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SPATIAL MODEL OF WETLAND USE CHANGE AND FLOOD OCCURRENCE IN RESIDENTIAL AREAS

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ABSTRACT

This paper discusses the relationship between wetland use change and the occurrences of ftoods in residential areas of Palembang City. Palembang, well known as a wetland city in early 1919, has significantly converted its wetland up to 55% in 2010. The trend of flooding in the city has increased from 18 events in 2007 to 46 events in 2012. Uncontrolled urban development is assumed as the major drivers of the wetland conversion. The aim of this study is to estimate the relationship between land use change and the occurrence of flood happened in Palembang. In this paper, approximately 626 households from 4 residential areas were observed and 26 respondents were interviewed in March 2014 to gain information about the environment before, during and after the flooding and their relation to the wetland conversion. Literature review was also conducted in order to gain more insights about the phenomenon. By harnessing spatial correlation analysis, this study presents the relation between wetland conversion trend and flood occurrence in Palembang, which could be used to develop the appropriate policy to reduce the risks coming from flooding as well as preserving the urban environment in Palembang.

Keywords: Development, flood, land conversion, spatial correlation, wetland.

INTRODUCTION

Flood occurrence has been a common phenomenon in urban areas which grew dramatically in recent decades (IFRC, 2010; Jha et al., 2012). Flood I has made people exposed to some threats which lead to infrastructure destruction, job loss and fatalities. International Federation of Red Cross (I FRC, 2010) noted that compared to other natural disasters, flood claims the most destructive disaster with the biggest loss. Floods directly affect more than 99 million people per year in all over the globe from 2000 to 2008. Jha et al. (2012) even noted that there were 178 million people affected directly by the risk of floods in 2010.

The vulnerability of urban area to flooding Is a result of several factors, such as economy and social activities, population growth, economy growth, environmental degradation, and urbanization in urban area which are not supported by the sufficient urban planning and management (Adelekan, 2011; Birkman et al, 2010; Mekvichai, 2008, Razafindabre et al., 2012). The emergence of slums in flood plain urban areas and river banks, the density of population dwellings, and the unsufficient drainage capacity are some examples of vulnerability factors which leads to flood risks. On the other hand, the environmental change factors in global scale (i.e. the increasing of extreme rainfall events, uncertain rainy season period, the increasing of extreme storm events, etc.) also contributed to flood risk in urban area (Coumou and Rahmstorf, 2012; Guhathakurta et at., 2011; Rowe and Villarin, 2013; Trenberth, 2012; Wang et a1., 2013).

Compared to other South East Asian countries, Indonesia has many big cities which have dynamic trends of urbanization, increasing economy activities and growing population, such as Jakarta, Bandung, Medan and Surabaya (Jones, 2002). As the consequence, these cities require more land and space provision for the development. However, the scarcity of land and spaces in urban area lead to land use change phenomenon, especially the conversion from protected area into built area (Firman, 2009; Partoyo and Shrestha, 2013). For instance, flooding which happened in Jakarta in 2002, 2007 and 2013 showed a significant impact of land use change from agricultural areas to residential and industrial areas in the upstream region of Bogor, Puncak and Cianjur (Bopuncur) in the last two decades (Firman, 2009). The imbalance of rain water flow and the decreased capacity of catchment areas resulted in the emergence of the unabsorbed water mass which flowed into the downstream area and disembogued into the lower northern region, Jakarta. Moreover, the limitation of natural and artificial drainage capacities in Jakarta caused flooding in most of the Jakarta region become unavoidable (Sagala et al., 2013a).

In some cities in Indonesia, the land use change activities take place by wetlands 57tockpiling activities such as swamps and turfs with dry soil to extend the built area, such as residential area, commercial areas and infrasructures. The effort to stockpile or reclamate the wetland are commonly founded in some cities in Sumatra and Kalimantan Islands, such as Pekanbaru, Jambi, Palembang, Pontianak and Banjarmasin (Dahliani, 2012; Khaliesh et a1., 2012; Murod and Hanum, 2012; Pulungan, 2009; Sa'ad et a1., 2010). Some prior studies prove that the existence of wetlands are able to retain and filter water flow, control local climate, take part as the habitat of urban biodiversity, and prevents the flood occurences (Jia et al., 2011; Kim et a1., 2010; Lantz et al., 2013).

To decrease the flood risks in the future and to achieve the sustainable development, various strategies are important to be arranged. Up to this day, there are only few literatures and research studies which assess the wetlands use change and its relation to the emergence of flood risks potential in some cities in Indonesia. Moreover, the disaster risk reduction policy in some cities in Indonesia related to the effort of land use change is aimed to study the relation between wetland use change with flood disaster along with the policies related to flood disaster risk reduction.

The rest parts of the article will discuss the literature on wetlands and flood risks and their relationships. Further, the discussion goes on to the methodology of data collection and case study. Findings on how

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the wetland changes and flood hazards caused are discussed. Finally, the paper concludes with some relevant recommendations.

Wetlands are among the most productive, valuable, and yet most threatened ecosytem in the world (Bruland, 2008). The wetland contains pelnty of peat soils, plants and massy impermeable stratum; all of them have good water water retention performance; which make the wetland have huge water retention capacity and it is equal to huge impounding reservoir. The wetland can store excessie precipitation in rainstorm period and flooding period, and then drain the water through runoff in a long time. On this aspect, the wetland can effectively reduce flood peak, weaken the hazard of flood to the downstream reaches. Meanwhile the wetland can also is impact the local hdrologic situations and impound flood, where one portion of flood is preserved in the form of surface water, and the other portion of flood inflitrates into the underground water to increase the reserves of underground water; such underground water can can relieve the scarce water resources in the water scarcity season and then the purpose to regulate the water source is achieve (An and Wang, 2014)

Human activities have changed the environment and caused a series of wetland changes, prolonging dry season, altering groundwater levels, and decreasing connectvity and habitat heterogeneity (Airoldi and Beck, 2007; Brock at a1., 1999; Ivan et a1., 2008; Stendman et at., 2008). Along with the rapid economic development in estuarine area, the damage caused by the interference of human activities is becoming more and more obvious (Chen, 2002). Large areas of wetland are disappearing, and those remaining areas become vulnerable under anthropogenic impacts from industry, agriculture, aquculture, urban development and domestic waste (Charpentier, et a1. 2005; Marieke et a1., 2008; Li et al., 2010). The wetland area greatly decreased in the past 50 years due to wetland reclamation, population pressure, water diversion, dam construction, pollution, resource over-excavation, biological invasion, desertification, climate change, and the misguiding policies (Chen, 2002; Augusteijn and Warrender, 1998).

Flood control value of wetlands is not completely understood, but there is growing evidence that they can play an important role in flood reduction. Storage of runoff in wetlands average about 12 inches per wetland-surface acre and can be four times that amount. It is important to note that water from drained wetlands is that part of runoff that man can control. With an average annual loss of crops, transportation facilities and property of $100,000,000 in North Dakota, even a small reduction in flooding can result in substantial social and economic benefits (Cernohous, 1979).

In managing flood problems, planners and policy makers have to understand the factors which affect the flood risk. The emergence of flood in urban area can be caused by river, coast, rainfall, groundwater overflow and the artificial system fault (Jha et al., 2012). The cause of flood in urban area is resulted from the combination of meteorological and hydrological events, such as the sedimentation formed in the bottom of river and extreme flow. Nevertheless, this hazard-side factor is not the only one causing the flood. The unplanned and uncontrolled city growth can inrease the flood risks because the process can place the human life to be potentially exposed by hazard in some regions (Jha et a1., 2012). This undestranding is important in formulating the approach and solution in reducing the damages and losses caused by flood therefore the planners and policy makers are able to meet the need, urgencies and priority in implementing the flood risk measures.

Flood risk management is a process in controlling the problems about the risks caused by flood events. Plate (2002) argued that flood risk management needs to be seen in a wider perspective, in which planners and policy makers role to integrate the flood risk in planning system which comprises sustainable mesaures. This concept is based on the magnitude of hazard and vulnerability factors which change from time to time and result in the increasing of flood risk problems which are caused by the development process, such as rainfall volume and intensity which get higher due to the climate change and land use change and decrease the capacity of catchment area in absorbing the rain water (Jha et al.m 2012; Nicholls et al., 1999). Even Plate (2002) explained that systems and actions in managing flood risks which have been applied are not potentially able to cope the the increasing of the factor of hazard and vulnerability which is important for the planning aspect in managing the long-term flood risk problems.

Integrated approach in managing the urban flood risks is the combination of management actions which is either structural or the non structural (Brody et al., 2009). The structural actions aim to reduce the flood risks by controlling the water flow from outside and inside the urban residential area. Brody et al., (2009) and Correia et al. (1999) explained that the structural approach is referring to physical development to control the flood or protect human settlements, which is implemented by building the wall and dikes along the sea side and river side, arthesian well, water channel, and revetment. Moreover, in reducing the flood risks, the structural approach can be implemented by by modifying the environment structure through the development of dikes along the river side, channel and soil improvement. Such various technics will be effective if it is used corretcly as in the documentations about the succes story of Thames River management, sea protection in Netherlands and river management system in Japan.

Some solutions in managing the flood risk applied in urban area were still used the structural approach to control the hazard of flood (Correia et a1., 1999; Nicholls et al., 1999; Plate, 2002). Risk reduction solution was implemented by using the classical technic approach where flood problems can be solved by using the hidrology methods such as the studies about flood hazard and the solution about infrastructure development (i.e., the development of canals, water channels, huge dikes and so forth) (Plate, 2002). However, Jha et al., (2012) and Holway and Burby (1993) argued that even the structural aproach still has some limitations, such as: (1) overcapacity flood will spill over and significantly damage the structural of dikes design, (2) structure such as channels and dikes can increase the level of river, increase the flood level and water velocity in downstream area by retaining the waterway and natural flood plain which shorten the flood time in upstream area and cause bigger flood in upstream area, (3) structural solution can offer temporal safety to public, (4) structural actions often spend more financial cost, (5) the development of dam and the other structure of flood control contribute to induce negative impact to environtment. The 2013 flood disaster in Jakarta showed that the structural approaches such as river normalization and the development of huge canal undertaken by the provinical government of SCR of Jakarta, were still not able to solve the risk problems (Sagala et al., 2013a).

As perfect as any structural actions were used, the integrated and non-structural approach are still needed to reduce the flood risk. Non-structural actions cover various preventive measures or adjustments to reduce the flood risks through modifying the vulnerability of development activities which cause the damage in flood plain. This thing covers the prediction of flood event, early warning system, flood disaster insurance, preparation and emergency plan and the regulation of land use to control development (Correia et a1., 1999; Hansson et al., 2008). The non-structural actions do not necesarrily need big investement in advance, however it depends on human undestanding about the threats of flood and reliable forecasting systems as in emergency evacuation plan will not function if the were no prior warning. Moreover, the realization of this effort needs comprehensive approach with support from institution capacity and public participation, especially in society order and complex urban neighbourhood problems (Pearce, 2003)

METHODS

This study uses the spatial correlation approach. In this context, the spatial correlation aprroach refers to the effort to find the relation between two or more phenomenons which located spatially. Spatial autocorrelation is the correlation among the values of a single variable strictly attributed to their relatively close locational positions on a two-dimensional (2D) surface, introducing a deviation from the independent observations assumption of classic statistics. Spatial autocorrelation exists because real-world phenomena are typified by orderliness, (map) pattern, and systematic concetration, rather than randomness (Griffifth, 2009).

There are two group of methodology used in this smdy, data colletion method and data analysis method. Data colletion is conducted to gather the information required that contribute to the insights analysis. To collect data and information, observation and interviews are conducted. The observation is aimed to gather the physical condition of houses in the residential areas of Bumi Sriwijaya Indah, Municipal Officers (Pemkot) Residence, and Patra Residence, Polygon Residence and Pulokerto Residence. Since the location of Pemkot and Patra Residence is close, both of the residential areas are later grouped into one residential area so there will be four groups of residential areas in this study.

Burnt Sriwijaya (BSI) Residence comprises three smaller residential areas, eg. Burnt Sriwijaya Indah Residence, Griya Sejahtera Residence and The Residential Area of Macan Lindungan. The Pemkot Residence comprises two smaller residential areas, e.g. Palembang State Officers Residential Area and Patra Sriwijaya Residence. The Polygon residence comproses three smaller residential areas, e.g. Bukit Sejahtera Residence, Putri Kembang Dadar Residence and The Residential Area of Tanjung Rawo. The Pulokerto Residence in this study only covers the Griya Asri Residence.

There are 26 respondents interviewed in this study which consist of six respondents from each residential area. The interview was conducted in March 2014. The respondents are the residents in those four residential areas. The interview is aimed to collect additional information about the land use changes and flood coverage changes phenomenon in the past which those people expirienced. They were asked about the history of the land use changes and the condition when flood happened.

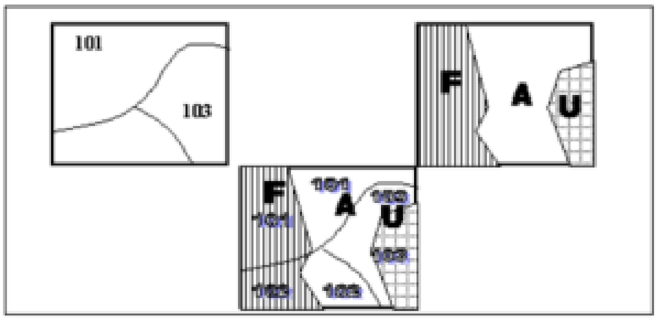

Figure 1. Example of Multi Layers Operations

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Actually, there are two kind of maps which provided in this study: (1) maps of land use in each residential area and (2) maps of flood coverage in each area. For the land use maps, the maps are available in 2001 and 2011 maps, while for the flood coverage maps, the 2004 and 2012 maps are available. Intersecting those maps is done to produce the direction of the land use and flod coverage.

Figure 2. Location of The Observed Residential Areas in Palembang Urban Area
Source: Analysis, 2014

RESULTS

There are four groups of residential areas observed in this study. Each residential area has its unique situations, either in physical or socio-economic aspect. Table follow presents the description of those residential areas.

Table 1. Physical Aspect of Observed Residential Area

	BSI	Pemkot	Pulokerto	Polygon
Elevation	5 mdpl	7-8 mdpl	6 mdpl	7 mdpl
Total Area	6 Ha	32 Ha	25 Ha	80 Ha
Housing Unit	±170	±3350	±1500	

In general, all of the observed residential areas are inhabited by the medium to low income family with various jobs, such as state officers, enetrpreneur and so forth. Some houses and neighbourhood infrastructure are improves as the response to the flood event that frequently happen, such as elevating the floor of the house, deepening the drainage channel and building a small emabrkement. Even though, as the impact of the frequent flood events, some of the houses are rented by the owner or even abandoned.

There are two main intersecting activity in this study: (1) intersecting the land use map and (2) intersecting the flood coverage map. In this section the intersecting of land use is presented first per residential area.

Figure 3. Land Use Changes in Burnt Sriwijaya Indah Residence in 2001 and 2011
Source: Analysis, 2014

Housing development in BSI Residence was identified to be massively conducted in the last ten years in the residential area. The increasing rate of residential area reached 71.35% from 2001 to 2011. The opposite thing happened to the changes of proportion of both wetland and dryland. Those land had decreased respectively 24.33% and 8.44% from 2001 to 2011. This phenomenon showed that about

266,574 square meters of wetland and 26,311 square meters of dryland were converted into housing areas.

Figure 4. Land Use Changes in Pemkot and Patra Residential Areas in 2001 and 2011
Source: Analysis, 2014

For both housing in Pemkot and Patra residential areas, there had been massive housing development conducted in the last 10 years. Based on the picture above, both areas in 2001 comprised wetland and dry land and almost of them were turned into housing areas by the year of 2011. Compared with the other three residential areas, the increasing rate of housing growth in Pemkot and Patra combined were the highest at the increasing rate of 658.76%. Moreover, in these areas, factories were also developed and increased at 3.76% rate from 2001 to 2011. On the other hand, wetland and dryland decreased with the rate of 27.06% and 6.44% respectively. This phenomenon showed that about 222,752 square meters of wetland and 82,891 square meters of dryland were converted into built areas e.g., housing areas and factories.

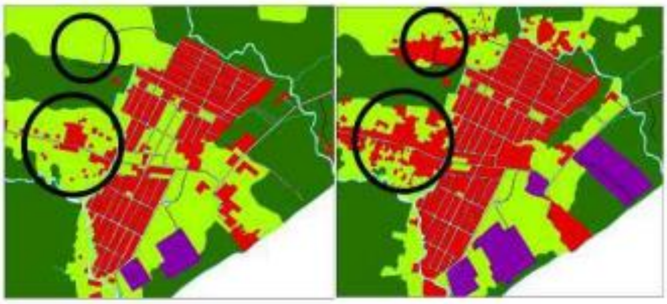

Figure 5. Land Use Changes in Pulokerto Residence in 2001 and 2011
Source: Analysis, 2014

Figure 6. Land Use Changes in Polygon Residence in 2001 and 2011
Source: Analysis, 2014

Massive housing development in Pulokerto Residence was conducted from 2001 to 2011 at the increasing rate of 54.60%. Moreover there have been factories development conducted in that time line with the increaing rate of 81.12%, the highest rate among all residential areas in this study. On the other hand, wetland and dryland had decreased from 2001 to 201 I with the rate of 17.62% and 10.05% respectively. This shows that from 2001 to 2011, there had been wetland and dryland with the area of 150.550 square meters and 52,949 converted into housing areas and factories.

Even though the residential coverage was already massive in Polygon Residence yet it seemed developed continously. From 2001 to 2011, the residential area increased at 68.35% rate while the wetland and dryland decreased at 27.65% and 8.93% respectively. Factories were also developed in the residential area. The increasing rate of the housing area is 42.77%. Based on these numbers, it is indicated that about 560.072 square meters of wetland and 87.444 square meters of dryland were converted into housing area and factories from 2001 to 2011.

Generally, there had been some land use changes happened from 2001 to 2011 in the four residential areas. However, each residential area had different growth rate, where land use change into residential area in Pemkot residence was higher than the others. The graph below presents the land use change rate between the residential areas.

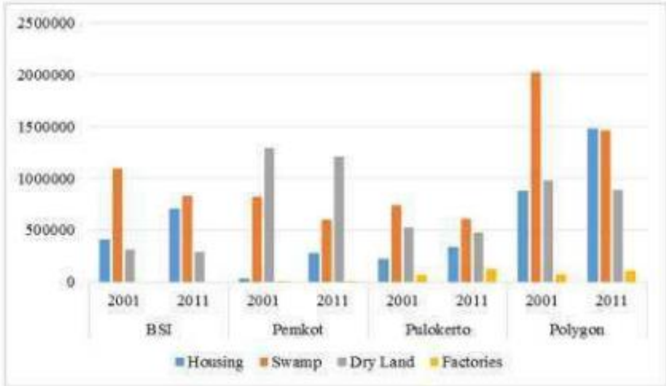

Figure 7. Trend of Landuse Change in Residential Areas in Palembang
Source: Analysis, 2014

Based on the chart, housing increased for 10 years in whole residential areas, especially in Polygon which had the highest growth rate on housing. In addition, the factories were also increased in some residential area, but not as much as the housing grew. On the contrary, both swamps and dry land were decreasing from 2001 to 2011, where swamps seemed dramatically decreased in Polygon. These phenomenons indicated that there had been a trend where people convert the swamps and dry land into housing and factories. These activities are perceived as the driven factor that encourage the flood occurrence in those residential area, which got higher every year. The graphic below shows the coverage of flooding in BSI residence from 2004 to 2012.

The flood events also changes from time to time in Palembang urban area, especially in observed areas. As follow in this section is presented the result of flood intersecting analysis.

Figure 8. Flood Coverage in Bumi Sriwijaya Indah Residence from 2004 to 2012
Source: Analysis, 2014

There had been flood coverage change happened between 2004 and 2014 in BSI Residence. Based on the figure above, there are some changes with the depth of the inundation which got deeper in 2012 compared to 2004. From the total 124 Ha area of study in the BSI residential area, the coverage of uninundated land seemed a little bit increasing with the reate of 9.76% from 2004 to 2014. On the other hand, the coverage of flood with the inundation level of 0-15 centimetres was increasing 30.27%. On the contraty, the flood coverage of 16-50 centimeres was decreasing 65.89% from 2004 to 2010. However, those loose number became worse since it turned into a more deeper inundation with the level of 50-100 centimetres or equal to knee to waist of normal adult. This level of inundation covered 52.54% of total area of inundation in 2012. This 50-100 centimetres inundation had not existed in 2004, yet the 16-50 centimetres inundation already covered 84.62% of all flood area and it only shared 28.92% coverage in 2012.

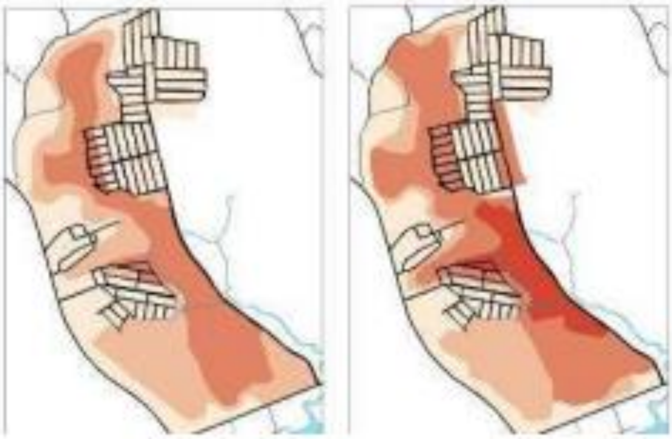

Figure 9. Flood Coverage in Pemkot and Patra Residential Area from 2008 to 2012
Source: Analysis, 2014

The coverage of flood inundation in the Pemkot and Patra Residential area seemed to expand from 2008 to 2012. Although the proportion of uninundated land and 0-15 cm flood inundation were decreasing 11.65% and 33.89% respectively, the medium level inundation with the depth of 16-50 cm was increasing on the same time 27.99%. In 2012, the level of inundation got higher as the flood level of 50-100 cm was emerging while in 2008 the highest inundation was only 16-50 cm. By the proportion, the uninudated land and 015 cm inundation were decreasing while the 16-50 cm was increasing. The new level of inundation, 50-100 cm, only shared 8.63% of total area in 2012.

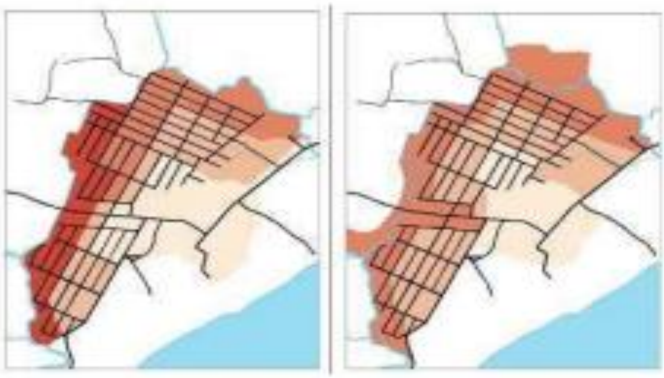

Figure 10. Flood Coverage in Pulokerto Area from 2004 to 2012
Source: Analysis, 2014

The inundation happened in Pulokerto Residence from 2004 to 2012 seemed increasing. Even though the coverage of the inundation with the depth of 50-100 cm totally perished in 2012, the uninundated coverage land decreased by 27.26% which inidctaed that the coverage of inundation was getting higher. In fact, the inundation with depth of 0-15 cm rose 38.96% and the 16-50% rose l2l.79% in from 2004 to 2012. By the proportion, all class of inundation showed the inducation that imply the condition where the coverage of the flood was getting higher. In fact, the uninundated land only shared 22.31% of total observed area in 2012 when it shared about 33.11% in 2004. The 0-15 cm and 16-50 cm inundation sharead 34.27% and 43.43% respectively in 2012 when they only shared 26.63% and 21.14% respectively in 2004.

Figure 11. Flood Coverage in Polygon Area from 2004 to 2012
Source: Analysis, 2014

The inundation in Polygon Residntial Area increased from 2004 to 2012. Even though, the coverage of uninundated land rose a little by 11.92%. The 0-15 cm inundation decreased by 55.52% from 2004 to 2012, whihc in turn, it converted into 16-50 cm inundation which rose by 75.65% from 2004 to 2012. By the proportion, the dominant categories, the 0-15 cm inundation, which shared 40.72% of total observed area in 2004 came as the least categories in 2012 proportion (17.92%). On the other hand, the 16-50 cm inundation, which came as the least categories in 2004 proportion (26.10%) rose as the dominant categories in 2014 proportion (45.35%).

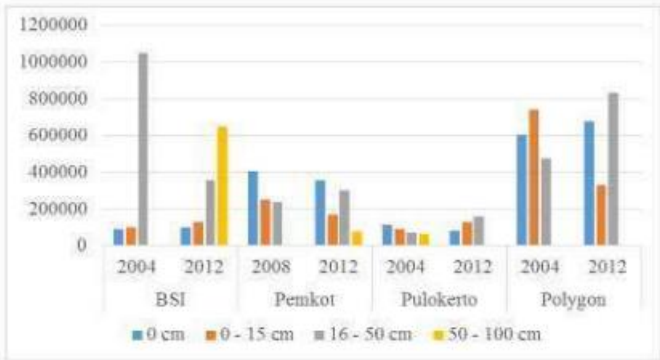

Figure 12. Trend of Flood Coverage Change in Residential Area of Palembang
Source: Analysis, 2014

Based on the Figure 10. the BSI and Polygon Residential Area have deeper inundation than the others. The figure shows that BSI residence area suffered from the inundation with the depth of 50-100 cm which emerged dramatically in 2012. Pemkot residential area, on the other hand, did not show any significant inundation change, yet dramatical increasing of the 16-50 cm depth inundation still took into consideration to be solve. The Pulokerto residential area has a more significant change, indicated by two opposing groups of bar charts which concluded that the coverage of inundation was gettting wider in general. The Polygon residential area also suffered from the inundation that got deeper from 2004 to 2012.

As the two main information sources are already collected, the description of both land use trend and flood coverage trend seem to be spatially clear. Based on both trends, there is a significant similarity appear between each phenomenon for each group of residential area. Generally, the land use change phenomenon on each group of residential area shows that there is a trend where ousing and factories development try to convert the dry land and wetland into housing and factory areas, which can rise a threat for the residential and factory activities themselves since the developmen distrub the natural system of water balance in the enviroment where those activities happen. On the other hand, the flood coverage change phenomenon also show the same trend, where the coverage got wider and deeper from 2004 to 2012. Comparing these two phenomenons, adjusted with the theoretical and empirical prior works, it can be proposed that the land use change has contribute to the phenomenon of flooding in the residential area.

Spatial correlation through the technic of intersection will heps to determine the unit of flood coverage changes as the result of land use canges in residential areas in Palembang. By undertaking double map overlaying, first, overlay the similar phenomenon in each residential group and then overly the land use map with the flood map, in order to produce the unit of the causing factor (land use change) and the impact factor (flood coverage).

DISCUSSION

This study aims to support the idea that the land use changes have significantly contribued to widen and deepen the flood coverage in the built up area, which in this case refers to residential area and factories area. This idea come from the real condition where Palembang as the well known dominated wet land area have grown into a huge built area, such as residential area and commercial areas (Sagala et al 2013b). The massive developments have sacrificed the wetland by stockpilled it which obviously disturbs the balance of water system in the area and can lead to flooding. As the anticipated threat predicted, the flooding in urban area in Palembang has become real and grown wider and deeper from time to time.

Based on the analysis in the previous section, there have been some significan land use changes in four observed residential areas. Results show that the housing and factories development grew I92.48% agregately. On the other hand, the wet land and dry land decrease 17.83%. Meanwhile, the flood coverage change analysis shows the similar pattern. Based on the analysis, aggregately, the total area of uninundated land decreased about 4.31% and the total area of inundated land increased 8.02%. By using the comparison between the growth rate of housing development with inundation coverage in the same residential area, it is concluded that for 1% agregate the housing and factories development rise, the inundated area will get wider 0.04%. If this comparison is identified in residential group level, there will be some differences in results. Pulokerto residence and Pemkot residence have direct proportion with the aggregate result, while the other two show the opposite result. For every landuse changes in Pemkot and Pulokerto Residential Areas, there will be an increasing rate of flood coverage in those areas for 0.02% and 0.42% respectively. BSI and Polygon residential area on the other hand, will have a decreasing rate of flood coverage by 0.01% and 0.06% respectively if the landuse changes happen in those area by 1%.

In a general perspective, those residential areas already proofed that landuse changes lead to the emergence of inundation, which in this case is inundation in residential area. This hypothesis is relevant to Pemkot and Pulokerto residential area situation, while it seem a little bit different for BSI and Polygon Residential Area where landuse changes does not seem to contribute to flood coverage changes. Some factors have been identified which can cause this situation. Based on the observation, it seems that in these two residential areas have done some preventive measures to reduce the risks from flood inundation, such as elevating the pavement of the house, elevating the height of the houses and deepening the drainage channel. Of course, both Pemkot and Pulokerto residential areas have done the same measures, but it still applied bigger in BSI and Polygon rather than in Pemkot and Pulokerto. Still, these for residiential areas still suffered from inundation which got wider each period.

Some previous studies support the findings of this study, especially in providing the additional insights about the different phenomenon happen in Palembang urban area. Actually, the Palembang Muncipality has produced some policies related to land use control in the area, such as the permitt in wetland reclamation for the development of Bukit Sejahtera Elite Residence or Polygon and Jakabaring Sport City area in 2004, Regional Regulation No. 11 Year 2012 About Wetland and Governor Regulation No. S Year 2013 about the Activity Control in Upstream Area. Moreover, the government also issues the policy which encourages the structural approach by developing the retention pond as the flood control in bult area, the development of plaster on Musi River, the normalization of Musi River and the development of the catchment area by using the green open space. These measures are believed to follow the study conducted by Brody et a.l. (2009) which explained the form of strategics integration by combining the structural and non structural approach in reducing the flod risks in urban area and Beatley (2009) and Jha et a1., (2012) which supports the idea of mainstreaming the land use management in development planning process in urban area.

CONCLUSIONS

This study has contributed to support the empirical results where land use change can contribute to the change of flood inundation in urban area. Study objects, which in this case is residential areas located along main river, show that trend of land use change can result in different impact of flood coverage. As a half of study object indicate a direct proportion of land use change with flood converage change, the rests are shows the opposite. Therefore, there is a need to identify other factors that can contribute to this result as this study only focus to the comparison between the land use and flood coverage changes. However, the results of this study are useful to explain such phenomenon. The result of this study can also be extended by applying them to similar phenomenon in urban area. In addition, other external factors can be taken into consideration. In this study, the history of flood events and land use changes are the main consideration with some addition coming from some literature review. This study can be seem as an replicable study as long as the specific factors are sufficient enough to be accounted into the analysis.

This study provides the description about the model of land use changes along with the flood coverage changes as the effect of it. The main findings explain that there are some tendencies where the land use change contributes to flood coverage changes and others engaged other factors to understand the relationship between these two. Palembang urban area is not only known for its past dominated wetland, but also for its proximity to Musi River, the biggest river in the province. Based on the fact that landuse changes were massively undertaken in the area, flood events grew as the major natural phenomenon happened all the years. This study provides the insights through some spatial models that there are some indications that the land use changes phenomenon in Palembang residential area had contribute to the emergence of flood in the area.

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