Alternative Method in Selecting Location of Subsidized Housing Loan in Medan and Deli Serdang, Indonesia

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Abstract. Indonesia is the fourth most populous country in the world. Therefore, the Indonesian government needs to provide a significant amount of housing for Indonesian citizens. In the place and time people live today, housing prices have risen so fast and so high that the lower classes cannot afford to buy their own houses where the government must provide housing for the citizens. To maximize the government's efficiency in making subsidized housing, the government needs to examine many variables to determine which place is most suitable for housing subsidies. Some examples of values that need to be the object of study are to assess the quality of life or life support value of each location such as the local environment, how strategic the place is in terms of how close it is to public facilities. All information provided is not in numeric values. To apply this model to the analysis, it is necessary to carry out the stages of converting values into the same class for each variable. After assessing and converting all the information into a certain value, it can then be calculated to obtain an objective value to determine the most suitable place for subsidized public housing using two types of modelling systems to get the most accurate results.

1 Introduction

Housing and settlement problems are increasingly serious and critical in Indonesia [1]. The Director-General of Housing at the Ministry of Public Works and Public Housing, said that based on data from the 2020 National Socio-Economic Survey (SUSENAS), the housing ownership backlog reached 12.75 million. This number also does not include the growth of new families, which is estimated at around 700,000-800,000 per year [2]. By the year 2025, it is predicted that the total Indonesian population will reach 272 million lives. Indonesia itself has a vast land that consists of 5 main big islands such as Sumatra, Borneo, Java, Sulawesi, and Papua. However, 56,1% of the population is concentrated on the island of Java [3].

To avoid overpopulation in one region, there needs to be an even distribution of population in each region. This can be achieved by creating a new settlement area in other regions outside of Java. The government has issued quite several programs to make it easier for low-income people to access housing. Despite that, the government itself still faces various problems such as the limited availability of cheap housing land and the increasing number of backlogs [4]. To help finance housing for low- income communities, in April 2015 the government issued a program to build a million houses per year and the progress has also continued to increase to more than one million units since 2019 [5].

Therefore, there is a need to find a suitable location to build a new housing area in a different location outside Java that also accommodates the solution to the problem stated above. There is already various research using different methods to find a suitable location such as Fuzzy Simple Additive Weighting (FSAW) and Analytical Hierarchy Process (AHP). The result of the research using the AHP method only provides the hierarchical list of factors that will contribute to finding a suitable location without providing the actual location itself [6]. Meanwhile, the result of the research that uses the FSAW method only produces a single specific location based on the category [7]. Therefore, decided to use a different method that will produce more detailed results with more options. With the usage of GIS with the multi-criteria decision making (MCDM) method, the next apply determine the suitable location for the development of subsidized houses. The objective of this research is to determine the suitability of the location for the development of subsidized housing for low-income housing for low communities (MBR).

2 Literature review

First, A place to live is an essential part of the needs of human life, therefore every person or family must have their own place to live. A place to live which can be regarded as one of the indicators of people's welfare so that providing affordable housing can be called a government obligation.

The government itself has tried to provide affordable housing or shelter for the lower-class people, however, they often experience difficulties with this. From a community perspective, people also think for long term

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consequences about affordable housing provided by the government. There are multiple factors that need to be put forward by the government when searching for the location of housing factors, such as whether the house is far from the source of the search for residential communities [19], the cost of the land to be developed, the geology of the area [7] , the possibility of a disaster in the area [3], and comfort factors for residents such as climatic conditions [4] and available facilities. In addition to focusing on the location of house construction, the government also needs to increase the efficiency or effectiveness of land use, namely the use of vertical houses [20]. In theory, vertical housing will double the land area without having to consider the actual land area, such as a house that has an area of 100 hectares. When applying the concept of a (vertical) level building, it can be doubled to 2-8 times. Another factor that needs to be considered by the government is the population density factor. By creating land for subsidized housing, of course, it will create density in the area so that the government must make the population density factor in the area to be built a deep consideration [21]. In the construction of subsidized housing, apart from the location factor and potential future problems, also consider factors about how the building will be formed or more specifically the use of building materials and building models that are safe for habitation. What is considered in the use of building materials is based on the safety materials used and in terms of the comfort/health of the occupants of the house such as adequate air ventilation [22]. Another external factor that needs to be studied further in the construction of subsidized housing is the vulnerability to natural disasters. Factors of vulnerability to natural disasters can be analysed through 5 parameters, namely (slope, disaster vulnerability, river and coastal boundaries, and protected areas) [26].

In making housing, the developer not only just focus on the land or building itself, but also need to learn more about the target residential users so that the focus of the government itself is not only on land and buildings but also to the community. An example of a real scenario is whether the occupants are young or old workers. Because it is impossible or highly unethical to place elderly residents in the centre or in a metropolitan area [24]. The main objective of establishing new subsidized housing is to provide affordable housing for the community, So the government must carefully prepare other supporting matters, such as the cost of living because if there is instability with economic factors, the cost of living which initially became a solution that tried to be solved by the government could become a new problem for the residents [23]. The intended target population is also an important factor. In the distribution of housing, cannot conducting the theory of first come, instead need a selection method regarding who is the priority to get subsidized housing such as people with disabilities, veterans, or people who do not have a place to live [27]. All the factors that have been mentioned can be taken into consideration in finding a suitable housing location.

Searching for suitable housing locations using a geographic information system can be done using the analytic hierarchy process (AHP) method [1, 9], pairwise comparison method, and weighted overlay method. The ANN method can be used to get a forecast of the future value of land prices [8]. Some experiences use network analysis, remote sensing, GIS techniques, cost-distance analysis, map rasterization, map grouping, pairwise comparison method, spatial analysis tools, surface tools, conversion tools, Euclidean distance tools, model builder tools, and weighted overlay matching tools as well as the AHP method [10][11][14][16][17][18]. As a reference, a slightly different literature can be used. The topic is about finding a suitable hospital place. It uses the pairwise comparison method and the weighted overlay method and uses a raster map [12]. Another paper uses the WLC Score, FDEMATEL, and CMA-ES methods [13]. A certain study uses a spatial quantitative analysis based on ArcGIS 10.2, ENVI5.0[15].

By using ArcGIS as part of a GIS tool, researchers can analyse and create a summary matrix of an area so that it can be seen how strategic the location is, for example whether the land to be built is suitable for development [25]. Most studies require a map rasterization step. Land suitability analysis with a geographic information system can be more easily understood using a raster map [10]. This is because the study area will be in the form of pixels or a grid. Each cell of the grid will be filled with a number (degrees) to represent a different environmental phenomenon.

In addition to the method, the dataset of a study also needs to be considered carefully. One example uses datasets from the Aqaba Special Economic Zone Authority (ASEZA) and the Department of Geographic Information Systems, Ministry of Public Works, and Public Housing [10]. Another research uses datasets from field observations, digital data and census data from the Matara Secretariat Division and City Development Authority in Matara and Colombo as well as data from other literature [11]. There is also research that uses a dataset from Google Earth Image and Topographical Map of Survey of India (SOI) [12]. Another example also comes from Google Earth and the results of the questionnaire [13]. The other research that uses datasets that comes from the New York State (NYS) tax parcel map, NYS Clearing House, New York State Department of Education (NYSED), the census database, city tax assessment, LODES census data set, Digital Elevation Model of Erie County [14]. Another example of datasets that was used came from the Computer Network Information Center of the Chinese Academy of Sciences, National Meteorological Information Center, NASA Earth Observation System, National Centers for Environmental Information (NCEI), Ministry of Environmental Protection, Data Center of Resources and Environmental Sciences of the Chinese Academy of Sciences [15]. Research that uses a dataset from Satellite Image, SRTM DEM 30m Resolution 2012, Landsat-8 OLI (Operational Land Image – 2015) [16]. The dataset is derived from a geo-referenced base map using geo-coordinates obtained in the field using a handheld GPS on a geo-referenced device [17]. The following research was conducted based on the datasets from interviews, observations,

questionnaires, and literature studies or agency surveys related to the preparation of materials [18].

After carrying out the methods that have been mentioned, the results obtained vary according to the factors determined to search the area and the method used. Some of the results of this process only produce very little suitable area [5]. This is because there are too many determining factors or the limited empty area available for development [2, 6].

3 Proposed method

The stages of research implementation are consisting of the stages of determining research objectives, literature study for previous research and determining category, model development, data collection, model implementation and result and model evaluation (Figure 1). After conducting previous research, the next step is to determine the selected category to assess the suitability of the location for the construction of subsidized housing. The selected category such as public amenities, mobility factors, economic factors, population factors, land property factors, environmental factors, and land use type and restriction. The details of each factor can be explained as follows:

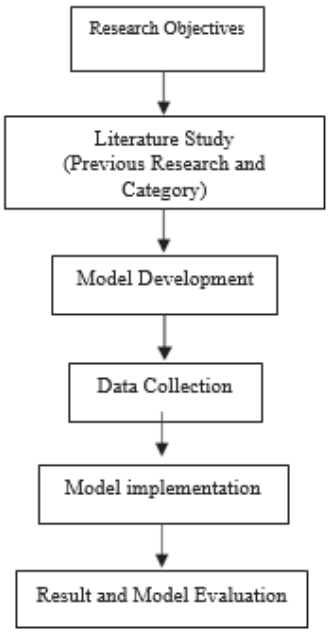

Fig. 1. Research methodology flowchart.

- The public amenities category can be magnified into more selected variables such as emergency facilities, bus stops, bus terminals, industrials, schools, banks, malls, hospitals, restaurants, train stations, parks, and playgrounds.
- The mobility factor can be determined by how many people are moving during the night-time based on cellular data
- The economic factor category can be magnified into a specific variable like job opportunity and poverty rate ratio.
- The Population factor category can be magnified into specific variables such as population change and racial composition.
- The Land Property category can be magnified into specific variables like property value and housing rent.
- The environmental factor category can be magnified into specific variables such as gentle slope, distance to an industrial site, and state park.
- Land Use Type and Restriction category can be magnified into specific variables like land use and residential land usage.

By assessing all aspects, as previously mentioned using GIS in terms of position and suitability, it can then be determined whether Medan city is a suitable location for the subsidized housing program. And then, where are they located, and how much does each location cost?

Table 1. Source of data used.

Data	Sources of data
POI's area	Google POI
Emergency facility	Kemendagri - MoHA
Industrial area	Land use - BIG
Medium to high-income neighborhood (Family Income)	Susenas - BPS
Low population density	Bappeda SUMUT
Fixed mobility at certain times of the night	Cellular Data - Cellular Provider
Land property value	ATR/BPN
Low elevation	DEM - USGS
Distance to industrial site	Land use - BIG
Non-flood area	Bappeda SUMUT
Residential land use	Land use - BIG
Unproductive land (scrubs or vacant land)	Land use - BIG

3.1 Public amenities

The points of interest that are taken into consideration when creating the model are emergency facilities, bus stops, bus terminals, industries, schools, banks, malls, hospitals, restaurants, train stations, parks, and playgrounds. The distance to the points of interest is divided into multiple classes based on distance in kilometres which are shown in Table 2.

Table 2. Distance class for each POI.

List of POI's	Distance in Kilometer (Km) (Fu and Xiong, 2015)
Emergency Facility	0.25; 0.5; 0.75; 1.0;1.5
Bus Stop	0.25; 0.5; 0.75; 1.0;1.5
Bus Terminal	1.0; 1.5; 2.0; 3.0
Train Station	1.0; 1.5; 2.0; 3.0
Road Networks	0.25; 0.5; 0.75; 1.0; 1.5, 2.0 and 3.0
School, Bank, Mall, Hospital, Restaurant	0.25; 0.5; 0.75; 1.0; 1.5, 2.0 and 3.0
Park and Playground	0.25; 0.5; 0.75; 1.0;1.5
Emergency Facility	0.25; 0.5; 0.75; 1.0;1.5

3.2 Mobility factors

The Data below indicates point cellular data. The Point Cellular Data will indicate the density of cellular data transmission and distribution within the area. The grey colour indicates there is no activity of the cellular provider user in the grey area (blank spot). By using the distribution of cellular data, information about mobility in each population at night can be seen more clearly the pattern. People mobility data shows the density of mobility in the population, where red indicates very

dense and yellow indicates less dense. Hotspot value is obtained from point density over the distribution of Mobile users' Economic factors can be determined by 3 variables which are high job opportunity, medium income neighbourhood, and low poverty rate. High job opportunity category can be assessed by looking at industrial area variables.

The Medium Income Neighbourhood factor can be determined by looking at the family income. Poverty rate factor can be determined by looking at the average poverty rate within the area. The population factor can be measured by seeing the population density where low population density is preferred more. The variable approach for land property value is that the lower the land value, the more suitable it is to determine the location of subsidized settlements. For land property data, it is necessary to change the value to land in a new class with a certain value in the new value table. The lower the land value, the more suitable it is to determine the location of subsidized settlements.

Environmental factors can be determined by seeing the elevation/slope of certain areas where gentle slope is more preferred. High slope area also indicates the area have very low suitability. The slope data was obtained from DEM surface data analysis. Besides looking at elevation and slope, also determine the environmental factor by assessing the flood area. After getting the value for each type of data, the next step is to input those values into the analysis model to get land suitability results (See Table 2 and Tables 3).

Table 3. Value transformation of all the data.

Data	New Class Value
Service Area	1, 2, 3, 4, 5
People Mobility	1, 2, 3, 4, 5
Land Use	0, 1, 2, 3, 4
Land Property Value	0, 1, 2, 3, 4, 5, 6, 7, 8
Low Elevation / Slope	1, 2, 3, 4, 5, 6
Non-Flood Area	0, 1
Forest Area	0, 1, 3

The data that will be inputted into the analysis model are service area with new class value of 4 and 5, people mobility with new class value of 4 and 5, land use with new class value of 3 and 4, land property value with new class value of 5, 6, 7, and 8, low elevation/slope with new class value of 5 and 6, non-flood area with new class value of 1, and forest area with new class value of 3.

The modelling steps that will be used to get the results are as follows:

- Setup transform variable based on type of data
- View variable which has been transformed
- View output suitability new value for each variable is added and every change in transform data
- Transform layer and suitability map will automatically appears
- Sections, subsections, and subsubsections

There will be two analysis models used with details of each explained below:

Analysis Model 1. The steps to build the model.
Transforms (reclassifies) all variables into new values according to their suitability based on their respective data attributes. Carrying out a raster overlay weight sum process and giving a multiplier value to each variable such as land use, service area, and land value are the most important variables, so the value of the weight variables is 2, the other variables are considered the same so that the value is 1 (Figure 2)

Analysis Model 2. The steps to build the model
The basic difference between model 1 and model 2 is that model 1 does not make the existing built-up area a limiting factor. In model 2, the built-up area is used as a limiting factor with the assumption that the areas that have become settlements, offices and built-up areas are not possible to be used as alternative locations for the construction of new houses except in special cases (Figure 3).

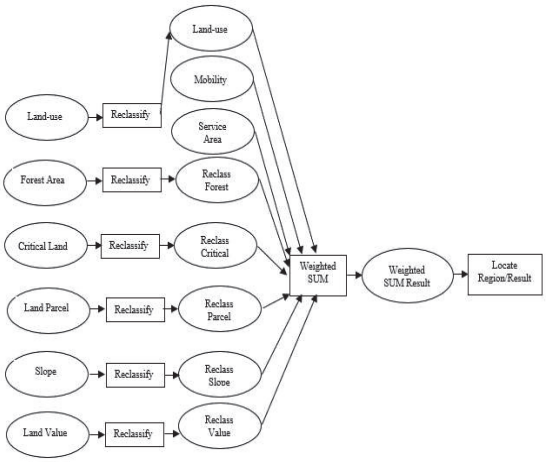

Fig. 2. Flow analysis for model-1 using ArcGIS model builder.

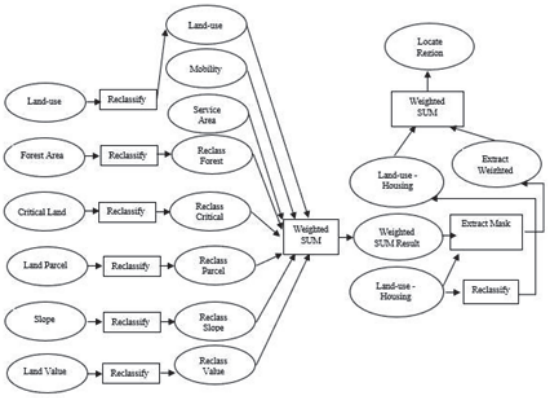

Fig. 3. Flow analysis for model-2 using ArcGIS model builder.

4 Result and discussion

This study shows the results of the analysis according to the location of two different spatial analysis models. The output of Model 1 is a raster with values ranging from 6.5 to 61. This value is the sum of the pixel values of all variables and the multiplication based on the weight of each variable. Figure 4 in Map No.1 is a projected simulation of the if the suitable area is taken from the highest values in the range of 49.1-61 and Figure 4 in

Map 2 of the range 53.5-61. However, this will lead to another question, what is the range value that will be used to select the pixels that enter the recommended area? Therefore, need to validate the model result with actual KPR data. In model 1, the factor of the existing settlement and the built-up area is not a limiting factor, so it is very possible that the selected location is in fact already a residential area.

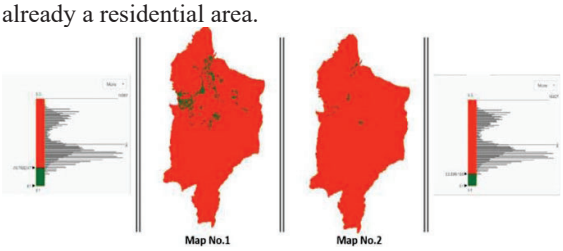

Fig. 4. Suitable location for subsidized house based on model-1.

In model 2, the factor of existing settlements and built areas has been used as a limiting factor so that the selected location is an area that is still empty, and housing can be built. The output from model 2 is a raster with a value range from 7.5 – 57 (Figure 5). This value is the sum of the pixel values of all variables and the multiplication based on the weight of each variable without land use for settlements and other built-up areas.

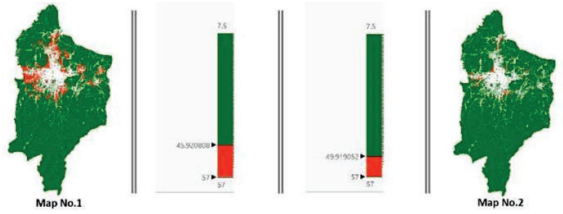

Fig. 5. Suitable location for subsidized house based on model 2.

To validate the results of the analysis, then a comparison of the results of locations suitable for subsidized housing with the location of existing housing that have been built is carried out (Figure 6). The comparison results show that the suitable location for housing which spreads in Medan City and Deli Serdang Regency, in many places, shows good location suitability, especially in the south, east and southwest of the study area (marked by circles on the map).

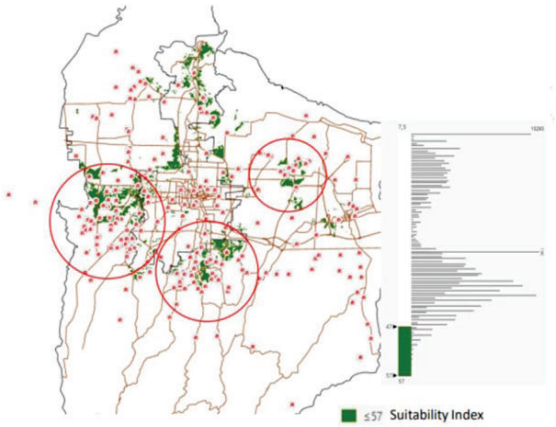

Fig. 6. Comparison between suitable location for housing and existing "subsidized KPR" in the city.

In the future, to get more accurate results, the research can add more variables into consideration such as socio-economic data (income, poverty), and transportation that can be measured by the movement of people. Regional analysis based on SUSENAS and PODES data can also help improve results.

5 Conclusion

This paper proposes an alternative approach to determine the best and specific location for the construction of subsidized housing for low-income communities. Two models of spatial analysis for determining the best location are proposed in this paper, namely a model that uses settlement data as a limiting factor and one that does not use a limiting factor. The best location for the construction of subsidized housing can be determined based on two different models with validation results showing similarities between the location of the modelling results and the actual location of the existing subsidized housing development.

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