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Detecting the Development of Land Use Patterns for Building in Urban Areas by Using High Resolution Image

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Abstract. This study aimed at obtaining factual information and overview to the development of land use patterns for buildings in urban areas by interval time period, both spatially and aspatially, by utilizing high-resolution satellite photo image (high resolution spatial image) combined with field observations. This research used survey method approach. The data of this study consisted of primary and secondary data classified into spatial and aspatial data in the form of time series obtained through documents recording techniques, field observations, previous mapping sources, as well as depth interviews. The analysis technique used Image Processing Analysis through programs and software Arc View. The result of research showed that there was a quite rapid development of land use patterns for building in Palu within the last 50 years (≤ 1970 till 2010) It had building addition in 65,173 units (82.28%), from 14,032 units in ≤1970 to 79,205 units in 2010, and the addition of extensive use of land for building was 4723.52 ha (89.06%), from 516.98 ha in ≤ 1970 to 4723.52 ha in 2010. The development level of land use patterns for building was getting along with the size of distribution and population growth in Palu.

Keywords: *land use, buildings, urban areas, high-resolution image.*

Introduction

City, in the time passed, is always growing and developing, and one of the causes of the growth and the development of the city is the economic growth. According to (Alonso, 1964) in the presence of economic growth, a city or a country tends to grow, to increase in size and to change in structure. Element associated with the growth of city is population. As the development of urban economic activities, it causes population growth as a means of implementing and increasing demand for land as a place for activities.

Problems in land use are common throughout the world, both developed and developing countries. It will be particularly prominent along with the increasing of population and industrialization process. Intuitive idea in land use has actually been had for a long time, but the idea of using land more efficiently or plannedly had been gotten clearly after World War I (Sitorus, 1995)

Population growth in the urban areas is always followed by the increasing of land use needs. City as a geographical manifestation is always changing from time to time. There are two main factors which have roles in changes, namely population and demographic aspects (Yunus, 1987). In terms of demographics, the most important thing is quantity. Demographic aspects such as politic, social, economy and technology are always

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changing. The quantity and quality of activity always increase with the increasing of urban population, thus the space/land for activities always increases with the increasing of urban population, and consequently, the space/land for activities is always increasing.

As well as the phenomena occurring in urban areas, Palu, as one of the cities in Indonesia, also has the same problem related to the population growth together with the increasing of urban land use, particularly the land use for building. The land use for building which keeps increasing, especially in Palu as a city of bay, will cause problems later on. This is due to the limited extensive land while the land needs for building and yard are always increasing together with the increasing of population and urban activities. Consequently, at a certain moment Palu will be full of buildings (Amar, 2012).

Building is one of urban land-cover types which are very important in the classification of land use. Distribution and land use for building in a city are very important information for urban planning and environmental studies. However, the collection of data and information on the land use for building is not an easy thing (Zhang, 1999).

One of the efforts in gathering data and information on the land use for building is to use remote sensing technology through the use of high resolution satellite photo image (high spatial resolution image) that is able to detect object of earth up to 0.50 meters. According to Sabins [6], image is the fundamental unity of several aspects such as scale, brightness, contrast and resolution as well as color and texture that affecting the power to capture object. Another important character of the image is the power to recognize object (recognizability) and the power to detect (detectability). This technological leap gives a blessing for the fields of science that directly relating to spatial data such as the science of urban planning and design. The power of spatial data tapping technology can accelerate the process of urban planning and design.

After understanding the problems above, it would be very important to know the spatial factual picture of the development of the land use patterns for building in urban areas, particularly in Palu as the object of this study. From time to time in line with the level of population growth as the land users, due to the information availability for the development of land use patterns for building in the space zones, it is expected that spatial planning and spatial development of Palu will be clearer and more focused ahead as well as the quality of the environment can also be well maintained and sustainable.

Research Method

The research approach emphasizes the disclosure approach of the phenomenon (explanative research) conducted by using a survey method. This study was conducted in 2011 which was located in Palu as a city of bay with an area of 37860.83 ha ± (378.61 km^2). The data of this study consist of primary and secondary data. They are classified into spatial and aspatial data in the form of time series data which obtained through documents recording techniques, field observations, previous mapping sources, as well as depth interviews.

The technique of analysis used in this study is Image Processing Analysis through the use of programs and ArcView software by using the availability of high resolution satellite photo image, namely: *Ikonosakusisi* in 2005, *Quick Birdakusisi* in 2009, and *World Viewakusisi* in 2011. They have a high accuracy/resolution between ± 1.00 to 0.50 meters as the basis to collect data on digital maps and to analyze the development of land use patterns for building based on age or year of building, the number of buildings, and the extensive use of building land and yard in the last 50 years (≤ 1970 to 2010). All of them is grouped into five periods of time, namely the time period up to the year 1970 (≤ 1970); the time period from 1970 to 1980; the time period from 1980 to 1990; the time period from 1990 to 2000, and the time period from 2000 to 2010.

Image processing analysis is the analysis system which utilizing geospatial data, such as maps, aerial photos, satellite images, statistical data, and so forth, as its unit and analysis process. Geospatial data is then be input through the digitization process to be used as an ingredient in the analysis process. Basically, mapping analysis technique is developed by using technology-based geographic information system (GIS) [7].

The base of SIG analysis is spatial data in digital form obtained through satellite data or other digitized data. In addition, the data presentation technique in GIS can be displayed in images by using software, such as ArcView, AutoCAD Map, and ER Mapper [8].

Image processing satellite is to obtain the data or the information regarding the latest land use and other information, such as buildings, roads, housing facilities, hospitality facilities, shoreline, and specific locations or strategic areas generated from satellite image conducted in several stages activities which covering:

a. Image Pre-Processing Stage

In the image pre-processing satellite, several stages of activities are conducted, namely (Pohl, 1996; Jansen, 1996 and Lillsand and Kiefer, 2000) in Subaryono, 2003:

1) Radiometric Correction

   Radiometric Correction is done with the aim at improving the image visual quality as well as improving the pixel values that do not correspond to the spectral reflectance or emission of actual object, as a result of atmospheric disturbances in the form of scattering and absorption that causes the difference of brightness value in each pixel of satellite data on some channels. Radiometric correction is done by subtracting the bias value of a channel to the all spectral values of the line.

2) Geometry Correction

   Geometry correction is done in order to produce a more accurate image in the planimetric aspects. In this correction, coordinate system or particular map projection is used as a reference, so that the resulting image has a uniform coordinate system and scale. Geometry correction is done by adjusting the position of the satellite image with the real position on earth with the basic map reference, in the form of roads and rivers appearance (physical appearance of relatively unchanged nature) as a reference. The physical appearance of nature and man-made that is easily recognizable and relatively unchanged among other branches of river and road. Geomerty correction can be done with the tool of GPS (Global Positioning System) which is a hardware or a tool to make observation or measurement of ground control points (GCP) radially (Subaryono, 2003).

3) Classification

   Classification which is done to obtain information on land use is multispectral classification using a single criterion, namely spectral values (brightness value) on multiple channels at the same time supported by field data that can produce a ready-yo-use thematic maps. Assuming that every object on earth can be distinguished from other objects based on spectral values, so that each object is likely to provide a specific spectral response pattern. Spectral pattern recognition is one of automatic pattern recognition. The concept of land use map can be prepared after the classification process, based on the classification of land cover/land use which has been done.

   The approach in processing image data, particularly for extracting the earth surface appearance, is through head-up digitizing and unguided classification. In the unsupervised classification, it needs a minimal in-put from analysts because the image is processed by numerical operations by grouping pixels that have the same spectral values reflected by the appearance on earth through multispectral. Analysts using computer hardware and software of image processing enable to identify land cover

classes with mean and co-variance matrix.

If the image data is already classified, the analyst will extrapolate the value of the selected class naturally into the intended land cover classes. Satellite image photo of Ikonos, Quickbird and Wordview can be processed to extract data/information.

4) Determination of Land Use Class

Land use is associated with human activity on certain plots. Information of human activities on the land can not always be interpreted directly from the land cover. Therefore, additional information to complete the land cover data obtained from the field check is required.

Land use classification which is used refers to the forestry classification or is developed by Sutanto, et al. (1981) in Subaryono, 2003 with modifications as follow:

a) Forest Area;
b) Bush;
c) Dry and Wet Reed;
d) Plantation and Agriculture;
e) Barren/Vacant Land;
f) Body of Water;
g) Settlement;
h) Industry, Trade, and Office Services;
i) Transportation Facilities Areas;
j) Means of Worship;
k) Recreation and Tourism, and so forth.

b. Image Processing Stage

Image processing which is done to obtain information about land use, particularly forest land and non-forest land is to follow the standard rules of the satellite image processing using a single criterion, namely spectral values (brightness values) supported by the field data to produce a ready-to-use thematic map.

Assuming that every object on earth can be distinguished from other objects based on its spectral values, so that each object is likely to provide a specific spectral response pattern. Spectral pattern recognition is one of automatic pattern recognition forms. The concept of land use map can be prepared after the classification process, based on the classification of land cover/land use which has been done.

c. Image Digitizing Stage

Image digitizing is the process of inputting data sourced from maps or aerial imagery through digitization method that can be performed manually by means of a digitizer or by using software with *on screen* digitizing technique. The software can be used for this digitization, such as Auto CAD, R2V, and others. Types of digital data that are inputted are in vector and raster formats. Vector stores digital data in the form of coordinate cluster (x, y) while the raster makes graphic data in the form of a series of squares that are stored as pairs of figure stating the rows and the columns in a matrix (Budiyanto, 2002).

d. Field Check Stage

Field check is conducted to examine the dubious objects (from satellite image), to correct the interpretation result of satellite image, and to investigate the changes that occur in the field.

This field check is conducted globally including samples taken for all areas (pilot projects) which are covered in satellite imagery.

e. Reclassification Stage

After having field check to the sample objects (either to a dubious object seen from satellite image or to objects that have undergone changes in land use), then, the mapping of the new land use is done. The resulting of land use maps reflects the existing land use (current condition). After the digital image interpretation of land use by using Ikonos, Quickbird and Wordview has been completely done as well as re-interpretation stage has, the next step is to prepare land use maps.

Schematically, the image prosessing flow-chart can be seen in Figure 1 below.

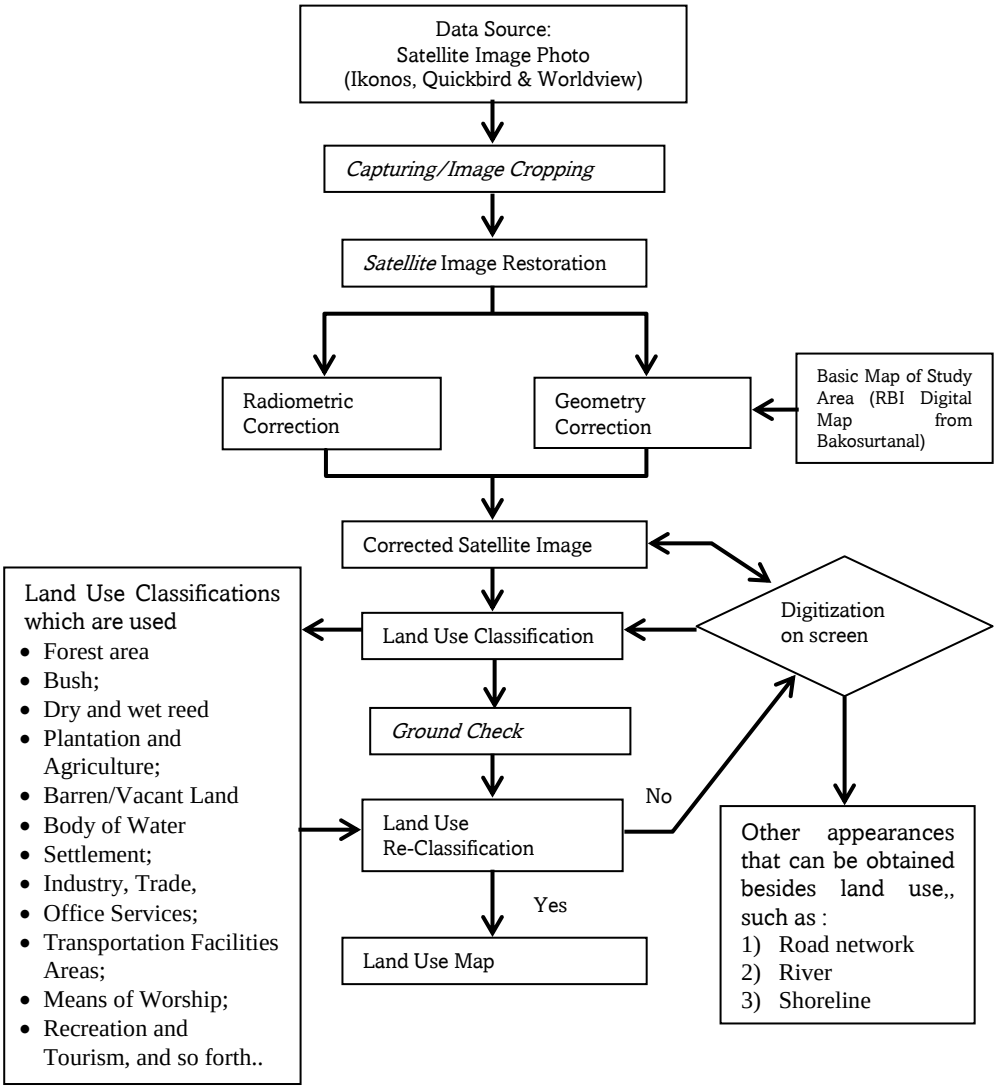

Figure 1 Image Processing Flow-Chart

Result and Discussion

The Boundaries and the Width of Palu

The width of an area generally can be divided into two parts, namely land and sea areas, especially the areas which have the ocean as water boundary. The area of this study is more focused on the width of the land area of Palu.

Palu is geographically located in the middle area of Donggala district. It is precisely along the shoreline of Palu bay or extending from east to west which is located on the south of Equator at coordinate points 0^0.36"-0^0.57" south latitude and 119^0.45"-120^0.01" east longitude. Administratively, the location and position of Palu can be described as follows:

1. On the north side, bounded by Palu bay and Donggala district (Nupabomba dan Labuan sub-districts);
2. On the south side, bounded by Sigi district (Sigi Biromaru, Dolo, and Marawola sub-districts);
3. On the west side, bounded by Palu bay and Donggala district (Banawa sub-district);
4. On the east side, bounded by Donggala, Parigi Moutong, and Sigi districts.

Palu land area which is administratively under the guidance of Regional Spatial Planning (RTRW) Technical Content of Palu in year 2010-2030 is ±395.06 km^2 or ±39.506 ha consisting of lowlands (coastal), undulating lands, and highlands. However, Palu area which becomes the reference of study is approximately ± 378.61 km^2 or ± 37860.83 ha with the governmental administrative region consisting of four districts and 43 villages (Amar, 2011). This area is the land area which is technically based on the digitization result through Ikonos satellite photo image in 2009 to the administrative boundaries of Palu aligned and synchronized with the administrative boundaries of the surrounding area (see Figure 2).

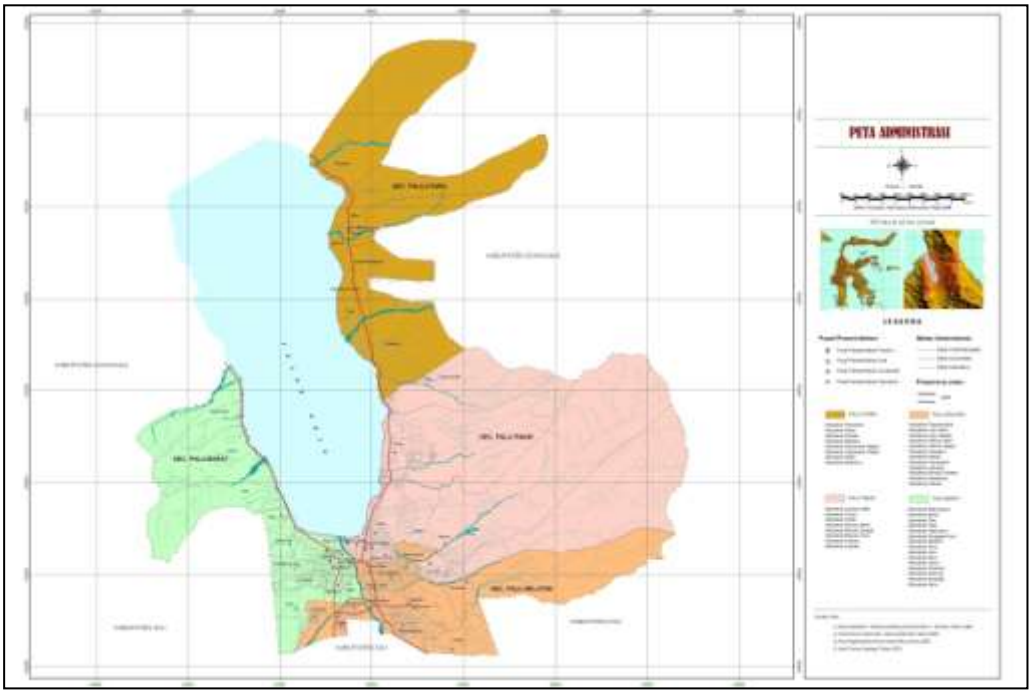

Figure 2 Map of Administrative and Extensive Area of Palu City in 2010

Due to its geographic form, Palu has specific physical characteristics such as the landscapes of mountainous topography and coastlines of Palu bay. They are located around Palu city and the flow of Palu river that divide Palu city into two major parts, namely the western region and the eastern region. This physical condition plays a role in the formation of Palu city and the environment is more orientated towards the formation of bay city which is characterized by the valley (graben) where the city centre is located in the central part of the valley (Amar, 2011).

Population Condition of Palu

Based on the enumeration of SP2010 [10], the population of Palu is 336.532 people. It consists of 169.878 men and 166.654 women with sex ratio 102 and it shows that the population of men is more than the population of women. The number of sex ratio 102 can be interpreted that in every 1.000 women population, there are 1.020 male population. With such population, Palu, according to Northam R. M. in Yunus (2009), can be categorized as a large city (100.000- < 800.000 people).

From the results of SP2010, it can be seen that the population distribution of Palu is still based on South Palu sub-district which amounted to 36.18%, and followed by West Palu sub-district at 29.34%, East Palu sub-district at 22.57%, and North Palu sub-district at 11.61%. Furthermore, it can also be proposed about an idea of the number of households, the average population per district and per household based on the population of Palu city in 2010 (see table 1).

Table 1 The Number and Distribution of Population, Village, Household and Population Rate per Village and per Household in Palu City based on Sub-district in 2010

Sub-district	Total			Number of Household	Population Rate	
	Population	%	Village		Per Village	Per Household
West Palu	98.739	29,34	15	22.080	6.583	4
South Palu	121.752	36,18	12	29.164	10.229	4
East Palu	75.967	22,57	8	19.711	9.496	4
North Palu	39.074	11,61	8	8.286	4.884	5
Total	336.532	100,00	43	79.241	7.826	4

Table 2 Total Population of Palu City and the Growth based on Sub-district in 1990 – 2010

Sub-district	Total Population			Population Growth SP 2000 – SP 2010 (%)
	SP 1990	SP 2000	SP 2010	
West Palu	64.901	82.010	98.739	1,87
South Palu	62.232	93.081	121.752	2,72
East Palu	48.310	62.863	75.967	1,91
North Palu	24.002	31.129	39.074	2,30
Total	199.445	269.083	336.532	2,26

The population growth rate of Palu per year for the last 10 years from the year 2000-2010 is 2.26% (see table 2). Population growth rate per year in South Palu sub-district is the highest compared to other sub-districts in Palu city which is 2.72%, while the lowest is in West Palu sub-district which is 1.87%. Although having the lowest population, North Palu sub-district has relatively high population growth rate which is 2.30%. Furthemore, by using the classification of population growth rate as shown in Table 3, the population growth rate of Palu, according to Salladien (1987), is 2.26% classified as population explosion.

Table 3 The Classification of Population Growth Rate

Rate of Growth	Classification
0,0 %	Stationary Population
0,0 % – 0,5 %	Slow Growth
0,5 % – 1,0 %	Moderate Growth
1,0 % – 2,0 %	Rapid Growth
1,5 % – 2,0 %	Very Rapid Growth
> 2,0 %	Population Explosion

Founding History of Palu

Palu city was originally a kingdom of Kaili land with king traditional governance system. Kaili land governance was led by a king known as To Manuru. Kings degeneration To Manuru called Madika. Kaili land kingdom had four kingdoms, namely: Palu kingdom, Tawaili kingdom, Sigi kingdom, and Banawa kingdom (Abdullah, 1975)

Palu is "New Town" located at the estuary. Kruyt (1938) outlines that Palu is actually a new place that inhabited by people (*De Aste Toradja's van Midden Celebes*). The beginning of the establishment of Palu was from Bontolevo villagers in Ulayo Mountains. After population movement to the lowlands, they finally arrived at Boya Pogego. Palu city today was originated from the unity of four villages, namely: Besusu, Tanggabanggo now named as Siranindi and Kamonji, Panggovia now named as Lere, and Boyantongo now called as Baru Village forming a kingdom in which Palu kingdom is as one of Kaili land kingdoms. The unity of four villages formed a Traditional Council called Patanggota, whose job is to select the king and his aides that closely associated with the activities of the kingdom.

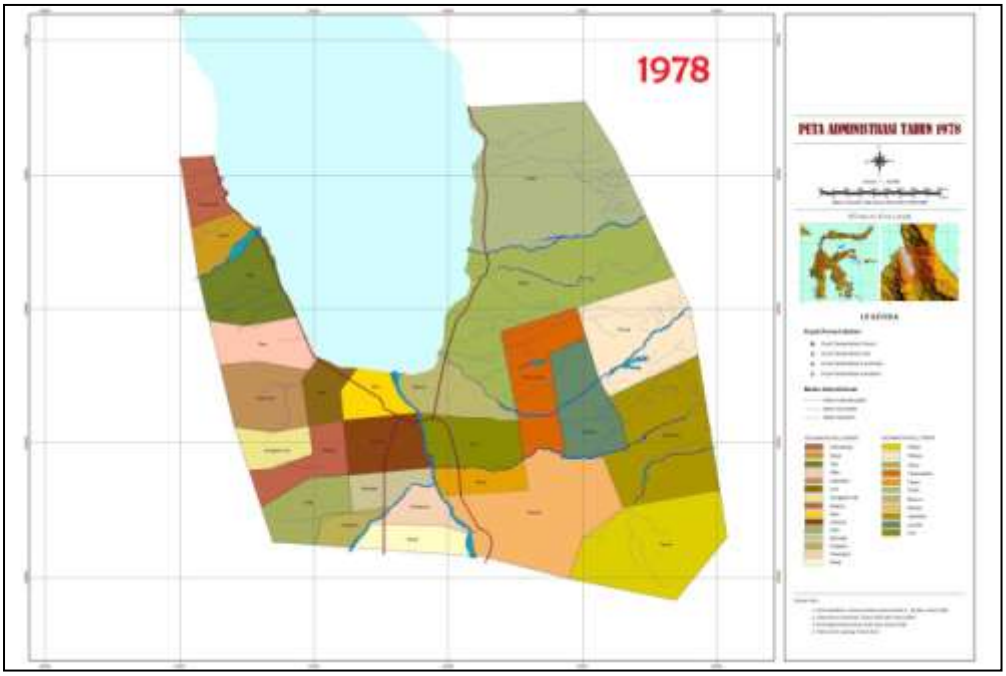

Figure 3 Map of the Administrative City of Palu in 1978

In the late of the nineteenth century, the influence of the Dutch resulted the conquest of the kingdoms in the Palu valley after preceded by war. The growth of Palu after the independence of Indonesia from the Dutch and then Japan in 1945 was more increasing. In independence era in line with the decision of the central government according to Act No. 44, 1950, Poso was set as the capital city of regional district of Central Sulawesi while Palu was only the place for the Head of Government Affairs (KPN) in the same level of *Wedana* (district chief). Then in 1952 as the Government Regulation (PP) No. 23, 1952, the Autonomous Region Level II Donggala was established.

Gradually, the government structure of the Republic of Indonesia (RI) was fixed by the central government adjusted with the wish of the people in regional areas through the splitting and merging for the regional area development, then autonomous government was unoccupied by releasing some regulations, among others Act No. 1, 1957 regarding the status of Palu city becoming the regency capital of Central Sulawesi Province, and Act No. 29, 1959 and Act No. 13, 1964 regarding the form of Regional Level I of Central Sulawesi Province, thus Palu was established as the capital city of Regional Level I of Central Sulawesi Province.

In the development of Palu city, through the Government Regulation No. 18, 1978 administrative city of Palu was existed on 1 July 1978 on the De-concentrated Basic Principles according to Act No. 5, 1974 regarding the Regional Government Principles, in which Palu served as the provincial capital of Central Sulawesi as well as the capital of Donggala district, and also the capital of administrative city of Palu. Palu was the tenth city set by government as administrative city.

After Palu designated as administrative city in 1978, in that period, the revision of Palu city spatial plan was undertaken for the first time by name as the City Master Plan Revision (RIK) Palu from 1978 to 2000. It had previously been drafted in 1975 by the Level II Government of Donggala district. In this revision, it was described that Palu city had ± 13947.26 ha which was divided into two districts, namely West Palu Sub-district and East Palu Sub-district (see figure 3).

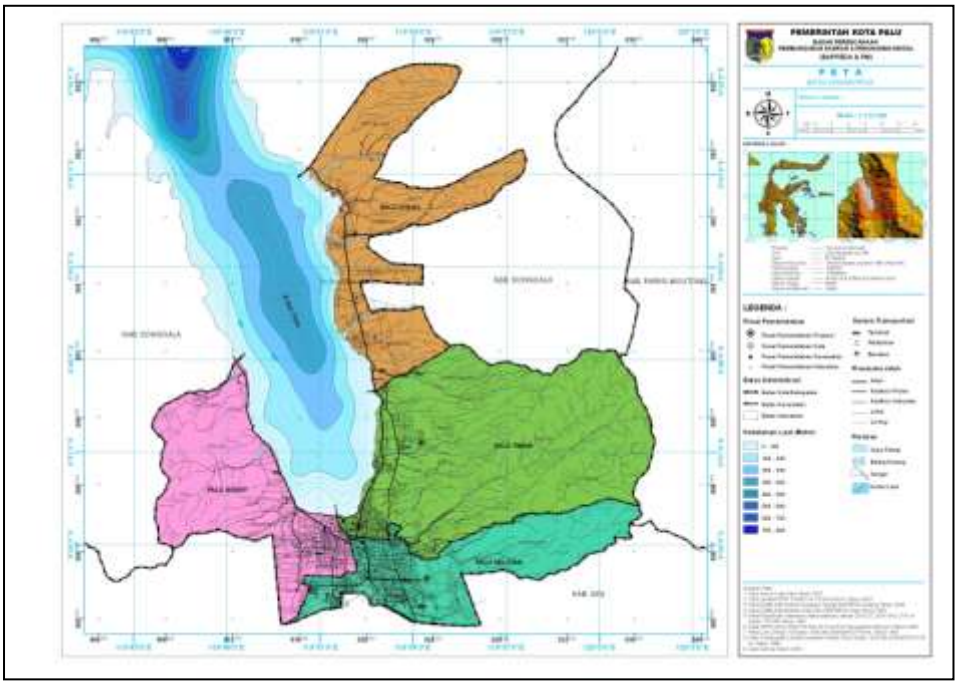

Figure 4 Map of the Administrative City of Palu from 1994 – 2010

In the next development, based on Act No. 4, 1994 on 22 July 1994, the status of Palu city as administrative city was upgraded to Level II Regional Municipality of Palu. By expanding the status of Palu to be a municipality, the area of Palu city in the law became expanded into four districts covering the administrative city of Palu region and a half part of Tavaili district by the name change of sub-district as North Palu Sub-district consisting of 8 villages, East Palu Sub-district consisting of 5 villages, South Palu Sub-district having 9 villages, and West Palu Sub-district having 14 villages. Since 1994, village expansion has been done, and since 2011 there have been 43 villages spread over 4 districts (see Figure 4).

Since having Regional Autonomy according to Act No. 22, 1999 which was further amended by Act No. 32, 2004 regarding Regional Government, Palu city has become as an autonomous region within a regional government known as Palu city government.

Detecting the Development of Land Use Patterns for Building in Palu

The population growth rate in Palu city from year to year has significantly increased the number of population although the percentage growth rate tends to decrease when compared to the prior year periods. In the period of 1980 to 1990, the percentage of population growth rate was 5.41% per year on average with the population of 199.455 people at the end of 1990. In the period of 1990 to 2000, the average was 3.15% per year with the population of 269.083 people at the end of 2000, and in the period of 2000 to 2010, the average was 2.26% per year, which the amount at the end of 2010 was 336.532 people (The result of SP2010 and BPS Palu city 2011).

Along with the increased number of residents in Palu city, the demand/need for land has increased, particularly in the land use for building. Based on the results of field surveys with the help of *Quickbird* High Resolution Satellite Photo Image in 2005 and 2009, and supported by the *World View* Newest High Resolution Satellite Photo Image in 2011 to the amount of data and the extensive of land use for building in Palu city suitable to the classification of the building age based on the year of establishment, it shows that the amount and the extensive land use for building in Palu city in the last 50 years (the period of 1970 till 2010) has increased significantly (see Table 4).

Table 4 The Number, Width, Growth of Building and Land Use for Building Based on the Year of Building in Palu City in the last 50 years

The Year of Building	Total Building (unit)	Growth Rate of Total Building (%)	Width (ha)	Growth Rate of Land Use for Building (%)
Up to 1970	14.032	-	516,98	-
1970 - 1980	21.936	4,57	835,81	4,92
1980 - 1990	42.071	6,73	1.602,99	6,73
1990 - 2000	65.668	4,55	2.502,99	4,56
2000 - 2010	79.205	1,89	4.723,52	6,56

Up to the year of 1970, the number of buildings in Palu city is only about 14.032 units with an area of land use for building and ground ± 516.98 Ha or only 1.37% of the total area of Palu city at the time (see Figure 5).By the time of 1970 to 1980, the number of buildings in Palu city had increased in the average of 4.57%, or by the last 10 years it had increased the number of buildings from 14.032 units of building with ± 516.98 ha (1.37%) of land use for building and yard in 1970 to 21.936 units of building with ± 835.81 ha (2.21%) of land use for building and yard in 1980 (see Figure 6). By the time of 1980 to 1990, the number of buildings in Palu city had increased in the average of 6.73% per year or by the last 10 years, it had increased the number of buildings from 21.936 units of building with ±

835.81 ha (2, 21%) of land use for building and yard in 1980 to 42.071 units of building with ± 1602.99 ha (4.24%) of land use for building and yard in 1990 (see Figure 7).

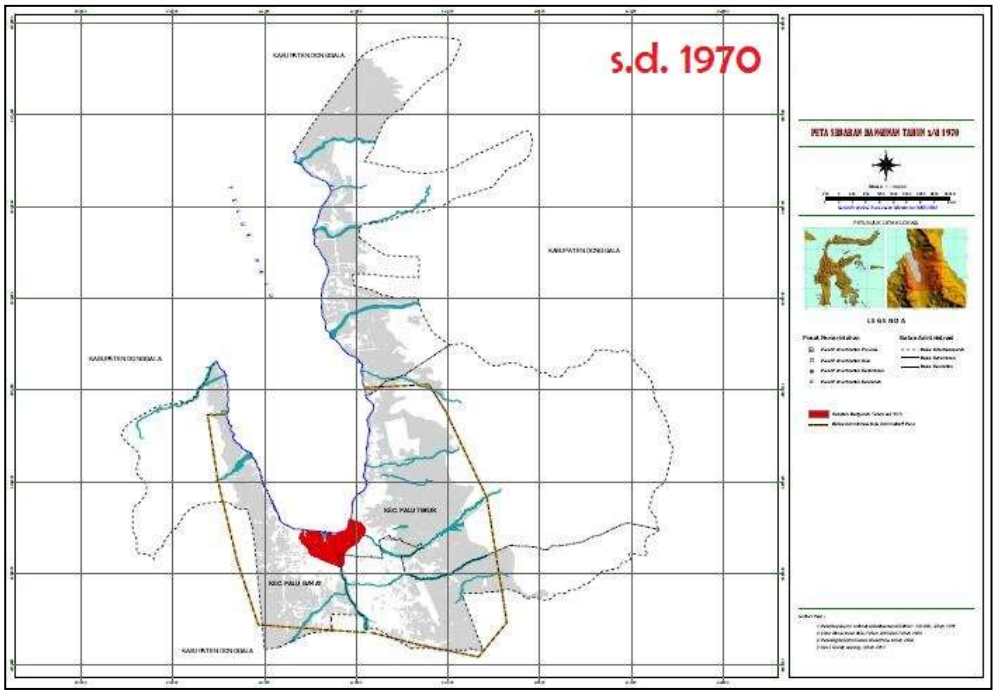

Figure 5 Distribution Map of Building until 1970

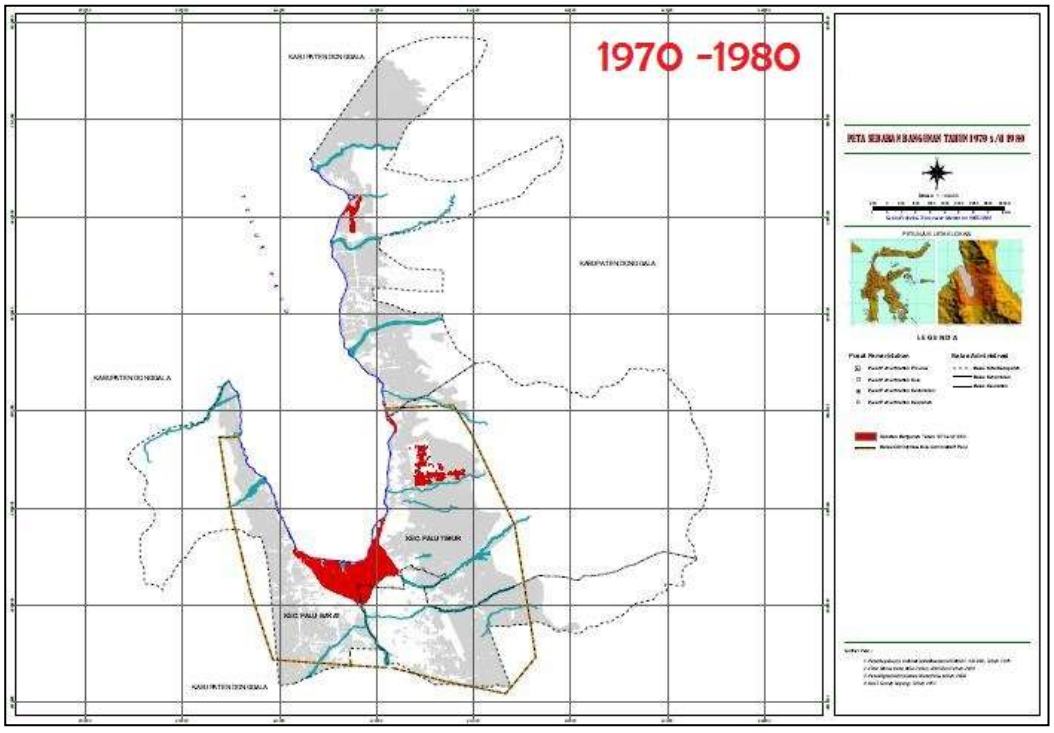

Figure 6 Distribution Map of Building from 1970 to 1980

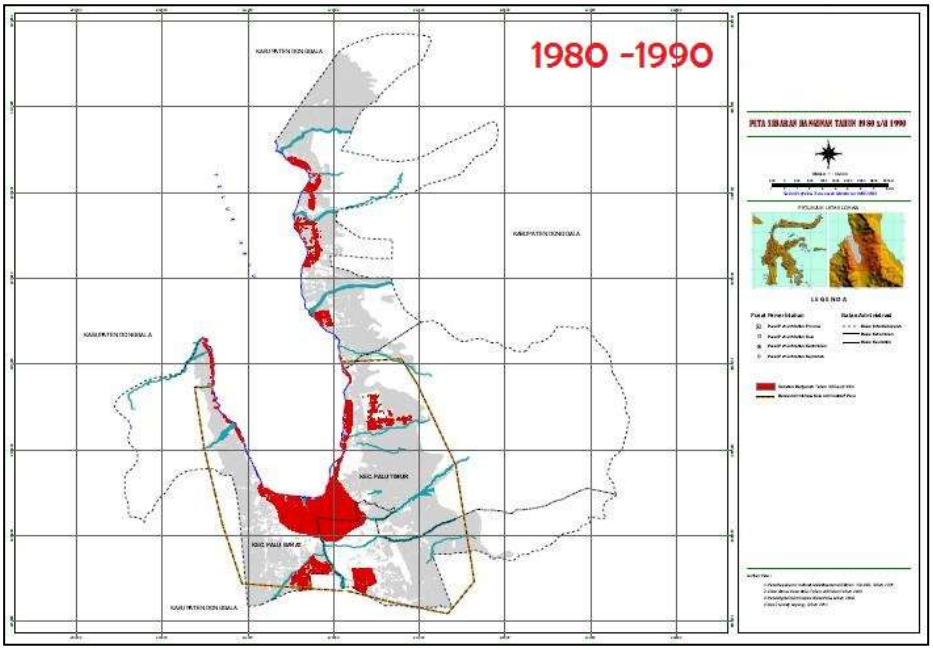

Figure 7 Distribution Map of Building from 1980 to 1990

Furthermore, by the period of 1990 to 2000, the number of buildings had increased in the average of 4.55% per year or by the last 10 years, it had increased from 42,071 units of building with ± 1602.99 ha (4.24%) of land use for building and yard in 1990 to 65.668 units of building with ± 2502.99 ha (6.61%) of land use for building and yard in 2000 (SP2000 Palu) [15] (see Figure 8).

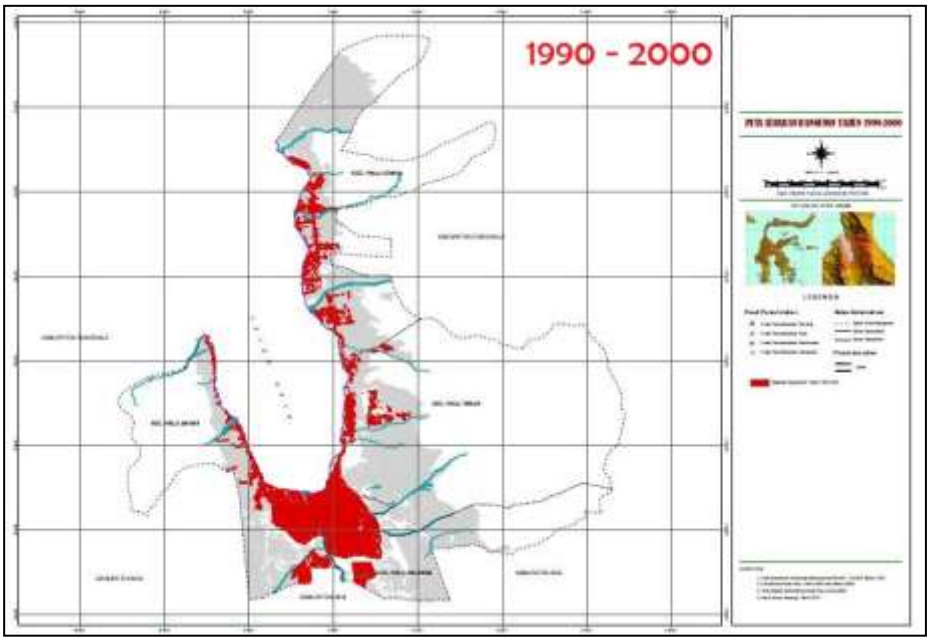

Figure 8 Distribution Map of Building from 1990 to 2000

While by the period of 2000 to 2010, the number of buildings had increased in the average of 1.89% per year or by the last 10 years, it had increased from 65.668 units of building with ± 2502.99 ha (6.61%) of land use for building and yard in 2000 to ± 79.205 units of building at the end of 2010 with ± 4723.62 ha (12.48%) of land use for building and yard including urban facility and infrastructure (see Figure 9).

Availability of Land For Building in Palu

Beside the detection of the development of land use patterns for building, from the analysis of image processing, there is an overview of the land availability in Palu city which is ± 14607.93 ha and categorized as land for farming activities, including the establishment of building, namely the biophysical land, especially from the aspect of topography and slope which is suitable to be used and developed as land for the development of cultivation activities. The appropriateness meant to facilitate the cultivation activities is the land can legally and technically support the growth of the land use for building optimally, and if the land is used properly, it will not disturb the sustainability of the resources and the environment (Amar, 2012).

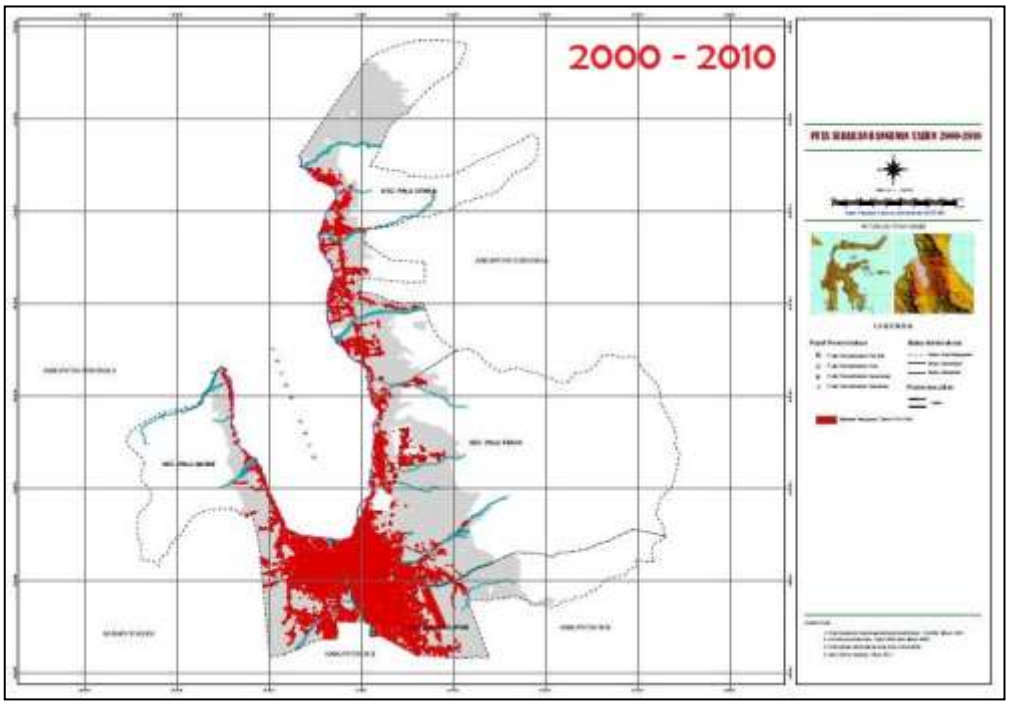

Figure 9 Distribution Map of Building from 2000 to 2010

Until the end of 2010, the amount of land that has been used as land for residential buildings, facilities, and infrastructures, both the old building and the new building, is ±4.723.52 ha (24.43%) of the cultivation area available (see orange colour area in Figure 10). It is beyond the land use land for the strategic area of city as the part of developed cultivated area. Thus Palu still has potency and opportunity that are relatively very large to make the physical construction such as residential buildings and housing and its infrastructure and supporting facilities in ±14607.93 ha (75.57%) including the Palu Industrial Area (KIP), which the land use area has been allocated in ±1456.80 ha (see grey colour area in Figure 10), by assuming that Palu city in the future will act as a nonagricultural-based metropolitan city, so the potency of the available agricultural land is

assumed to be converted to the developed lands to support the physical development of Palu city in the future.

Conclusion

Based on the explanation above, it can be concluded about some research findings related to the development of land use patterns for building in Palu as follows:

1. The delineation boundary and administrative area of Palu city show a significant difference between the guidance of Regional Spatial Planning (RTRW) Technical Content of Palu in 2010 - 2030 and the result of research studies based on the digitization result through the Ikonos satellite photo image in 2009 to the administrative boundaries of Palu which is harmonized and synchronized with the boundaries of administrative areas.

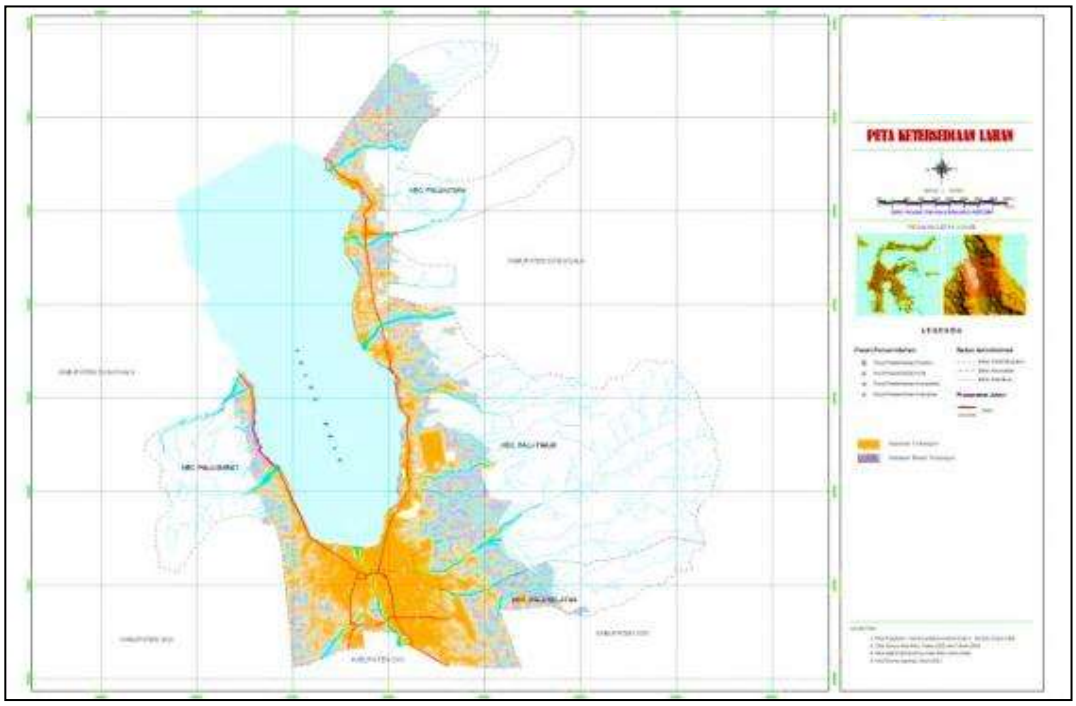

Figure 10 Map of Land Availability for Building in Palu City

2. The population growth rate of Palu per year in the last 10 years from 2000 to 2010 is 2.26% which can be classified as population explosion. The rate of population growth is mostly due to the migration factor than natural population growth (fertility and mortality).
3. The detection result by using high-resolution photo image shows that there has been the development of land use patterns for building quite rapidly in Palu in the last 50 years (≤ 1970 to 2010) which have additional building in 65,173 units (82.28%) from 14,032 units in ≤1970 to 79,205 units in 2010, with the addition of extensive land use for building in 4.723.52 ha (89.06%) from 516.98 ha in ≤1970 to 4723.52 ha in 2010.

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