BALI CITY FORECASTING : SIMULATION FOR CITIZEN AND GOVERNMENT

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ABSTRACT
Bali is most popular tourist destination in Indonesia which have rapid increasing number of population as well as tourist. The existing built-up area will expand to meet the demand and land cover change became a challenge. Using GIS is an option to analyse those development and applied in urban planning modeling to create simulation how the city will be in future. Urban planning modeling useful to understand city growth, support urban planning for government and provide important information for citizen. Residential area, road network, infrastructure facilities and another build-up area will take into consideration for the city growth. By using existing base map, open source data, statistical data and GIS analysis we can simulate city growth in Bali. To deliver the information not only to government but also to citizen, it is needed to develop the application in web based. The result of this simulation show information of cities to citizens about their future environment and hopefully could satisfy their Quality of Life (QOL). The result consist of population number change based on age classification, budget and accessibility to facility in grid 500x500m.

1. INTRODUCTION

Bali is one of the province in Indonesia that called as Gods Island or paradise island because the beautiful scenery and the cultural heritage. As most popular tourist destination in Indonesia, Bali is growing rapidly and has become the center of trading, education, and industry. Population increase of 1.14% per year in Bali is accompanied by rapid developments in many areas (Statistics of Bali Province, 2016). Government needs to balance the rise number of population with development or increase carrying capacity of public facilities and infrastructure to satisfy resident Quality of Life (QOL).
Bali consist of 9 city or regencies with Denpasar as the capital city. Denpasar as the heart of Bali has become the center of commercial, business, education and governmental activities. Tourism in Bali has created economic opportunities for small local businesses entrepreneurs in Denpasar and its surroundings. Denpasar has become one of the wealthy cities in Bali and a favorite destination for many people from other regency and other islands in search of employment and business opportunities. Thus can lead unbalance development among the others city/regency. This situation can be worse because the increasing population and residential area not well distribute among the others regency and unbalance with development road network. It is urgently needed to develop an efficient and reliable compact city to the region so the population can access the public facility faster and low fuel consumption.
Several countermeasure to overcome dense population and unbalance development in Bali can adopt from the other big cities around the world. There are alternative to solve it, in example built smart city / compact city, built new road network, built new central business district, develop new infrastructure / public facility in rural area, and press the population growth. For the first step, some activity is needed to simulation of city in the future in Bali using spatial and statistical data. Predict the city in future is still a challenge. Using GIS technology and web services could give initial forecasting of city development and get the feedback from government as well as citizen. This research aim to generate web application using spatial and statistical information related city forecasting for citizen and government.

2. METHODOLOGY

There are several indicators that could be take into account for city forecasting. City development may be related to topography, transportation, land use, social structure and economic activities, but demography and economies are the two most important driving factors for urban expansion (He et al., 2008). To analyse city forecasting and put it in web application already develop in Japan version as a tool for citizens that shows information about the future of their city to enhance their awareness and communication with urban planners (Hasegawa, 2015).

In Japan version city forecast, they have a lot of open data to analyse and already calculate for all over Japan. Japan city forecast faced decreasing number of population up to 2040, meanwhile population in Bali still increasing up to 2035. Comparison between Japan city forecast and Bali city forecast show in Table 1.

Table 1. Comparison between Japan city forecast and Bali city forecast

No	Data	Japan city forecast	Bali city forecast
1	Population forecasting	up to 2040	up to 2035
2	Age classification	0-4, 5-9, 10-15, …., 75-79, 80-85, >85	0-4, 5-9, 10-15, …., >75
3	Residential area	available	available
4	Building age	available	not-available
5	Facilities data	medical, school, administrative, supermarket, nursing, welfare, park	medical, school, administrative, prayer venue

The input data were selected in Bali city forecast are population data, public facility data, road network data and economic data (Table 2). The result will be shown in grid 500m x 500m as mapping unit to make easier analysis and better understanding for citizen and government.

Table 2. Input Data and Indicators for Bali City Forecasting

No	**Input Data**	**Indicators**	**Data Source**
1	Population data	a. Total population	Statistic Agency
		b. Elderly rate	
		c. Youth rate	
2	Public facility data and road network	d. Access time to medical facility	Base Map and OSM
		e. Access time to school facility	
		f. Access time to administrative facility	
		g. Access time to prayer venue	
3	Economic data	h. Administrative cost per citizen	Statistic Agency

Population recognize as important factor in urban planning and city development. From the population data and land use data, we can determine the density each residential area. The population data consist of total number of population per regency for each group age and gender. In population projection, it's consider fertility, mortality and migration. To match with our mapping unit analysis, we need to allocate the population data per grid 500m x 500m based on total polygon residential area.

$$\frac{RA(i)}{\Sigma RA} \times \Sigma pop \qquad (2.1)$$

The population allocation is to divide the residential area in grid-i ($RA_{(i)}$) per total residential area (ΣRA), then multiple by total population (Σpop). We can allocate this population by each administrative population data, in case of Bali we used city population data because there no other detail data in district or village.

Public facility in the urban environment has a significant effect on the citizen quality of life. Good quality an sufficient number of public facility such as education, health and administrative facility are the key factor for better human resources. Better and more accessible education and health facility can improve local, regional and national growth. Comparison between public facility and population number should be maintain. The number of public facility will be likely increasing along with the rising number of population.

The accessibility to public facility and central business district can determined citizen to choose their place of life or settlement. The route choices in this research used simple Dijkstra method, shortest path between Origin and Destination nodes, with time duration as a link cost of Open Street Map (OSM) data (Wijaya, 2016). This interpolation didn't consider link congestion, citizen can go over all links without waiting at a node. With this analysis we can deliver time-distance information from settlement area to nearest public facility.

Administrative cost per citizen could be estimated based on the statistic agency data of regional revenue for each city. The method of calculation is to predict some sectors revenue will up and depends on the number of population and number of facilities. We calculate the sum of revenue and divide it with the total population. In this research, we also offer compact city concept. We assume 30% citizen that lived outside the compact city grid will move to compact city grid every year.

$$px[m] = px[m] + ((sum(px)*0.3) * wx[m] / sum(wy)) \quad (2.2)$$

px[m] : population of destination mesh
sum(px) : sum of population of all source meshes to move
wy[m] : weighting factor of destination mesh
sum(wy) : sum of weighting factor of all destination meshes from move

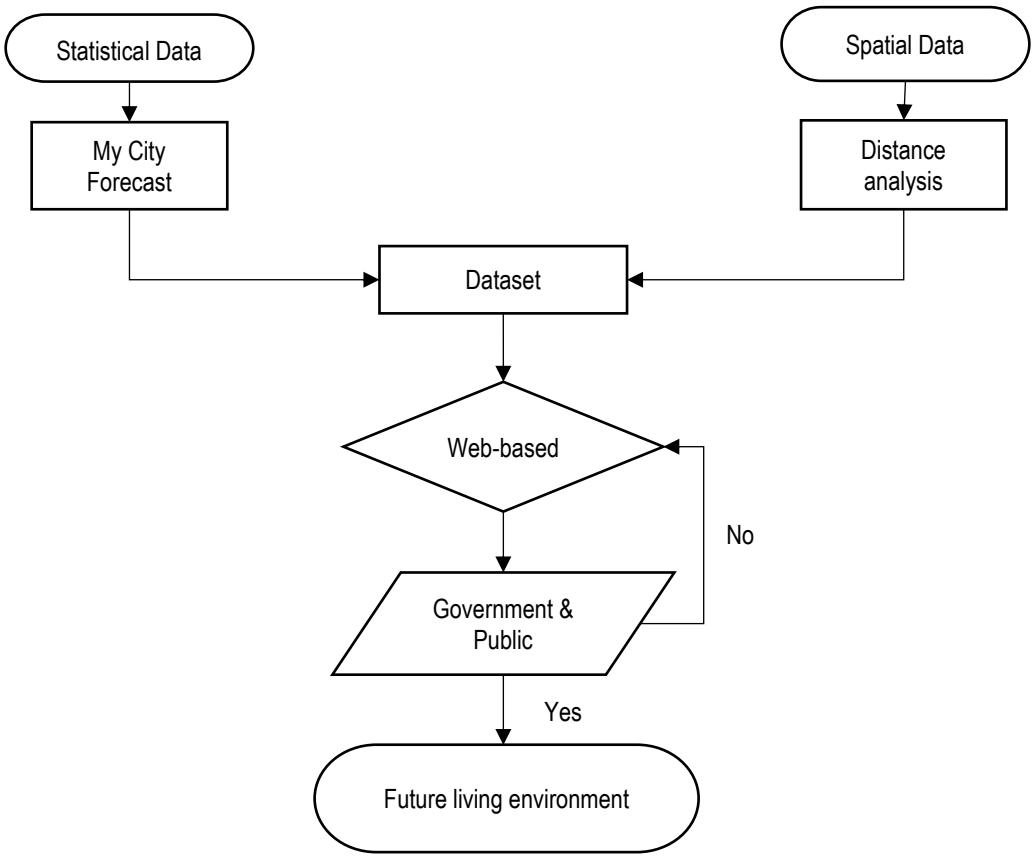

Figure 1. Flowchart of Bali City Forecasting

The simulation run forecasting for the output indicators for every 5 years for the urban transition simulation with 'Business as usual' (BAU) concept as well as concept of compact city.

3. RESULT AND DISCUSSION

The number of population in Bali are totaled 4,200.1 thousand people (2016), consisting of 50.36% of male and 49.64 of female. With an area of 5,636.66 km^2, the population density in Bali reached 754 people/km^2. But this distribution was concentrated in city, especially in the Denpasar as capital city. The population density in Denpasar was 7,022 people/km^2, with an only 127.78km^2 area. Population issue become essential for sustainable of Bali development.

Nowadays, population in Bali still increasing every year and could be reach 4,912.4 thousand in 2035. Government and citizen should concern about this. Government should consider this in their urban planning, meanwhile citizen can imagine how the environment will be and decide where they should live.

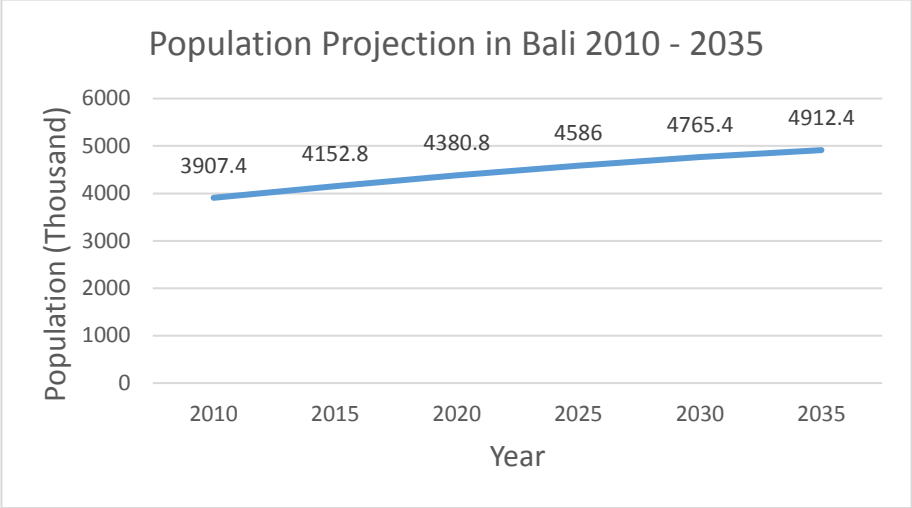

Figure 2. Population Projection in Bali 2010 – 2035 (Statistics, 2013)

Topography in Bali may differ among one city to another. Public facility spread entire Bali area, especially in city and flat area. The road network connected whole Bali city, but link number in Denpasar much more than others city. Primary road network connected one to the others city along the coastline. The popular transportation mode in Bali are car and motorcycle, they didn't have railway network.

In term to visualize the future condition to citizen and government, simple and user-friendly application is necessity. Citizen can know what their environment will be in the future, and the government could make better urban planning. Government also can encourage citizen to collaborate with their program, in example if resettlement is needed to better future with compact city concept. The designated compact city grid show in orange grid boundary.

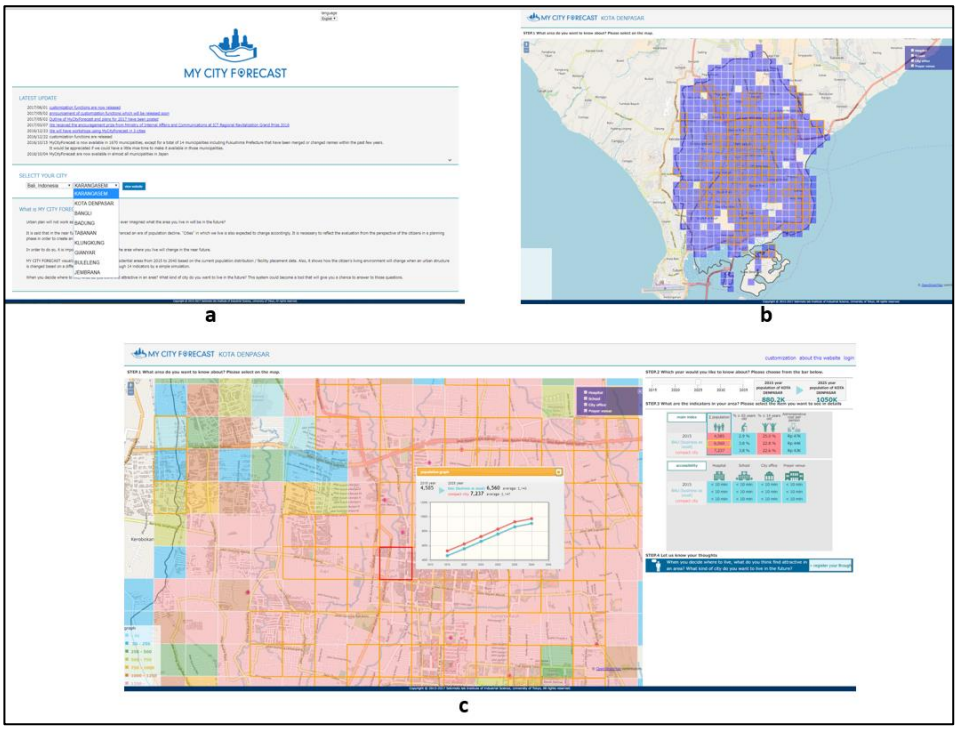

Figure 3. Interface design of Bali City Forecasting

The interface design is as shown in Fig.3, user's operation procedure is as follows:

1. Select a city in Bali province (Figure 3.a)
2. Navigate to zoom in, zoom out and panning. Display the distribution of public facility layer by check-mark than select a grid among the city to figure it the simulation (Figure 3.b).
3. Select a year between 2015 - 2035 (Figure 3.c).

4. The estimated value for the 8 indicators at the designated condition bottom will be shown. By clicking each value, the map layer shows the visualization map of the selected indicator, and by clicking again the graph that shows change accordance with year timestamp will pops up.

This application also could us as communication tools purpose. Citizen can express their needs and preference while government could react and accommodate citizen aspiration. We provide kind of sort questionnaire about citizen satisfaction and what facility is most important for increasing their quality of life.

We had meeting and discussion with various stakeholders to explore Bali city forecasting. We visited Bali to held workshop with citizen, local government, non government organization and university members. We also visited Jakarta to held meeting with national planning agency and geospatial mapping agency.
The citizen appreciate web-app Bali City Forecasting because it inform them in simple way about the development of the city. The local government think this web-app very useful because not only to show the zonation or population projection but also gave the accessibility analysis to the nearest public facility. They hope in the future the calculation also consider disaster and new master plan infrastructure that will be built in Bali in the near future.

4. CONCLUSION

City forecasting can be analyse from statistics data and spatial data combine with GIS software. Using population projection data, public facility data, road network and economic data, we can made forecasting for the future what your city will be look alike and show the accessibility to nearest public facility. In this research we also can make several assumption in example with Business as usual concept and compact city concept.
It is very useful to create web-app Bali city forecasting in simple and user friendly interface. Citizen can easily operate and show the result of calculation by themselves and can feel the difference or imagine how their city will be look alike in the future. The hoped it also run in customized way and add another factor such as disaster map.

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