Conference Paper

Spatial Dynamics Model of Land Availability and Level of Income and Education in Parangtritis Coastal Village, Bantul Regency

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Abstract

Parangtritis coastal village is located on the southern coast of Bantul Regency that popular with tourism and capture fisheries activities. The advantages of the tourism and capture fisheries sector make Parangtritis Village seen as a field to earn a living and causes healing in population or people income of Parangtritis Village. This situation can affect the need for space and land, which can have an impact on decreasing the carrying capacity of the environment so that predictions are needed on land availability using a model of spatial dynamics. This study aims to build a model of spatial dynamics for land availability and analyze the relationship among these models with the education level and income of Parangtritis Village. The methods that used in this study is a spatial dynamics modeling method which using population data for 2008-2018 and Google Earth imagery in 2008, 2013, and 2018, and interview with grid area used for the level of education and income. The development of the built area observed through a spatial dynamics model of the relationship between population growth and land availability in the period 2008-2100. The model prediction shows that the developed land has developed from the appropriate area to meet the regional capacity that is not appropriate in 2039. The analysis results showed that the fastest growth of the built-up area was in areas with high levels of education and high-income levels.

Keywords: spatial dynamics, population, land availability

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1. Introduction

Parangtritis Village has suitable physical conditions for coastal tourism activities. Beach tourism income in Parangtritis Village is more significant-higher than that of coastal tourism villages in other villages or sub-districts [1]. Revenues from 2013 to 2017 Parangtritis Beach tourism rises significantly every year. In addition to coastal tourism activities, Parangtritis Village also has the potential for capture fisheries. Data from the Mina Bahari Fish Auction Place in Depok Beach states that capture fish production in Depok beach is a TPI with the highest fish production in Bantul Regency from 2013-2017.

Revenue can be a benchmark for the quality of education in a region. This is because someone with low income tends to be less aware of education for his child --- the higher parents'' level of income, and also the higher interest in continuing the school level. In Parangtritis Village, the increasing income of the village is also followed by increasing the level of village education. According to data from the Kretek District Central Bureau of Statistics, in 2016 the people of Parangtritis Village had an education level reaching S1, where the average education level of the village community was only reaching junior high school.

The coastal potential possessed by Parangtritis Village has caused many immigrants to seek their fortune in Parangtritis Village. Data from the Central Statistics Agency of Bantul Regency in 2013-2018 stated that Parangtritis Village had the highest population growth compared to other coastal villages in the Bantul Regency area. The population growth that occurs can affect the process of development of activities and development of a region that will increase the need for space or land. Residents have basic needs for land to be used as settlements or other buildings to carry out socio-economic activities. The higher the population will cause the need for land to be higher, while the existing land area is permanent so that if it crosses the boundary, there will be a decrease in carrying capacity of the environment [2]. Carrying capacity achieves good quality if the amount of land area for the built area is between 30-70% of the total land that can be used [3].

Parangtritis village, which is used as a coastal tourism village, managing marine products, certainly makes population growth grow. On the other hand, according to Bantul District Regulation No. 4 of 2011 concerning the Bantul Regency RTRW for 2010-2030, Parangtritis Village is used as the South Coast Strategic Zone, namely the Coastal Development and Marine Management of Depok Beach, the Pasir Parangtritis Gumuk Strategic Area as a scientific development and research. The village of Parangtritis, which is used as a dune conservation area is not allowed to be built in the area. Based on this, it is necessary to predict the availability of land for built-up land control that can be done by a model of spatial dynamics. This spatial dynamics model is based on the relationship of dynamic population growth and the availability of land for built-up areas [4]. The spatial dynamics model is made in the form of development of the built area which is adjusted by the degree of suitability of the built area so that it can show when the carrying capacity of the land in Parangtritis Village can no longer meet the development of its population. This study aims to built a model of spatial dynamics for land availability and analyze the relationship among these models with the education level and income of Parangtritis Village.

2. Methods and Equipment

This research was conducted with quantitative approaches and spatial analysis. The study was conducted in Parangtritis Village based on population growth data, as well as physical data. This research is an illustration of the interaction between the population and the land where they live. This interaction is manifested through the phenomenon of reduced land availability due to population demands for land whose numbers always increase over time so that the available land must be converted into built-in land to meet the needs of the population both for housing needs, the economy or the need to develop activities other. This phenomenon is applied in spatial modeling to determine land-use changes that occur temporally and mathematically. The model results in the magnitude of the trend of the relationship between population growth, built-in area and the availability of open land which is then projected to predict population growth and availability of land, especially for future developed regions. Then the prediction of land availability was analyzed by the level of education and income of the people of Parangtritis Village.

The primary data used in this study were obtained from the results of field surveys to obtain information about changes in land use and validation, as well as obtain information on income and education of the community, and the process of extracting information from Google Earth imagery. The secondary data used consists of social variables in the form of population data in 2008 - 2018, and spatial data of the Parangtritis RTRW to determine the boundaries of protected areas.

After the data is collected, the data is processed. Primary data in the form of extraction of land use information from Google Earth imagery that has been validated with survey results, then poured into causal loop diagrams (CLD) and stock-flow diagrams (SFD) to create dynamic system models. Secondary data undergo different processing. Population data are included in CLD and SFD for the next dynamic system model. The boundary area of the RDTR and land-use change data are then overlayed in order to obtain a spatial dynamics model.

The level of income and education of the community can be obtained from interviews on the existing grid, then accumulated into the level of income and education per hamlet in Parangtritis Village. The results of the spatial dynamics model of land availability were then analyzed descriptively with existing levels of income and education to find out whether the development of the land was built highest in hamlets with high levels of income and high levels of education.

Last, validation is performed to determine the suitability between the results of the simulation with the symptoms or processes that are imitated. The model can be stated either if the error or deviation of the results of the simulation of symptoms or processes that are imitated is small. The validation of the model's performance is done by a simple statistical method, namely Average Mean Error (AME) between the simulation results and empirical data. Model can be declared valid if the deviation between the simulation results and the actual data is <30% [5].

3. Results

3.1. System Dynamics Model

One of the most important goals of making a model is to take into account developments or reactions from the environment in response to human interactions with the environment. System dynamics use causal relationships that can affect the structure inside, both directly between two structures, as well as the results of various relationships that occur in several structures to form causal loops. A causal loop can be divided into positive causal and negative causal. According to the background on modeling issues as a story, a model variable, and an assumption, then made a Causal Loop Diagram (CLD) from the model of land availability and built-up area that showed on Figure 1.

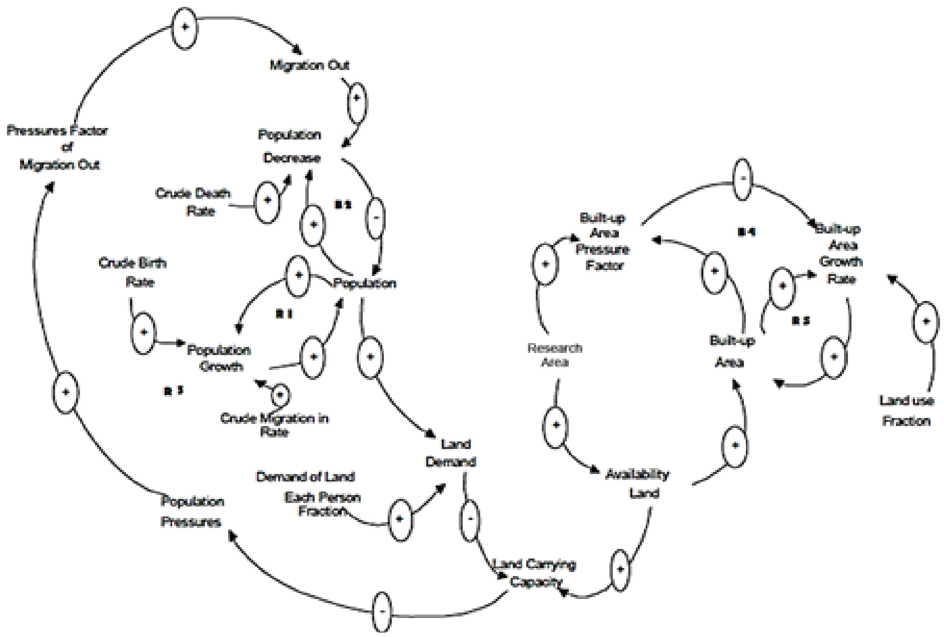

Figure 1: The Causal Loop Diagram of the Land Availability and Built-up Land Model [6].

According to Figure 1. the Causal Loop Diagram of the land availability and built-up area model consist of five feedbacks, that is two negative feedbacks and three positive feedbacks. Loop R1 describes relation between population and population growth. Population amount increase, then the population growth will increase. Population growth increase, then the population amount will also increase. Loop B2 describe population decrease, when population amount increase, then the mortality (population decrease) will increase. Conversely, if mortality (population decrease) increase, then the population amount will decrease. Loop R3 happened when population amount increase, then the land demand will also increase. Land demand decrease, then the land is carrying capacity decrease. Land carrying capacity decrease, then the population pressures increasing. Population pressures increase, then the pressures factor of migration out will increase. Migration out (emigration) increase will cause the population to decrease which population amount will decrease eventually. Loop B4 explain built-up area increasingly widespread, then the built-up area pressure factor also increasingly widespread, so the built-up area growth rate increasingly fast. The built-up area increasingly widespread, eventually. Loop R5 explain that built-up area increasingly widespread, causing built-up area growth rate increasingly fast. The built-up area increasingly widespread, eventually.

According to the Causal Loop Diagram (CLD), a system dynamics model for land availability and built-up area, then the next is made Stock and Flow Diagram (SFD), that is showed by Figure 2.

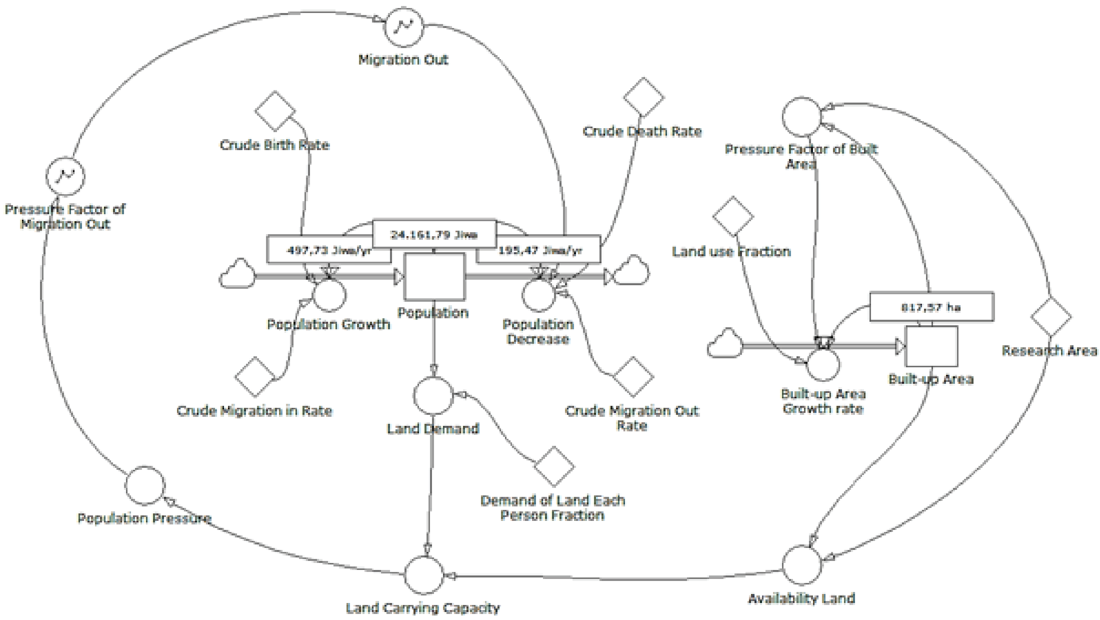

Figure 2: Stock and Flow Diagram (SFD) System Dynamics Model for Land Availability and Built-up Land.

After the model of the existing problem is entered into the Causal Loop Diagram (CLD), the next is to simulate the existing system as outlined in the Stock Flow Diagram (SFD). With details of the area of the water body of 32.36 Ha and the area of the protected area of 282.46 Ha, the area of the Parangtritis Village used in this model is 818.24 Ha. The last year of this modeling is 2100, where in Figure 2 we can see that in 2100 the population will increase to 24,161 inhabitants and the area of land developed reaches almost the entire land area of parangtritis village which is 817.57 Ha.

3.2. Dimensional Consistency Analysis

Dimensional Consistency Analysis has the shape of variable and dimension that be obtained from Stock and Flow Diagram (SFD) of land availability and built-up area model as follows:

1. stock Population = 7437<<Person>>
2. stock Built-up Area = 177,64<<ha>>
3. aux Land Carrying Capacity = 'Availability Land'/'Land Demand'
4. aux Availability Land = ''-'Built-up Area'
5. aux Built-up Area Pressure Factor = 'Built-up Area'/''
6. flow Built-up Area Growth Rate = ('Built-up Area'*'Land use Fraction')*(1-'Built-up Area Pressure Factor')
7. flow Population Growth = (Population*'Crude Birth Rate')+(Population*'Crude Migration in Rate')
8. flow Population Decrease = (Population*'Crude Death Rate') + ('Crude Migration out Rate'*'Migration Out'*Population)
9. Constanta Crude Migration out Rate = 0,85<<%/year>>
10. Constanta Crude Death Rate = 0,69<<%/year>>
11. aux Demand of Land each Person Fraction = 0.25<<ha/Person>>
12. Constanta Crude Migration in Rate = 0,85<<%/year>>
13. Constanta Crude Birth Rate = 1,21<<%/year>>
14. aux Population Pressures = 1/'Land Carrying Capacity'
15. Constanta Research Area = 818,24 <<ha>>
16. Constanta Land use Fraction = 4<<%/year >>
17. aux Migration Out = GRAPH('Migration out Pressure Factor';0;1;{0;0,14;0,16;0,23;0,28;0,30;0,31;0,32;0,36;0,40;0,43;5//Min:0;Max:5//})

18. aux Pressures Factor of Migration Out = GRAPH('Population Pressures',0;1;{0,00039;0,00040;0,00040;0,00041;0,00042;0,00043;0,00044;0,00045;0,00046;0,00048;0,00049;1//Min:0;Max:1//})

19. aux Land Demand = Population*' Demand of Land each Person Fraction '

According to the model variable, several assumptions is used in the model, as follows:

1. Pressure Factor of Migration Out: Assume a scale of 0 - 1, where if population pressure is high, the suppressor of outgoing migration is also high. This is due to factors from within the research area such as limited land ownership, concerning the majority of the population engaged in agriculture, competition for land can occur and will encourage residents to move out of the research area to other areas that are considered more profitable.
2. Migration Out: Assume a scale of 0 - 5, where if the outflow suppression factor is high, then the outgoing migration that occurs is also high.

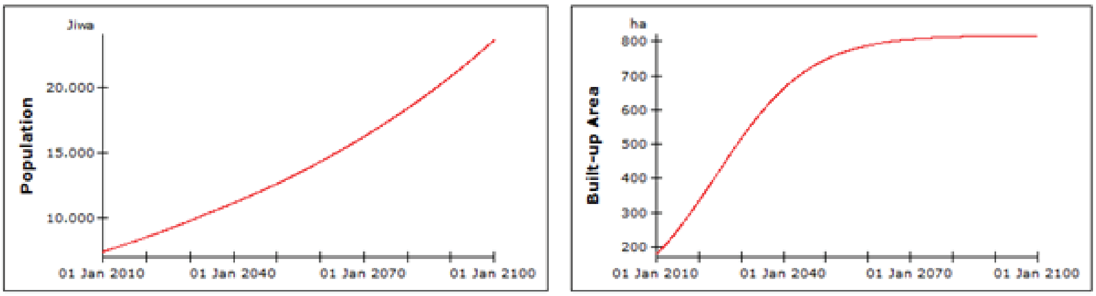

Figure 3: (a) Simulation of Population (b) Simulation of Built-up Are.

3.3. Simulation Result

The following Line Graph illustrated the simulation result shown in Figure 3a and 3b.

On Figure 3a and Figure 3b, It can be seen that the amount of population has a unique pattern with the exponential growth pattern (behavior). The variable of the built-up area also have a unique pattern then horizontal. Therefore, it has the feature of the sigmoid pattern (behavior).

3.4. Model Validation

After simulating the model of the relationship between population growth and land availability with Stock Flow Diagrams, it is necessary to test the accuracy of the simulation model so that the validity level of the model can be known. Accuracy test using error testing, namely Average Mean Error (AME) between the variable built-up area and population in a certain period. The period is adjusted between the time of accuracy testing and the actual data, namely in the period 2008 to 2018.

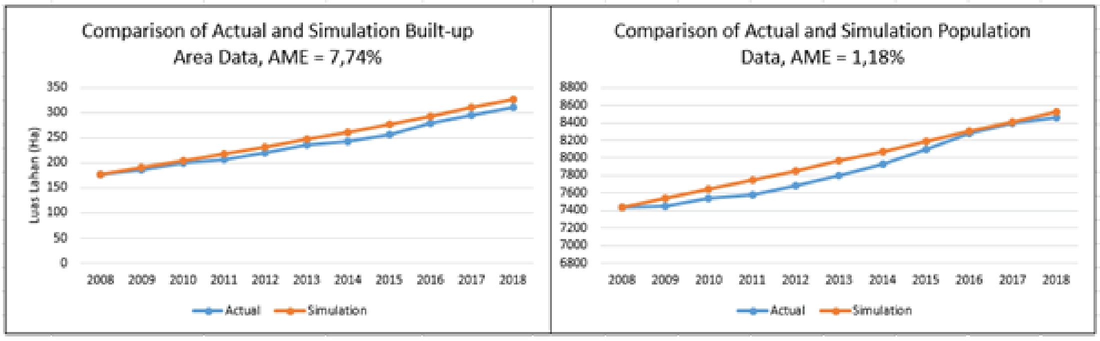

Figure 4: (a) The amount of population in 2008-2018, (b) The extensive built-up area in 2008-2018.

In the population subsystem, the actual population data in the past ten years has an average of 7,878 people; this number does not show much difference with the average of the simulation results which is 7,971 people. Based on the actual data and simulation, the results of the model validation between both of them produced a figure of 1.18%. In the built-in subsystem area, the actual data shows an average value of 233.30 Ha, while the average simulation results show 251.38 Ha. The AME test results between the actual built-up area and the simulation are declared valid and can be used for further analysis of 7.74%.

3.5. Model Simulation

On Figure 5, showing the development of the built-up area on Parangtritis Village is tend to rise, while the land availability tends to fall. The encounter of development line of built-up area and land availability (50% from the extensive of research area) will occur in 2022. Then the comparison between the built-up area and the land availability reach the ratio of 70:30 in the years among 2031 and a ratio of 80:20 in 2039.

3.6. Spatial Dynamics

In determining the built-up area, people tend to choose a place that is safe, comfortable, and strategic to fulfill their daily needs. Physical factors and accessibility factors can be used as limiting factors that can help residents choose locations for the built area. From these factors, it can be determined that the area of land suitability built. The result of the model simulation is included in the suitability area so that the results in Figure 6.

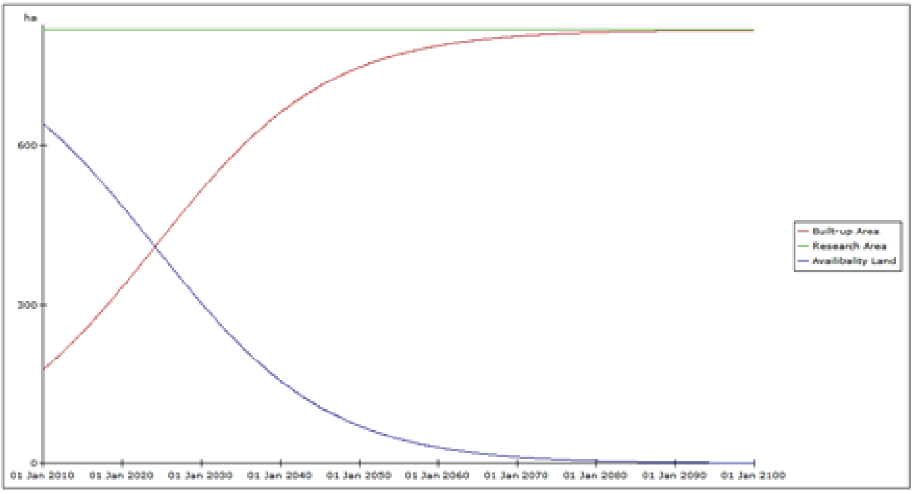

Figure 5: The relation of the population amount and the built-up area with simulation until 2100.

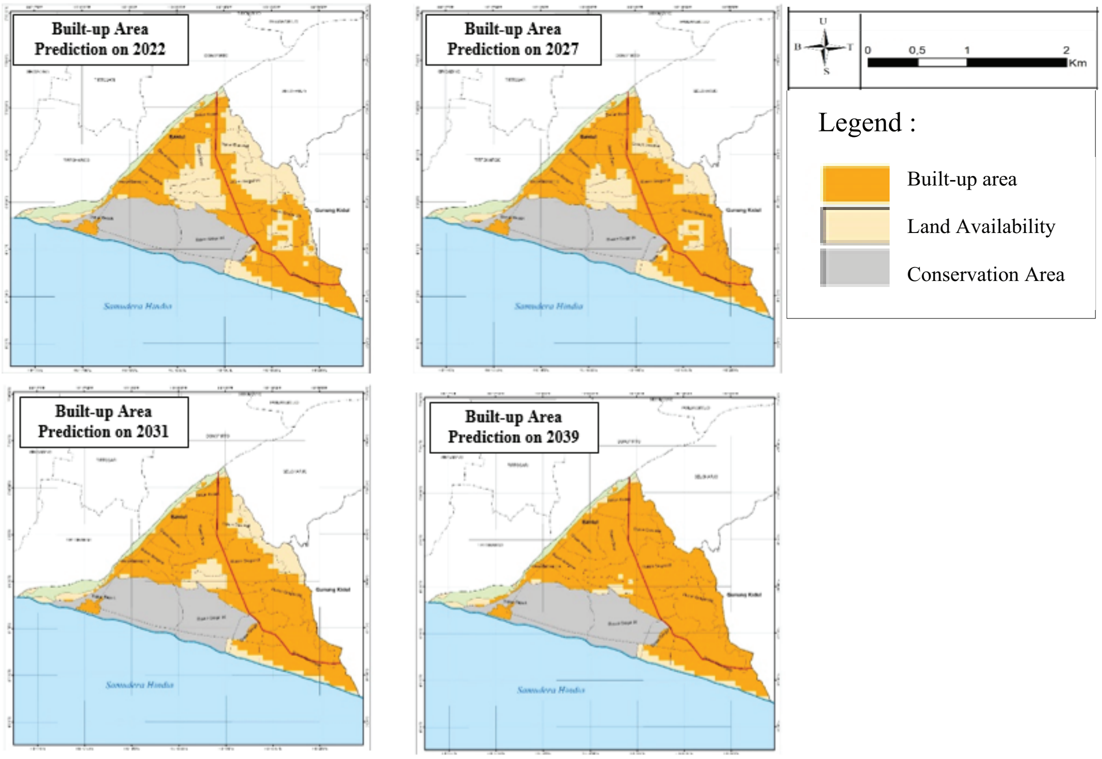

Figure 6: (a) The development of the built-up land area in 2022 reached 50%, (b) The development of the built-up land area in 2027 reached 60%, (c) The development of the built-up land area in 2031 reached 70%, (d) The development of the built-up land area in 2039 reached 82%.

3.7. Level of Income and Education

The level of income and education in this study was obtained from the results of interviews from existing hamlets.

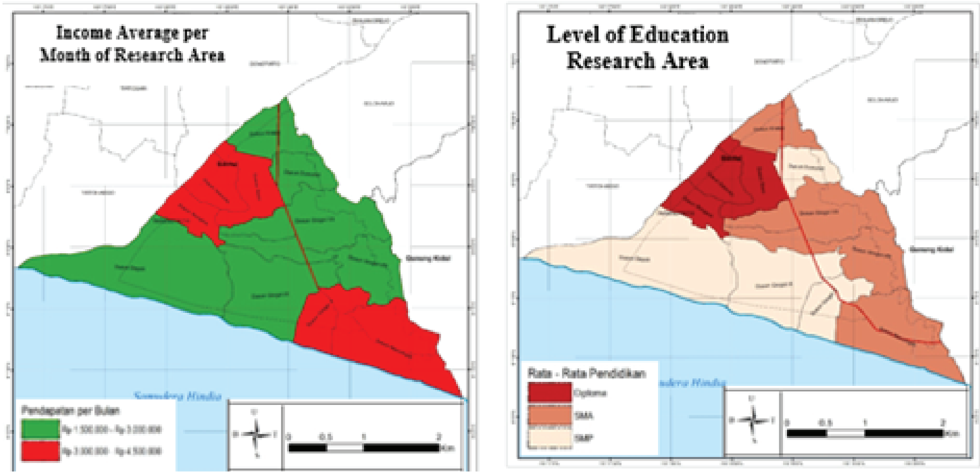

Figure 7: (a) Average of Income per Month, (b) Level of Education for Research Area.

The average income of the people of Parangtritis Village still ranges from Rp 1.500.000 - Rp 3.000.000, which means that the people of Parangtritis Village are in the middle-income group. Hamlet of Mancingan, Bungkus, and Samiran have high population densities, but the average income of the community is Rp. 3.000.000 - Rp. 4.500.000. The income of an individual can be a benchmark for the quality of education of the individual. The higher the income of parents, will increase desire in continuing the school level. With high parents' income, students feel that all basic needs in school are always fulfilled. Thus the interest in continuing schooling is higher because students feel facilitated by parents. This is evident in the Hamlet of Bungkus, Samiran, and Sono. However, it is not following the conditions of Mancingan Hamlet, even Grogol X Hamlet. Mancingan Hamlet is already included in the class of modern society, where a minimum level of education in modern society is senior high school.

4. Discussion

If it is associated with the level of income and education of Parangtritis Village, the prediction of the model in 2022 is relatively straightforward. Hamlet of Samiran, Bungkus, and Mancingan, which are the regions with the highest population have high income and education levels in 2019. In the prediction model in 2027, hamlets that have high levels of education and high levels of interest are still hamlets with growth in built-up land also high. Sono Hamlet is a hamlet with the highest land growth built among hamlets that have other high levels of education and income.

Whereas in 2031, the hamlets with the highest levels of education and income have a high level of built-up land, both the Mancingan Hamlet, Grogol X Hamlet, Sono Hamlet,

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Samiran Hamlet, and Bungkus Hamlet. The built-up area then leads to the hamlet with a moderate income level and high school education level. In 2039, all hamlets have almost reached their land availability threshold. Hamlet of Bungkus has started to run out of land availability, and Grogol VII hamlet is a hamlet with the highest land growth. Development of built-up land no longer focuses solely on areas that have high levels of education and income but also have spread to the level of education and moderate-income.

5. Conclusion

The decrease in land availability is shown by the spatial dynamics model shown by the development of the built area. The research area is predicted to reach 50% of the built area in 2022, 60% of the area will be built in 2027, and reach the environmental carrying capacity threshold of 70% in 2031. The land will develop and meet the regional capacity that is not suitable or has exceeded the threshold, which reached 82% in 2039. Areas that have high levels of education and income levels have high growth in built-up land, thereby reducing the availability of land and will continue to grow to reach the threshold of land availability.

Acknowledgement

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