs. Several things that pose a threat to the existence of food land include: population growth and low rents for agricultural land. The population increase in the Garut Urban Area in 2019 was 8.79%. Along with the increase in population, the space requirements for settlements will also increase, this is in line with the prediction of changes in land use, especially for residential and building land use classes. Policy scenarios such as the protection of agricultural lands need to be applied to protect agricultural lands so that food security, especially in the Garut Urban Area, remains fulfilled. When no policy scenario simulation is carried out such as the existence of regulations for vertical housing, land use in the Garut Urban Area in the future will be covered by residential land and buildings.

The increasing number of population means that the number of needs becomes greater, one of which is the need for land. According to the Ridwan (2009) The process of the conversion of agricultural land to non-agricultural uses is caused by several factors including external factors (the dynamics of urban, demographic and economic growth), internal factors (socio-economic conditions of agricultural land users' households), and policy factors (issued regulatory aspects. central and local governments related to changes in the function of agricultural land) [8].

Conclusions

Changes in land use inevitably occur in line with the increase in population so that space requirements continue to increase. Changes in land use in the Garut Urban Area. Overall, the most significant change in land use area from 2015 to 2031 was forest area of 753.35 Ha or 47%, while the most significant increase was the settlement / building area of 3,340.49 Ha or 80%. Policy scenarios such as the protection of agricultural lands need to be applied to protect agricultural lands so that food security, especially in the Garut Urban Area, remains fulfilled.

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