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GEOMATE Journal Review and Evaluation

Submission Date	2017-12-07 11:02:11
Paper ID number	18652-Dinar
Paper Title	INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING
i. Originality	3
ii. Quality	2
iii. Relevance	3
iv. Presentation	2
v. Recommendation	4
Total (sum of i to v)	14
General comments	It is noted that the research objective is clear while the investigation method is sound, although the abstract was not well written. Great effort required to conduct such a research. Reasonable discussions and presentation of figures and tables can also be found throughout the paper. Although English is not their first language, I can feel that this paper still need much work to improve English writings. The author is required to resubmit an improved version with respect to Abstract, Conclusion and English grammar. There are many big mistakes in grammar which I cannot approve acceptance at this stage. I can recommend acceptance of the paper, provided that the paper has been further revised. Find attached the file for the changes required.
Mandatory changes	It is noted that the research objective is clear while the investigation method is sound, although the abstract was not well written. Great effort required to conduct such a research. Reasonable discussions and presentation of figures and tables can also be found throughout the paper. Although English is not their first language, I can feel that this paper still need much work to improve English writings. The author is required to resubmit an improved version with respect to Abstract, Conclusion and English grammar. There are many big mistakes in grammar which I cannot approve acceptance at this stage. I can recommend acceptance of the paper, provided that the paper has been further revised. Find attached the file for the changes required.
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Submission Date	2017-12-11 10:42:41
Paper ID number	18652-2
Paper Title	INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING
i. Originality	3
ii. Quality	3
iii. Relevance	5
iv. Presentation	3
v. Recommendation	5
Total (sum of i to v)	19
General comments	This paper can be accepted with the following changes.
Mandatory changes	1. Abstract: Rewrite in concise form. Add some results and conclusions in abstract 2. Introduction: Add more references in introduction 3. Conclusions: Add more results in conclusions 4. List of references: Follow template
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INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING

*Putranto DA Dinar[1], Sarino[2], Yuono AL[3], Juliana Ch Imroatul[4], and Hamim SA[5]

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*Corresponding Author, Received: 15 Oct. 2017, Revised: 00 Nov. 2017, Accepted: 00 Dec. 2017

ABSTRACT: The rapid growth of industry and urbanization has accelerated the transfer of land functions in urban areas. The impact of the land use change has changed the drainage patterns in the existing sub-basin area. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff. Run-off problems with flood peak and inundation characteristics, in addition to being influenced by [illegible] factors as mentioned above are also influenced by the influence of tides, sedimentation and riv[illegible] pollutants from upstream and other small rivers in the area. However, the connection between [illegible] management and spatial planni[illegible]st be done. On the basis of this, an analysis of hydrotopograph[illegible]time of rain, tidal height, was modeled using spatial analysis[illegible]al and water management. The use of the duflow model is us[illegible]low tracking in rivers [1]. The inundation distribution occur[illegible]by combining the results of hydrodynamic analysis and spa[illegible]is a National Strategic Plan that will be realized as a new Metropolitan City of Palembang, Betung, and Inderalaya. Hydrologically, the Patung Raya Metropolitan City Plan haved Lambidaro sub chatment with high critical level, because if the rain is more than one hour, the puddle height reaches 1.5 - 2.5 m above means sea level.

no ref in abstract!

I cannot follow what is written in abstract....

What is the main objective?

Keywords: Flooding and Puddles, Run-off, Water Management, Inundation, Spatial Planning

1. INTRODUCTION

Changes land use in some areas of the city in Indonesia is so fast, due to rapid urbanization and industrial development. These changes are almost entirely done by reclamation of swamps, the utilization of river banks, and conversion of forest land and agricultural land. The impact of changes in land use has changed the patterns of water drainage in sub-basin areas that exist in urban areas. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff [2].

Human activities have a very significant impact on water quantity, water quality and aquatic ecology. As a result, the dangers of flooding, household and industrial waste, which, after accumulating for a long time, are unlikely to return to normal or require enormous costs for recovery.

Run-off problems with peak flood and inundation characteristics are influenced by several factors, such as urbanization, unsuitable landfill, tidal effects, as well as sedimentation and river-flow pollutants from upstream areas and other small rivers that form the sub-watersheds in the area.

Flow management capability, run-off mitigation, infiltration and water quality all have relevance to land use conditions. However, the connection between the water management system and spatial planning is one of the important keys that must be done if they want to play a role in reducing the danger of flooding. However, in reality in every spatial arrangement, the two systems, namely spatial planning and water management are never done together. On this basis, an analysis of hydrotopographic conditions, type of land cover, duration and time of rain, tidal height, are modelled using spatial analysis, in order to support decision-making for spatial management and water management.

2. CITY DEVELOPMENT AND FLOOD PROBLEM

Similar to the development of several regions in Indonesia, the province of South Sumatra has the development of cities that are very significant. It can be seen from the population growth which averagely reached 2.13% with the population of 7,446,401 in 2010 [2] of which , 1,452,840 are in Palembang (19.5%). If the average population growth in South Sumatera remains at 2.13%, then it is estimated that in 2030, the population in South Sumatera province will reach 317,216,683 people and 42.6% will be in Palembang City.

With such a large population growth, there will be concentration of population in big cities in South Sumatera Province especially in Palembang City, which will cause expansion of land use for

various urban activities. The expansion that will change the various functions of the "water park" land, is transformed into a wake-up land, irrespective of the watershed ecosystem.

Based on data from BMKG (2010), the highest rainfall in South Sumatera Province is 18 - < 34.87 mm / day and the peak rainfall in November, and the lowest rainfall <18 mm / day, occurs every May-August. Surface water is difficult to predict its spread in space and time. While the observation system of discharge is done using AWLR in several locations along the river, many of which are not functioning properly. This has caused many problems to predict the occurrence of peak flood and areas that will occur. In October (2016), the city of Lubuk Linggau, and several sub-districts in Musi Rawas district have experienced floods, the city of Sekayu and several sub-districts in Musi Banyuasin regency in September (2016), Inderalaya city and several subdistricts in Ogan Ilir Regency (October, 2016), Kayu Agung city and several sub-districts in Ogan Komering Ilir regency, Pangkalan Balai City and several subdistricts in Banyuasin regency, and Palembang City itself always experiences flood every rain with high intensity.

Efforts to control floods have been undertaken by several cities that often experience floods every year. In Jakarta City by building a flood canal and make a hole biopore. In Semarang City, by building a polder system. But all of them have not yet shown that the problem of annual floods can be overcome. All flood control systems, must depart from existing watershed ecosystem conditions. From these conditions, It requires new analysis by simulation to determine the flood discharge of each return period, which finally can be used to determine the appropriate drainage system in the area [3]. Thus a specific approach through more useful and accurate techniques is necessary. Transforming data into a Geographic Information System using Multi criteria Spatial Analysis in decision making [4] can be used as a policy combination solution and technical, and also as a model in presenting the watershed environmental conditions for better data quality and analysis [5].

2.1 Case Study

Palembang Raya Metropolitan Area (Patung Raya), is a National Strategic Plan that will be implemented as a new Metropolitan City of Palembang Raya [6]. The new metropolitan area of Patung Raya covers Palembang, Betung, and Indralaya city.

Hydrologically, the Patung Raya Metropolitan City Plan is located in four sub-basins, namely Komering Sub-basin (9,199.916 Km2), Ogan sub-basin (9,415.88 km2), Batang Peledas sub-basin (848,898 km2) and Musi part of downstreem (2.258,154 km2) and the four are located in the territory of the Musi River Basin [7]. The quality of the condition of the four sub-basins is in critical condition (51.6%), somewhat critical (27.65%), and only 4.98% non-critical [8]. The most widespread area of critical condition is Ogan sub Basin (76.56%), second critical condition is Musi part of downstreem sub-basin (56.64%) and Komering sub basin up to 46.35% (Figures 1).

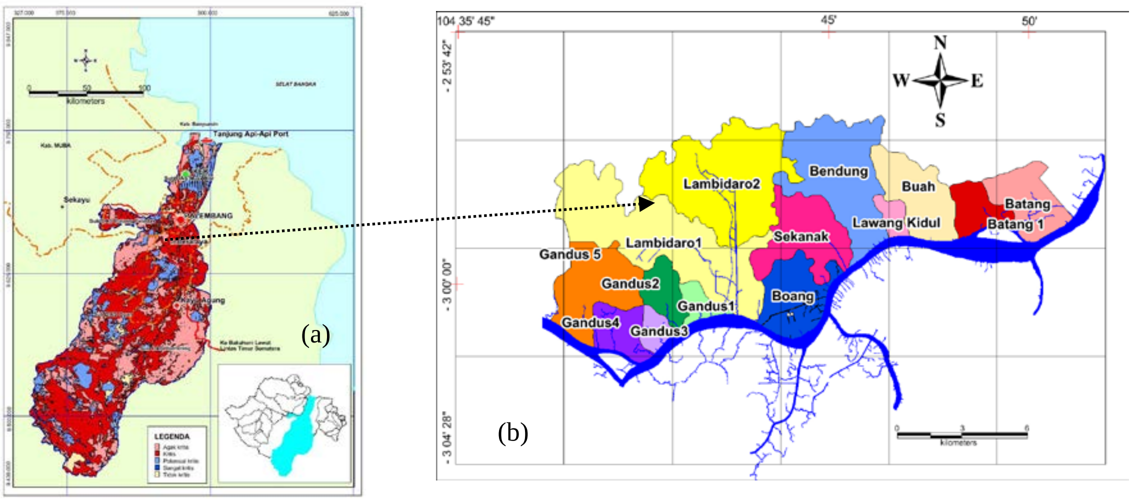

Fig.1 (a) Sub-basin area of metropolitan Patung Raya plan; (b) Lambidaro sub basin at Musi downstreem sub basin area

3. METHODOLOGY

To anticipate the amount of runoff water, due to inappropriate land allocation, multicriteria analysis is needed in every decision of land allocation. Land Allocation Management System (SIMAL) is a watershed analysis system developed using GIS or Geographic Information System (GIS) using land use change parameters, morphometry and hydrometry of DAS [9].

3.1 Research Site

As a study material is to explain the effect of surface runoff on land use change, the location of the study is the Lambidaro sub-basin (Figure 1b), which is one of 16 sub-basins that form the drainage system of Palembang and discharges into the Musi River, through the city of Palembang. With an area of 65.42 Km2.

3.2 Research Data

The data used in this research are river hydrometry data, longitudinal cross section (*l*) and river cross (*b*), river slope (*ls*) and area (*A*) and density (*r*). While spot height data and land use are needed to analyze the infiltration coefficient (*c*) and time concentration (*tc*). And the ever-changing dynamic data is the rainfall data (*R*) needed to calculate the rain intensity (*I*) in each sub-watershed.

3.3 Research Methods

The method used in this research is using hydrology model and Geographic Information System (GIS). The hydrological model used is to use HEC-HMS, while the hydrodynamic model used to calculate the amount of runoff that occurs is with Duflow which will also be used to track flood flow in rivers [9].

Hydrodynamic analysis was performed on selected river sub-systems that have been obtained from the results of cluster analysis. This analysis utilizes the 1D (Duflow) non-steady flow model with the maximum rainfall intensity conditions of the 25th anniversary period of the previous hydrological analysis results as well as the results of tidal observation forecasting at the sub-systems of selected river sub-systems. The first stage in hydrodynamic analysis by establishing a scheme of hydrodynamic network in sub watershed adapted to the results through terrain morphology and terrain processing analysis on ARCGIS-ARC Hydro and field conditions, then incorporating the dimensions of water structure, cross section, boundary conditions (tidal, rain Results of hydrological analysis) and flow discharge. After calculation of each segment / cross section will be obtained some hydraulic parameters such as flood water level, water flow rate, channel flow and water level in river and channel.

The inundation distribution occurring in the sub-river system is obtained by combining the results of hydrodynamic analysis and spatial analysis. The water level in the river and the channel is interpolated to obtain the distribution of water level in the selected river sub system. Then the distribution of water level is arranged with topographic condition of river sub system in the form of DEM 5m x 5m so as to obtain the distribution of classified high pools that occur in each selected river sub-system with 25th anniversary period.

With several scenarios of land use change it can be seen how much the changes in inundation height due to land use change in the selected sub-system. This scenario is used as a way to see the condition of sub-system of river which in turn will influence the pattern of river environmental control that will be done. The first scenario is to change the type of land use so that the value of C tends to decrease which becomes an indicator of the condition of the river sub system becomes better. The second scenario by changing the type of land use so that the value of C tends to increase, this condition can explain that a river sub system has a condition that is considered to be disturbed.

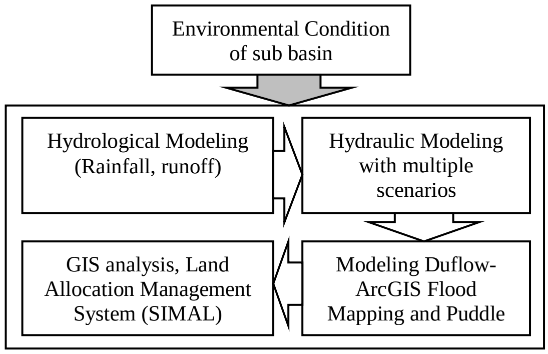

Fig. 2 Flow Chart of research methods

4. RESULTS AND DISCUSSION

4.1 Correlation Between Surface Run-off with Morphometric Characteristic Variable

This correlation is analyzed to address the problem of spatial relationships between land use and sub-basin morphometry and its effect on the extent of surface runoff. The strong correlation between independent variables (characteristic of sub-basin morphometry) and dependent variable of runoff (Q), is seen through Pearson correlation value. Correlation values range from -1,000 to 1,000. The value of -1.000 shows a very strong but negative correlation, while the value of 1,000 indicates a very strong correlation / very closely directed positively.

The results of the analysis (at 99% confidence level) obtained the correlation value between variables very high runoff (*Q*) ranges from 0.849 to 0.999 with variable length of river order (x_1), river length (x_2), watershed (x_3), roving watershed (x_4) , average *Rb* (x_5), Flow density (x_6), Texture ratio (x_8), Roughness number *Rn* (x_{10}).

This means that there is a strongly significant relationship between runoff and long river order, river length, basin area, perimeter watershed, average Rb, flow density, texture ratio, roughness number Rn. While the value of strong correlation is seen between runoff with *Tc* concentration time of 0.629. This means at a significance level of 5% or a 95% confidence level, there is a strong relationship between runoff and concentration time (*Tc*). The correlation value is strong enough at flow frequency (x_7), relief (x_9) and green area (forest, tree, shrub, yard / yard, rice field, field, garden) (x_{14}). Low correlation value between runoff and variable flow coefficient C (x_{12}) of 0.319 with significant level and negative correlation of 0.234 for variable circularity ratio Rc (x_{13}).

4.2 Caracteristic of Lambidaro sub Basin

As an example of frequent inundation in the Lambidaro sub-basin especially in the downstream area and around the floodplain, during the rainy season and high tides. Lambidaro sub basin with an area of 65.25 km2 is a sub watershed which has different morphometric characteristics with other sub watersheds. Based on the drainage pattern it is divided into two sub-watersheds namely part of left Lambidaro Sub-watershed and part of right Lambidaro sub-watershed which leads to the Musi river. The morphometric characteristics of the Lambidaro watershed are shown in Figure 3. Land utilization in the Lambidaro sub-basin is dominated by shrubs, trees, fields and forests ranging from 72%, settlements ranging from 4.74% to potentially changing land use, such as for settlement development. Settlement construction mainly occurs in right Lambidaro sub-watershed close to the main road / outer shaft of Palembang City (Musi dua bridge). At part of left Lambidaro sub basin is dominated by bushes and swamps. The sub-watershed of Lambidaro river has varying altitude less than 10 m msl in estuary area up to 36 m in upstream area. The percentage of the slope is dominated by 0-3% and more than 8% with a maximum height of 36 msl in the upstream area. River conditions are still natural, especially in part of left Lambidaro, while some rivers in part of right Lambidaro sub basin have been normalized by cliff reinforcement.

With the condition of land use, slope, flow density and soil type, the range of runoff coefficient in Lambidaro sub-basin shows the runoff coefficient value of 0.66. This means that 34% of the total rainfall falls on the Lambidaro river sub-basin can still be infiltrated (see Figure 3).

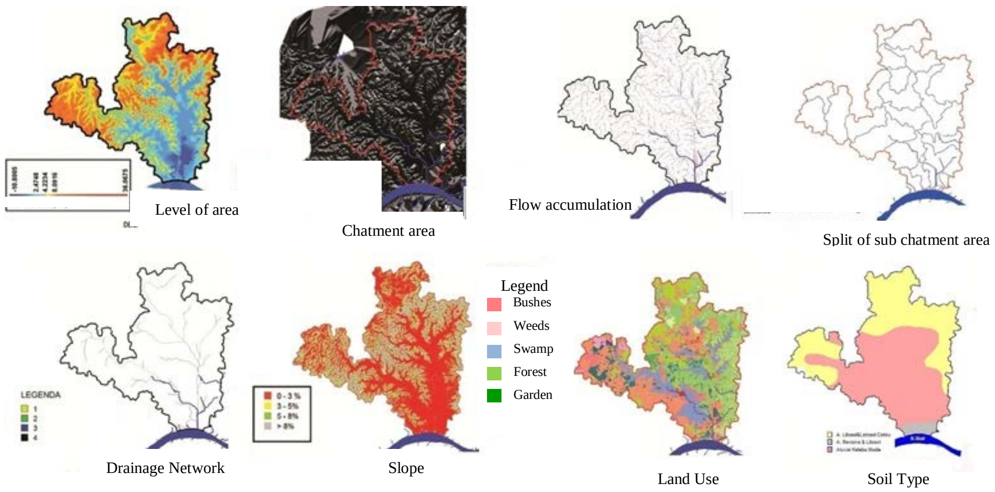

Fig. 3 Caracteristic of morfometry Lambidaro sub basin

4.3 Hydrodynamic model of Lambidaro watershed

The simulation of the Duflow-ArcGIS model was conducted on the Lambidaro watershed. Schematic of the water system based on DEM extraction with flow patterns that resulted in sub-basin and drainage line boundaries to illustrate runoff on the floodwaters constructed first (Fig. 4). The Lambidaro sub-basin network scheme was built by entering the cross-profile data as well as extending the channels per segment based on the measurement results in the field. Channel width ranges from 11 - 18 m. The boundary conditions for the Duflow model consist of upper boundary conditions such as runoff from upstream Lambidaro watershed and downstream boundary conditions, such as water levels at the mouth of the Lambidaro river. The rainfall hydrology parameter was taken from the analysis of the distribution of maximum daily rainfall by Gumbell method for a 25-year period of 163 mm / day. The weighted C values of each Lambidaro sub-basin were calculated from the results of spatial analysis of land use, slope, soil type and flow density per sub-watershed as shown in Fig. 4b. Water level in certain segments of drainage network of Lambidaro watershed is shown in Figure 4c. The results of the hydrodynamic modeling, the existing conditions of the Lambidaro sub watershed were approached with a 25-year return period scenario.

The water level on each segment is then transformed into the DEM sub of the Lambidaro sub basin, and interpolated by the Arc GIS procedure to obtain the inundation distribution that will occur for the 25 year anniversary scenario. The results of the analysis of the distribution of inundation of Lambidaro sub-basin were classified into six classifications, namely: (1) unlogged areas, (2) flooded with altitude less than 0.25 m, (3) altitude 0.25 - 0.5 m, (4) Altitude of 0.5-0.75 m, (5) altitude of 0.75-1 m and (6) heights of more than 1 m. Result of hydrodynamic modeling using Duflow model followed by analysis of inundation distribution that will occur with 25 year period return scenario seen as in Fig. 4d. The flooded areas of the Lambidaro sub-basin are the areas of flow accumulation and from field observations are low areas with a slope of 0-3% with the type of land use in swamp dominance. The calibration of this model is shown by the high suitability of inundation that occurs in the field with R^2= 0.869.

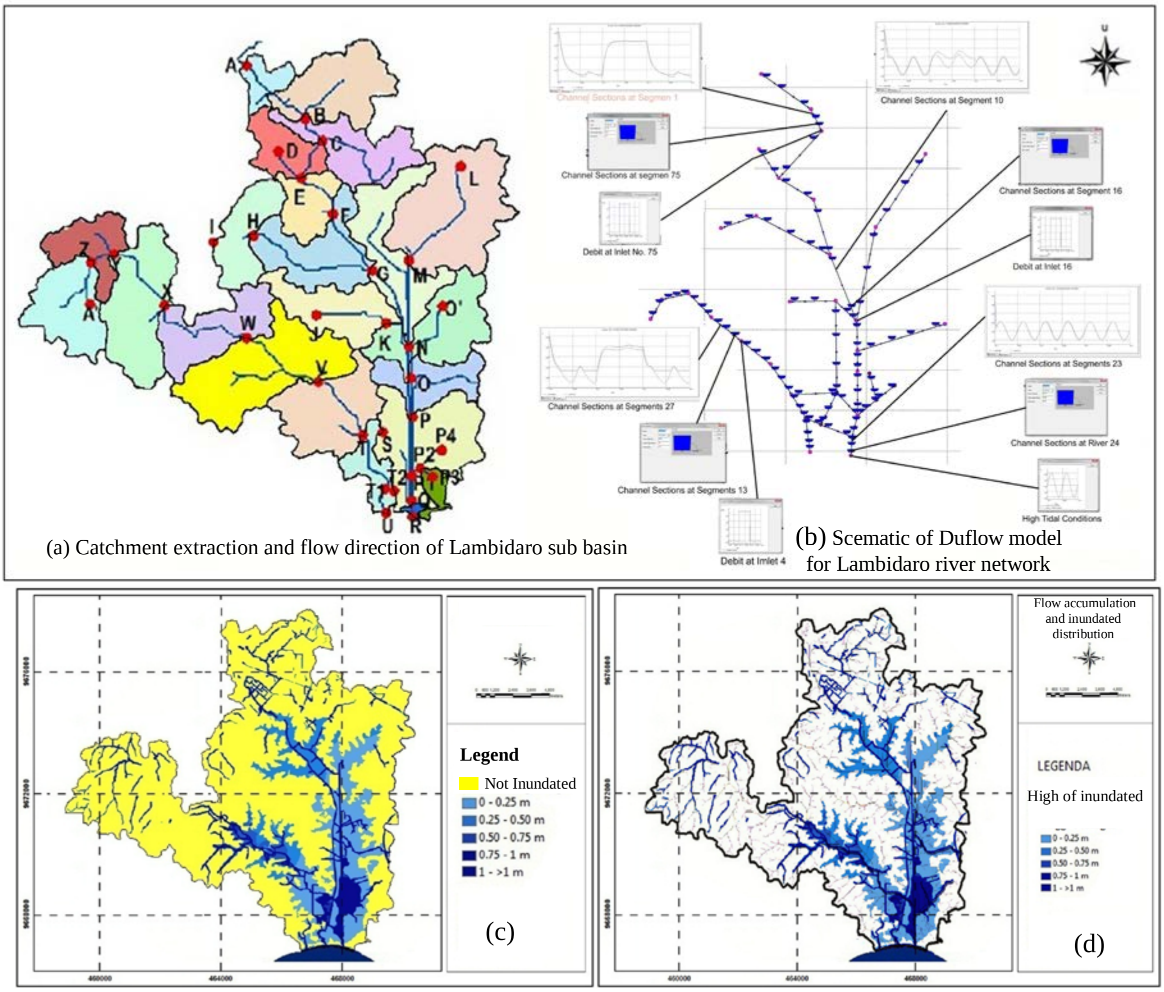

Fig. 4 Drainage network flood simulation of Lambidaro sub basin: (a) Chatment extraction and flow direction of Lambidaro sub basin (b) Scematic and drainage network; (c) distribution of inundation due to land use change; (d) the puddle area is assembled with flow accumulation

The influence of inundation in the upper Lambidaro watershed is 756.81 ha, 2821,6 ha and downstream 513,23 ha. As for the part of left Lambidaro sub-watershed, upstream area of 1854.5 ha, middle 380.5 ha and downstream 131.1 ha. The distribution of inundation stacked with Lambidaro sub-basin can be seen in Figure 5.

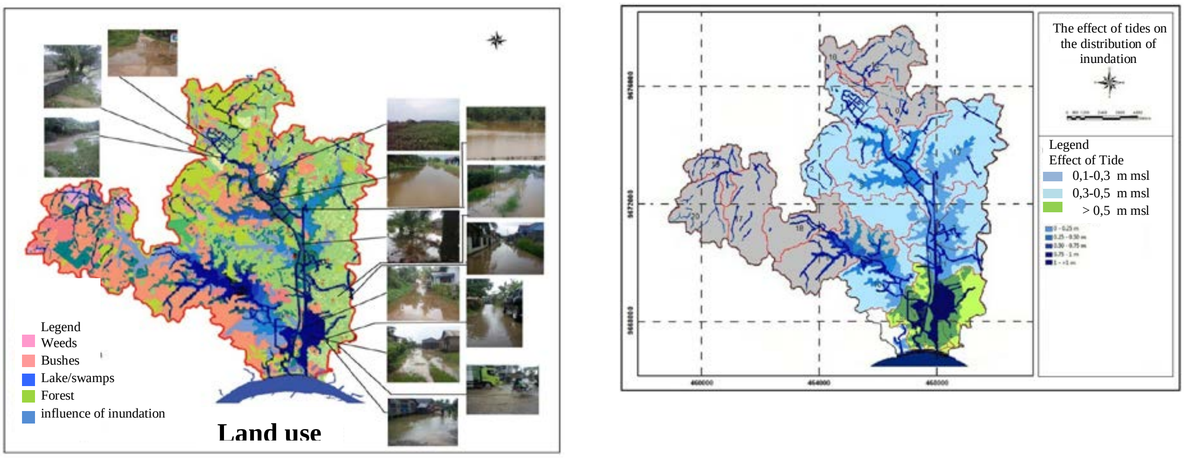

Fig. 5 Distribution of inundation is arranged with Lambidaro sub-waters upstream, middle and downstream

4.4 Land use change scenarios

Zoning scenario to see the effect of land use change on the inundation distribution that will occur in Lambidaro sub basin. Land use change scenario is made as many as 5 scenarios, namely :

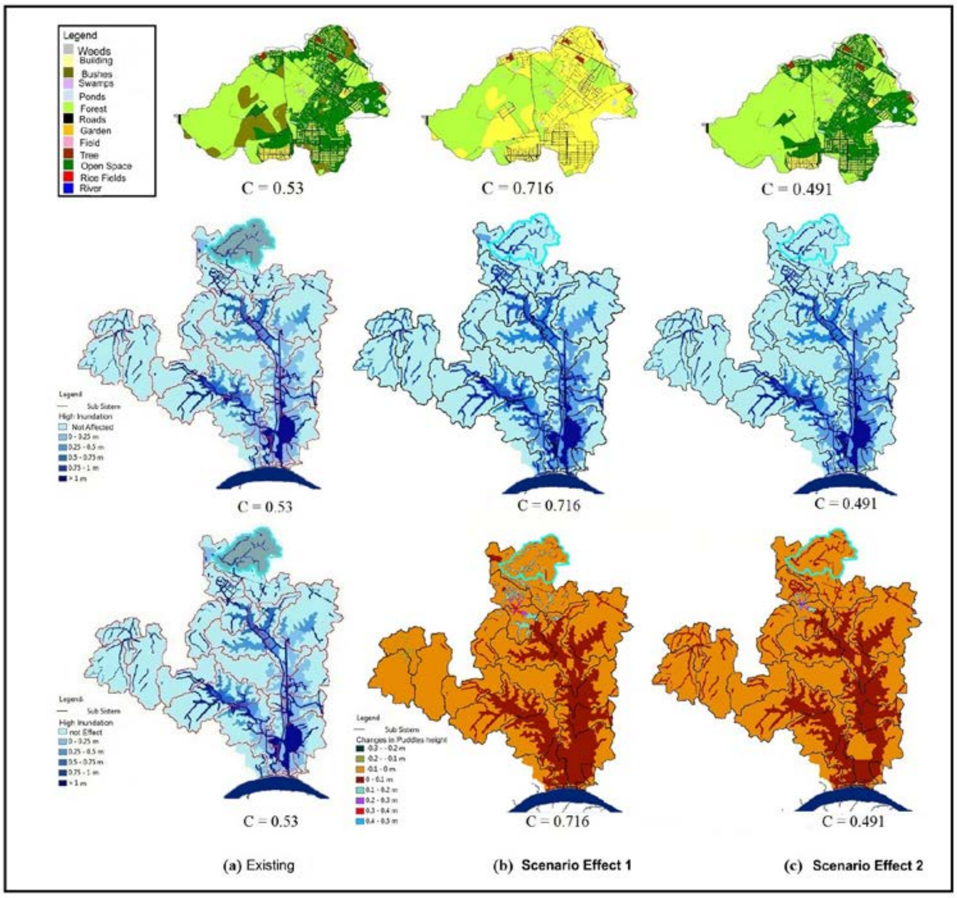

Fig. 6 Effects of land use change of Lambidaro upstream basin

(1) The first scenario by changing the type of land use area that is still possible to be converted into green area (urban forest, park) so it can decrease the value of C.
(2) The second scenario by changing the type of land utilization of Lambidaro sub-basin of the right section that may still be converted into a settlement (see the current city development) resulting in an increase in the value of C.
(3) The third scenario similar to the first scenario is only done on the part of left Lambidaro sub basin.
(4) The fourth scenario is the same as the second scenario only done on the part of left Lambidaro sub basin.
(5) The fifth scenario by changing land use with different C values ranging from 0.2 to 0.9

Some of the effects of land use change scenarios on upstream, mid and downstream sub watersheds by minimizing and increasing the value of the runoff coefficient C per sub-watershed were done to reduce and incre
in Fig. 6.

This is not a responsible conclusion

5. CONCLUSION

(1) Drainage capacity of Lambidaro River averaging 14.25 m3 / s, is unable to flow water discharge 25 year return period of 52,43 m3 / s
(2) The flood discharge of the 25-year return period resulted in 609.01 hectares or about 1.1% of the total Lambidaro river sub basin. The duration of the puddle varied from 3 hours to 59 hours with a puddle height between 0.01 m from the elevation of the left bank of the river +2, 5 m to 1.80 m from the river right bank elevation + 1.5m

6. ACKNOWLEDGMENTS

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7. REFERENCE

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- Response by Author

On Sat, Dec 16, 2017 at 5:19 AM, Dinar DA Putranto <noreply@jotform.com> wrote:

18652 : Dinar DA Putranto : Journal Revised paper

Paper ID number	18652
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INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING

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*Corresponding Author, Received: 15 Oct. 2017, Revised: 00 Nov. 2017, Accepted: 00 Dec. 2017

ABSTRACT: The rapid growth of industry and urbanization has accelerated the transfer of land functions in urban areas. These changes are mostly done by reclamation of swamps, riparian land use, agriculture and forest land conversion. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff. Run-off problems with the characteristics of flood peaks and inundation, in addition to being influenced by several factors as above are also influenced by the influence of tides, sedimentation and river flow pollutants from upstream and other small rivers which forms a sub-watershed in the area. The ability to manage surface flow, run-off mitigation, infiltration and water quality all have a connection with spatial planning. But in reality in every spatial arrangement, the two systems, namely spatial management and water management are never done together. On the basis of this, it is necessary to analyze the conditions of the watershed hydrometry, the type of land cover, the duration and the time of rain, the tidal height, which is modeled spatially, in order to support in decision making for spatial management and water management. Palembang Metropolitan City is one of the major cities on the island of Sumatra, which is regionally included in the Musi Watershed area. Hydrologically Palembang City is located at the mouth of the Musi river, with an altitude of less than 20 m above the mean sea level. When the maximum rainfall in the Watershed Area, Palembang City will be affected, where runoff on the sub-watershed in Palembang city can not be channeled the main channel through Palembang City, due to the tide of Musi river water. This study aims to show the relationship between watershed hydrometry, land use change management, rain intensity, and tidal influences on the watershed area, with various scenarios that will affect the runoff discharge and distribution of inundation that occur in the watershed area. Taking a case study of the Lambidaro sub-basin, in the Palembang city area, all sub-basin parameters that have been tested and are modeled by a duflow to calculate the extent of runoff and flood flow tracking in the river. The inundation distribution occurring in the sub watershed was obtained by combining the results of hydrodynamic analysis and spatial analysis. Based on the results obtained it is concluded that there is a strong spatial relationship between land use and sub-basin morphometry and its effect on the extent of surface runoff.

Keywords*: Land Use Change, flooding and pudles, Run-off, spatial Management*

1. INTRODUCTION

Changes land use in some areas of the city in Indonesia is so fast, due to rapid urbanization and industrial development. These changes are almost entirely done by reclamation of swamps, the utilization of river banks, and conversion of forest land and agricultural land. The impact of changes in land use has changed the patterns of water drainage in sub-basin areas that exist in urban areas. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff [1].

Human activities have a very significant impact on water quantity, water quality and aquatic ecology. As a result, the dangers of flooding, household and industrial waste, which, after accumulating for a long time, are unlikely to return to normal or require enormous costs for recovery.

Run-off problems with peak flood and inundation characteristics are influenced by several factors, such as urbanization, unsuitable landfill, tidal effects, as well as sedimentation and river-flow pollutants from upstream areas and other small rivers that form the sub-watersheds in the area [2].

Flow management capability, run-off mitigation, infiltration and water quality all have relevance to land use conditions. However, the connection between the water management system and spatial planning is one of the important keys that must be done if they want to play a role in reducing the danger of flooding. However, in reality in every spatial arrangement, the two systems, namely spatial planning and water management are never done together. On this basis, an analysis of hydrotopographic conditions, type of land cover, duration and time of rain, tidal height, are modelled using spatial analysis, in order to support decision-making for spatial management and water management [3].

2. CITY DEVELOPMENT AND FLOOD PROBLEM IN SOUTH SUMATERA AREA

Similar to the development of several regions in Indonesia, the province of South Sumatra has the development of cities that are very significant. It can be seen from the population growth which averagely reached 2.13% with the population of 7,446,401 in 2010 [4] of which , 1,452,840 are in Palembang (19.5%). If the average population growth in South Sumatera remains at 2.13%, then it is estimated that in 2030, the population in South Sumatera province will reach 317,216,683 people and 42.6% will be in Palembang City.

With such a large population growth, there will be concentration of population in big cities in South Sumatera Province especially in Palembang City, which will cause expansion of land use for various urban activities. The expansion that will change the various functions of the "water park" land, is transformed into a wake-up land, irrespective of the watershed ecosystem.

Based on data from BMKG (2010), the highest rainfall in South Sumatera Province is 18 - < 34.87 mm / day and the peak rainfall in November, and the lowest rainfall <18 mm / day, occurs every May-August. Surface water is difficult to predict its spread in space and time. While the observation system of discharge is done using AWLR in several locations along the river, many of which are not functioning properly. This has caused many problems to predict the occurrence of peak flood and areas that will occur. In October (2016), the city of Lubuk Linggau, and several sub-districts in Musi Rawas district have experienced floods, the city of Sekayu and several sub-districts in Musi Banyuasin regency in September (2016), Inderalaya city and several subdistricts in Ogan Ilir Regency (October, 2016), Kayu Agung city and several sub-districts in Ogan Komering Ilir regency, Pangkalan Balai City and several subdistricts in Banyuasin regency, and Palembang City itself always experiences flood every rain with high intensity.

Efforts to control floods have been undertaken by several cities that often experience floods every year. In Jakarta City by building a flood canal and make a hole biopore. In Semarang City, by building a polder system. But all of them have not yet shown that the problem of annual floods can be overcome. All flood control systems, must depart from existing watershed ecosystem conditions. From these conditions, It requires new analysis by simulation to determine the flood discharge of each return period, which finally can be used to determine the appropriate drainage system in the area [5]. Thus a specific approach through more useful and accurate techniques is necessary. Transforming data into a Geographic Information System using Multi criteria Spatial Analysis in decision making [6] can be used as a policy combination solution and technical, and also as a model in presenting the watershed environmental conditions for better data quality and analysis [7].

2.1 Case Study

As an example of frequent inundation in the Lambidaro sub-basin especially in the downstream area and around the floodplain, during the rainy season and high tides. Lambidaro sub basin with an area of 65.25 km2 is a sub watershed which has different morphometric characteristics with other sub watersheds. Based on the drainage pattern it is divided into two sub-watersheds namely part of left Lambidaro Sub-watershed and part of right Lambidaro sub-watershed which leads to the Musi river.

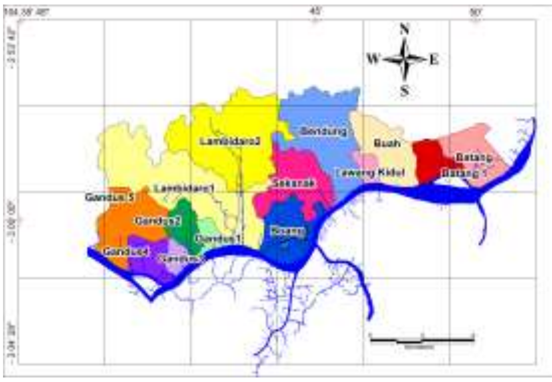

Fig.1 Lambidaro sub basin at Musi downstreem sub basin area

3. METHODOLOGY

To anticipate the amount of runoff water, due to inappropriate land allocation, multicriteria analysis is needed in every decision of land allocation. Land Allocation Management System (SIMAL) is a watershed analysis system developed using GIS or Geographic Information System (GIS) using land use change parameters, morphometry and hydrometry of DAS [8].

3.1 Research Site

As a study material is to explain the effect of surface runoff on land use change, the location of the study is the Lambidaro sub-basin (Figure 1), which is one of 16 sub-basins that form the drainage system of Palembang and discharges into the Musi River, through the city of Palembang. With an area of 65.42 Km2.

3.2 Research Data

The data used in this research are river hydrometry data, longitudinal cross section (*l*) and river cross (*b*), river slope (*ls*) and area (*A*) and density (*r*). While spot height data and land use are needed to analyze the infiltration coefficient (*c*) and time concentration (*tc*). And the ever-changing dynamic data is the rainfall data (*R*) needed to calculate the rain intensity (*I*) in each sub-watershed.

3.3 Research Methods

The method used in this research is using hydrology model and Geographic Information System (GIS). The hydrological model used is to use HEC-HMS, while the hydrodynamic model used to calculate the amount of runoff that occurs is with Duflow which will also be used to track flood flow in rivers [9].

Hydrodynamic analysis was performed on selected river sub-systems that have been obtained from the results of cluster analysis. This analysis utilizes the 1D (Duflow) non-steady flow model with the maximum rainfall intensity conditions of the 25th anniversary period of the previous hydrological analysis results as well as the results of tidal observation forecasting at the sub-systems of selected river sub-systems. The first stage in hydrodynamic analysis by establishing a scheme of hydrodynamic network in sub watershed adapted to the results through terrain morphology and terrain processing analysis on ARCGIS-ARC Hydro and field conditions, then incorporating the dimensions of water structure, cross section, boundary conditions (tidal, rain Results of hydrological analysis) and flow discharge. After calculation of each segment / cross section will be obtained some hydraulic parameters such as flood water level, water flow rate, channel flow and water level in river and channel.

The inundation distribution occurring in the sub-river system is obtained by combining the results of hydrodynamic analysis and spatial analysis. The water level in the river and the channel is interpolated to obtain the distribution of water level in the selected river sub system. Then the distribution of water level is arranged with topographic condition of river sub system in the form of DEM 5m x 5m so as to obtain the distribution of classified high pools that occur in each selected river sub-system with 25th anniversary period.

With several scenarios of land use change it can be seen how much the changes in inundation height due to land use change in the selected sub-system. This scenario is used as a way to see the condition of sub-system of river which in turn will influence the pattern of river environmental control that will be done. The first scenario is to change the type of land use so that the value of C tends to decrease which becomes an indicator of the condition of the river sub system becomes better. The second scenario by changing the type of land use so that the value of C tends to increase, this condition can explain that a river sub system has a condition that is considered to be disturbed.

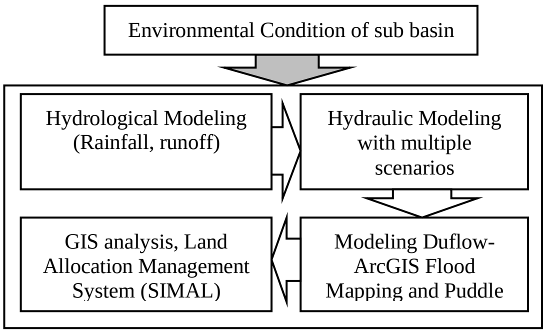

Fig. 2 Flow Chart of research methods

4. RESULTS AND DISCUSSION

4.1 Correlation Between Surface Run-off with Morphometric Characteristic Variable

This correlation is analyzed to address the problem of spatial relationships between land use and sub-basin morphometry and its effect on the extent of surface runoff. The strong correlation between independent variables (characteristic of sub-basin morphometry) and dependent variable of runoff (Q), is seen through Pearson correlation value. Correlation values range from -1,000 to 1,000. The value of -1.000 shows a very strong but negative correlation, while the value of 1,000 indicates a very strong correlation / very closely directed positively.

The results of the analysis (at 99% confidence level) obtained the correlation value between variables very high runoff (*Q*) ranges from 0.849 to 0.999 with variable length of river order (x_1), river length (x_2), watershed (x_3), roving watershed (x_4) , average *Rb* (x_5), Flow density (x_6), Texture ratio (x_8), Roughness number *Rn* (x_{10}).

This means that there is a strongly significant relationship between runoff and long river order, river length, basin area, perimeter watershed, average Rb, flow density, texture ratio, roughness number Rn. While the value of strong correlation is seen between runoff with *Tc* concentration time of 0.629. This means at a significance level of 5% or a 95% confidence level, there is a strong relationship between runoff and concentration time (*Tc*). The correlation value is strong enough at flow frequency (x_7), relief (x_9) and green area (forest, tree, shrub, yard / yard, rice field, field, garden) (x_{14}). Low correlation value between runoff and variable flow coefficient C (x_{12}) of 0.319 with significant level and negative correlation of 0.234 for variable circularity ratio Rc (x_{13}).

4.2 Caracteristic of Lambidaro sub Basin

The morphometric characteristics of the Lambidaro watershed are shown in Figure 3. Land utilization in the Lambidaro sub-basin is dominated by shrubs, trees, fields and forests ranging from 72%, settlements ranging from 4.74% to potentially changing land use, such as for settlement development. Settlement construction mainly occurs in right Lambidaro sub-watershed close to the main road / outer shaft of Palembang City (Musi dua bridge). At part of left Lambidaro sub basin is dominated by bushes and swamps. The sub-watershed of Lambidaro river has varying altitude less than 10 m msl in estuary area up to 36 m in upstream area. The percentage of the slope is dominated by 0-3% and more than 8% with a maximum height of 36 msl in the upstream area. River conditions are still natural, especially in part of left Lambidaro, while some rivers in part of right Lambidaro sub basin have been normalized by cliff reinforcement.

With the condition of land use, slope, flow density and soil type, the range of runoff coefficient in Lambidaro sub-basin shows the runoff coefficient value of 0.66. This means that 34% of the total rainfall falls on the Lambidaro river sub-basin can still be infiltrated (see Figure 3).

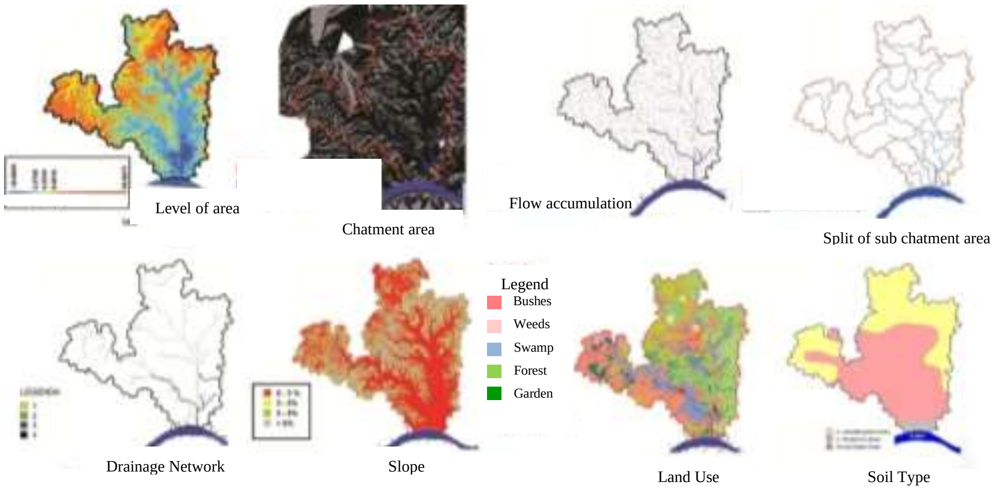

Fig. 3 Caracteristic of morfometry Lambidaro sub basin

4.3 Hydrodynamic model of Lambidaro watershed

The simulation of the Duflow-ArcGIS model was conducted on the Lambidaro watershed. Schematic of the water system based on DEM extraction with flow patterns that resulted in sub-basin and drainage line boundaries to illustrate runoff on the floodwaters constructed first (Fig. 4). The Lambidaro sub-basin network scheme was built by entering the cross-profile data as well as extending the channels per segment based on the measurement results in the field. Channel width ranges from 11 - 18 m. The boundary conditions for the Duflow model consist of upper boundary conditions such as runoff from upstream Lambidaro watershed and downstream boundary conditions, such as water levels at the mouth of the Lambidaro river. The rainfall hydrology parameter was taken from the analysis of the distribution of maximum daily rainfall by Gumbell method for a 25-year period of 163 mm / day. The weighted C values of each Lambidaro sub-basin were calculated from the results of spatial analysis of land use, slope, soil type and flow density per sub-watershed as shown in Fig. 4b. Water level in certain segments of drainage network of Lambidaro watershed is shown in Figure 4c. The results of the hydrodynamic modeling, the existing conditions of the Lambidaro sub watershed were approached with a 25-year return period scenario.

The water level on each segment is then transformed into the DEM sub of the Lambidaro sub basin, and interpolated by the Arc GIS procedure to obtain the inundation distribution that will occur for the 25 year anniversary scenario. The results of the analysis of the distribution of inundation of Lambidaro sub-basin were classified into six classifications, namely: (1) unlogged areas, (2) flooded with altitude less than 0.25 m, (3) altitude 0.25 - 0.5 m, (4) Altitude of 0.5-0.75 m, (5) altitude of 0.75-1 m and (6) heights of more than 1

m. Result of hydrodynamic modeling using Duflow model followed by analysis of inundation distribution that will occur with 25 year period return scenario seen as in Fig. 4d. The flooded areas of the Lambidaro sub-basin are the areas of flow accumulation and from field observations are low areas with a slope of 0-3% with the type of land use in swamp dominance. The calibration of this model is shown by the high suitability of inundation that occurs in the field with R^2= 0.869.

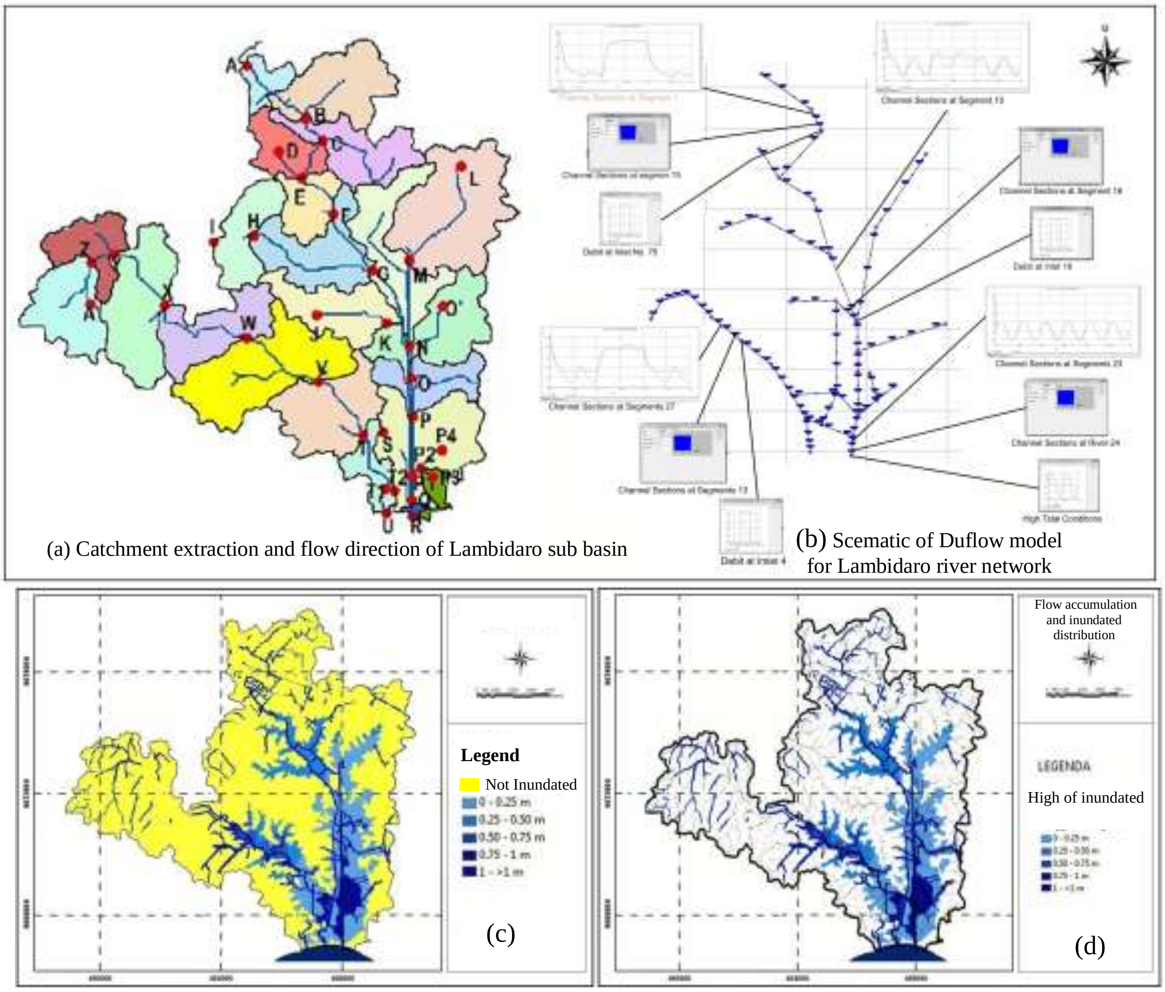

Fig. 4 Drainage network flood simulation of Lambidaro sub basin: (a) Chatment extraction and flow direction of Lambidaro sub basin (b) Scematic and drainage network; (c) distribution of inundation due to land use change; (d) the puddle area is assembled with flow accumulation

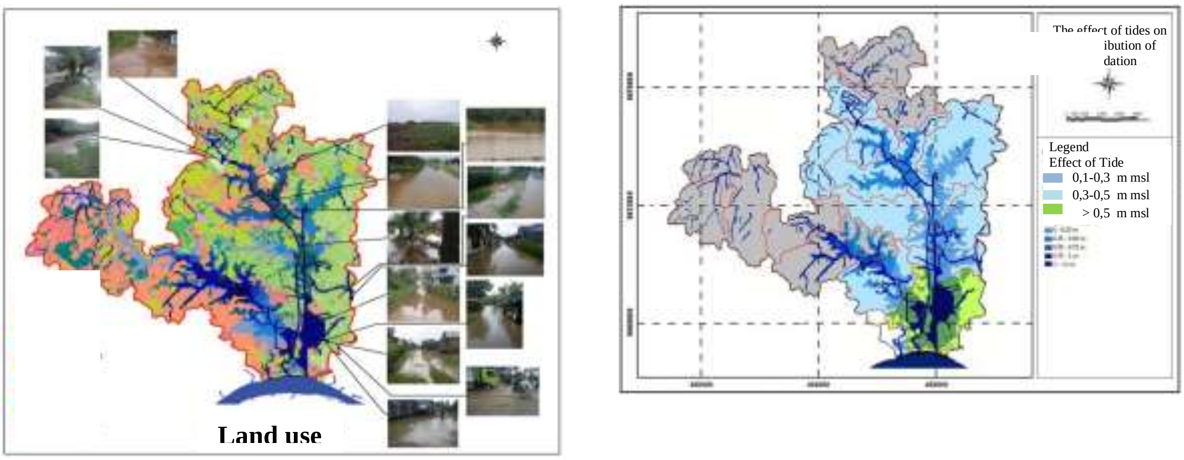

Fig. 5 Distribution of inundation is arranged with Lambidaro sub-waters upstream, middle and downstream

The influence of inundation in the upper Lambidaro watershed is 756.81 ha, 2821,6 ha and downstream 513,23 ha. As for the part of left Lambidaro sub-watershed, upstream area of 1854.5 ha, middle 380.5 ha and downstream 131.1 ha. The distribution of inundation stacked with Lambidaro sub-basin can be seen in Figure 5.

4.4 Land use change scenarios

Zoning scenario to see the effect of land use change on the inundation distribution that will occur in Lambidaro sub basin. Land use change scenario is made as many as 5 scenarios, namely :

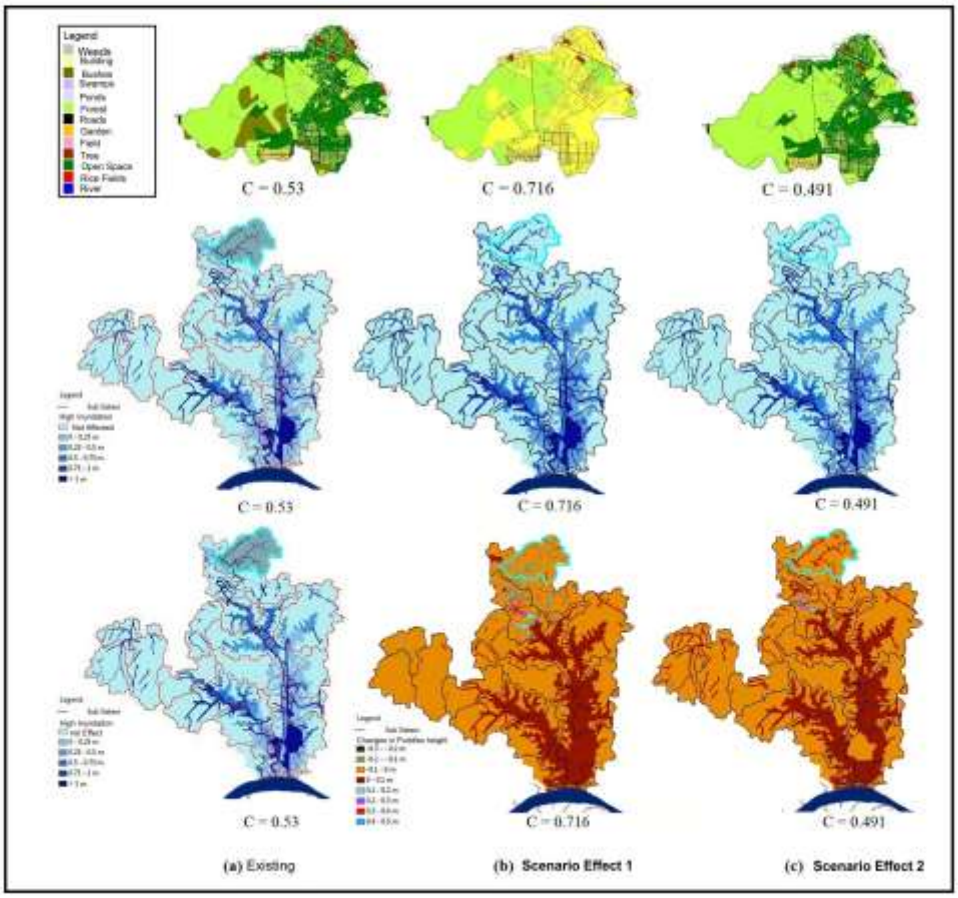

Fig. 6 Effects of land use change of Lambidaro upstream basin

(1) The first scenario by changing the type of land use area that is still possible to be converted into green area (urban forest, park) so it can decrease the value of C.
(2) The second scenario by changing the type of land utilization of Lambidaro sub-basin of the right section that may still be converted into a settlement (see the current city development) resulting in an increase in the value of C.
(3) The third scenario similar to the first scenario is only done on the part of left Lambidaro sub basin.
(4) The fourth scenario is the same as the second scenario only done on the part of left Lambidaro sub basin.
(5) The fifth scenario by changing land use with different C values ranging from 0.2 to 0.9

Some of the effects of land use change scenarios on upstream, mid and downstream sub watersheds by minimizing and increasing the value of the runoff coefficient C per sub-watershed were done to reduce and increase the inundation shown in Fig. 6.

5. CONCLUSION

1. There is a strongly significant relationship between runoff and river length, watershed area, perimeter watershed, average Rb, flow density, texture ratio, roughness number Rn.
2. There is a strong relationship between runoff and concentration time (Tc).

3. The correlation is strong enough on the Frequency of flow and Relief with the forest area
4. The effect of land-use change with several scenarios made in the Lambidaro sub-basin proves that if land use change is not well controlled, the extent of the inundation will extend from downstream, middle to upstream

ACKNOWLEDGMENTS

Acknowledgments are submitted to the Directorate of Research and Community Service, Ministry of Research Technology and Higher Education, for the support of Research Grants Higher Education grants for the period of study 2016-2018.

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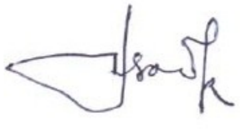
Response by Authors to Reviewer's Remarks/Comments

Integration of Surface Water Management in Urban and Regional Spatial Planning

Authors: *Putranto DA Dinar[1], Sarino[2], Yuono AL[3], Juliana Ch Imroatul[4], and Hamim SA[5]

The authors have summarized their replies to the Reviewers' comments in this response letter in a two column format. A revised manuscript is submitted addressing all the comments to the Journal of GEOMATE for possible publication.

No.	*Reviewer_A's Comments*	*Authors Response*
	It is noted that the research objective s clear while the nvestigation method s sound, although the abstract was not well written. Great effort required to conduct such a research. Reasonable discussions and presentation of figures and tables can also be found throughout the paper	The authors are grateful for the appreciation of the reviewers of the research that the author has done, although the writing in the feel is still very less, especially in the grammar written in English. Upon appreciation, the author tries to write back with some revisions that may still be lacking, but the author's hope to be re-assessed for improvements can the author do better in accordance with the provisions in the necessary publication.
1.	Abstract: Rewrite in concise form Add some results and conclusions n abstract	Improvements to the abstract have been done by the author. Likewise additions to the conclusions and objectives to be achieved.
2.	Introduction: Add more references n ntroduction	The addition of reference to the introduction has been done by the author
3.	Conclusions: Add more resuts n conclusions	Conclusions have been improved in accordance with the objectives to be achieved in research
4.	List of references: Foow template	Reference writing has been adapted to the existing template

DR. Ir. Dinar Dwi Anugerah Putranto, MSPJ 	Dr. Imroatul Chalimah Juliana, S.T., M.T 
Ir. Sarino, MSCE 	Agus Lesrti Yuono, ST,MT 

Review Results 2

International Journal of GEOMATE

ISI

- Pengantar dari Editor
- Correction 2

Re: 18652 : Dinar DA Putranto : Journal Revised paper

Dari: Zakaria (zakaria@bio.mie-u.ac.jp)

Kepada: dwianugerah@yahoo.co.id; yuono_al@yahoo.co.id

Tanggal: Kamis, 21 Desember 2017 16.00 WIB

Thanks.

Your revised paper has been examined by our external referees and then re-evaluated in-house. You will be pleased to know that your revised paper has been provisionally accepted. Congratulations.

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Best regards.

Editor-in-Chief
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On Sat, Dec 16, 2017 at 5:19 AM, Dinar DA Putranto <noreply@jotform.com> wrote:

> ## 18652 : Dinar DA Putranto : Journal Revised paper
>
> | | |
> |---|---|
> | Paper ID number | 18652 |
> | Revised Title | INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING |
> | Title/Position | Dr. |
> | Full Name | Dinar DA Putranto |
> | E-mail | dwianugerah@yahoo.co.id |

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Forward from Author 2

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INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING

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ABSTRACT: It is necessary to analyze the conditions of the watershed hydrometry, the type of land use, the duration and the time of rain, the tidal height, which is modeled spatially, in order to support in decision making for spatial management and water management. Palembang Metropolitan City is one of the major cities on the island of Sumatra, which is regionally included in the Musi Watershed area. Hydrologically Palembang City is located at the mouth of the Musi river, with an altitude of less than 20 m above the mean sea level. When the maximum rainfall occurs in the watershed Area, Palembang City will be affected by tidal water, and runoff on the sub-watershed in Palembang city can not be flowed through the main channel within Palembang City, due to the tide of Musi river water. This study aims to show the relationship between watershed hydrometry, land use change management, rain intensity, and tidal influences on the watershed area, with various scenarios that will affect the runoff discharge and distribution of inundation that occur in the watershed area. Taking a case study of the Lambidaro sub-basin, in the Palembang City area, all sub-basin parameters that have been tested were modeled by a using duflow to calculate the extent of runoff and flood flow tracking in the river. The inundation distribution occurring in the sub watershed was obtained by combining the results of hydrodynamic analysis and spatial analysis. Based on the results obtained it is concluded that there is a strong spatial relationship between land use and sub-basin morphometry and its effect on the extent of surface runoff.

Keywords: *Land Use Change, flooding and pudles, Run-off, spatial management*

1. INTRODUCTION

Land use changes in some areas of the city in Indonesia is so fast, due to rapid urbanization and industrial development. These changes are almost entirely done by reclamation of swamps, the utilization of river banks, and conversion of forest land and agricultural land. The impact of changes in land use has changed the patterns of water drainage in sub-basin areas that exist in urban areas. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff [1].

Human activities have caused very significant impact on water quantity, water quality and aquatic ecology. As the result, the dangers of flooding, household and industrial waste, which, after accumulating for a long time, are unlikely to return to normal or require enormous costs for recovery.

Run-off problems with peak flood and inundation characteristics are influenced by several factors, such as urbanization, unsuitable landfill, tidal effects, as well as sedimentation and river-flow pollutants from upstream areas and other small rivers that form the sub-watersheds in the area [2].

Flow management capability, run-off mitigation, infiltration and water quality all have relevance to land use conditions. Furthermore, the connection between the water management system and spatial planning is one of the important keys that must be done if they want to play a role in reducing the danger of flooding. However, in reality in every spatial arrangement, the two systems, namely spatial planning and water management have never been integrated. On this basis, an analysis of hydro topographic conditions, type of land cover, duration and time of rain, tidal height, are modeled using spatial analysis, in order to support decision making for spatial management and water management [3].

2. CITY DEVELOPMENT AND FLOOD PROBLEM IN SOUTH SUMATERA AREA

Similar to the development of several regions in Indonesia, the province of South Sumatra has the development of cities that is very significant. It can be seen from the population growth which averagely reached 1.44% with the population of 7,481,200 in 2010 [4] of which, 1,468,000 are in Palembang (19.62%). If the average population growth in South Sumatera remains at 1.88%, then it is estimated that in 2030, the population in South Sumatera province will reach 10,166,760 people and 18.97% will be in Palembang City.

With such a large population growth, there will be concentration of population in big cities in South Sumatera Province especially in Palembang City, which will cause expansion of land use for

various urban activities. The expansion that will change the various functions of the water reservoir land, is transformed into a developed one,and will neglect the watershed ecosystem.

Based on data from BMKG (2010), the highest rainfall in South Sumatera Province is 18 - <34.87 mm/day and the peak rainfall in November, and the lowest rainfall <18 mm/day, occurs every in May-August. Surface water is difficult to predict in relation to space and time distribution . While the AWLR which is used to record water level in several locations along the river has not worked properly. This has caused much constraints to predict the occurrence of peak flood and areas that will occur. In October (2016), the city of Lubuk Linggau, and several sub-districts in Musi Rawas district have experienced floods, the city of Sekayu and several sub-districts in Musi Banyuasin regency in September (2016), Inderalaya city and several sub-districts in Ogan Ilir Regency (October, 2016), Kayu Agung city and several sub-districts in Ogan Komering Ilir regency, Pangkalan Balai City and several sub-districts in Banyuasin regency, and Palembang City itself always experiences flood in every rainy season with high intensity.

Efforts to control floods have been undertaken by several cities that often experience floods every year. In Jakarta City floodway canal and biopore has been made and in Semarang City, a polder system has been also built. But all of them have not yet shown that the problem of annual floods can be overcome. All flood control systems, must depart from existing watershed ecosystem conditions. From these conditions, It requires new analysis by simulation to determine the flood discharge with each return period, which finally can be used to determine the appropriate drainage system in the area [5]. Thus a specific approach through more useful and accurate techniques is necessary. Transforming data into a Geographic Information System using Multicriteria Spatial Analysis in decision making [6] can be used as a policy and technical combination solution and technical, and also as a model in presenting the watershed environmental conditions for better data quality and analysis [7].

2.1 Case Study

As an example of frequent inundation in the Lambidaro sub-basin especially in the downstream area and around the floodplain, during the rainy season and high tides is Lambidaro sub basin with an area of 65.25 km2 is a sub watershed which has different morphometric characteristics from other sub watersheds. Based on the drainage pattern it is divided into two sub-watersheds namely part of left Lambidaro (Lambidaro-1) Sub-watershed and part of right Lambidaro (Lambidaro-2) sub-watershed which leads to the Musi river.

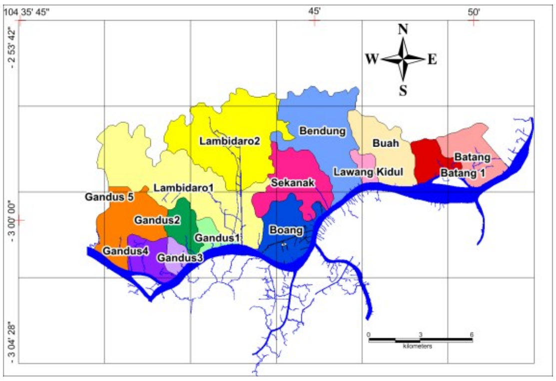

Fig.1 Lambidaro sub-basin at Musi downstreem sub-basin area

3. METHODOLOGY

To anticipate the amount of runoff water, due to inappropriate land allocation, a multicriteria analysis is needed in every decision of land allocation. Land Allocation Management System (SIMAL) is a watershed analysis system developed using GIS or Geographic Information System (GIS) using land use change parameters, morphometry, and hydrometry of DAS [8].

3.1 Research Site

The study material is to explain the effect of surface runoff on land use change, the location of the study is the Lambidaro sub-basin (Figure 1), which is one of 16 sub-basins that form the drainage system of Palembang which discharges into the Musi River, through the city of Palembang. With an area of 65.42 Km2.

3.2 Research Data

The data used in this research are river hydrometry data, longitudinal cross-section (l) and river cross (b), river bed invert (ls), watershed area (A) and density (r). While spot height data and land use are needed to analyze the infiltration coefficient (c) and time concentration (Tc). And the ever-changing dynamic data is the rainfall data (R) needed to calculate the rain intensity (I) in each sub-watershed.

3.3 Research Methods

The method used in this research is using hydrology model and Geographic Information System (GIS). The hydrodynamic model Duflow was used to calculate the amount of runoff, which

would also be used to track flood flow in rivers [11].

The hydrodynamic analysis was performed on selected river sub-systems that have been obtained from the results of cluster analysis. This analysis utilizes the 1D (Duflow) non-steady flow model with the maximum rainfall intensity conditions of the 25th anniversary period of the previous hydrological analysis results as well as the results of tidal observation forecasting at the sub-systems of selected river sub-systems. The first stage in the hydrodynamic analysis was by establishing a scheme of the hydrodynamic network in sub-watershed adapted to the results through terrain morphology and terrain processing analysis on ArcGIS-ARC Hydro and field conditions, then incorporating the dimensions of water structure, cross section, boundary conditions (tidal, rain Results of hydrological analysis) and flow discharge. After calculation of each segment/cross section will be obtained some hydraulic parameters such as flood water level, water flow rate, channel flow and water level in river and channel were obtained.

The inundation distribution occurring in the sub-river system was obtained by combining the results of hydrodynamic analysis and spatial analysis. The water level in the river and the channel was interpolated to obtain the distribution of water level in the selected river subsystem. Then the distribution of water level is arranged with the topographic condition of river sub system in the form of DEM 5m x 5m so as to obtain the distribution of classified high pools that occur in each selected river sub-system with 25th anniversary period.

With several scenarios of land use change, it can be seen how much the changes in inundation height due to land use change in the selected sub-system. This scenario was used as a way to see the condition of the sub-system of a river which in turn will influence the pattern of river environmental control that will be done. The first scenario is to change the type of land use so that the value of *C* tends to decrease which became an indicator of the condition of the river subsystem becomes better. The second scenario was changing the type of land use so that the value of *C* tends to increase, this condition could explain that river subsystem had a condition that was considered to be disturbed.

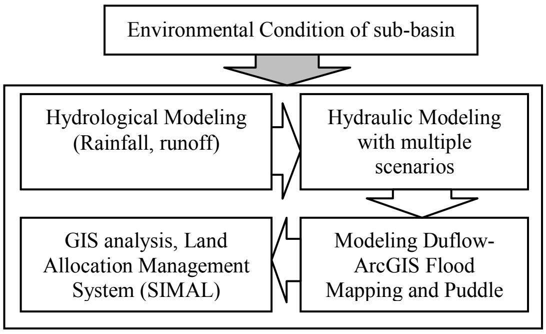

Fig. 2 Flow Chart of research methods

4. RESULTS AND DISCUSSION

4.1 Correlation Between Surface Run-off with Morphometric Characteristic Variable

This correlation was analyzed to address the problem of spatial relationships between land use and sub-basin morphometry and its effect on the extent of surface runoff. The strong correlation between independent variables (characteristic of sub-basin morphometry) and the dependent variable of runoff (Q), is seen through Pearson correlation value. Correlation values range from -1,000 to 1,000. The value of -1.000 shows a very strong but negative correlation, while the value of 1,000 indicates a very strong correlation/very closely directed positively.

The results of the analysis (at 99% confidence level) obtained the correlation value between variables very high runoff (Q) ranges from 0.849 to 0.999 with variable length of river order (x_1), river length (x_2), watershed (x_3), roving watershed (x_4) , average Rb(x_5), Flow density (x_6), texture ratio (x_8), Roughness number Rn (x_{10}).

This means that there is a strongly significant relationship between runoff and long river order, river length, basin area, perimeter watershed, average Rb, flow density, texture ratio, roughness number Rn. While the value of strong correlation is seen between runoff with *Tc* concentration time of 0.629. This means at a significance level of 5% or a 95% confidence level, there is a strong relationship between runoff and concentration time (*Tc*). The correlation value is strong enough at flow frequency (x_7), relief (x_9) and green area (forest, tree, shrub, yard, rice field, field, garden) (x_{14}). The low correlation value between runoff and variable flow coefficient C (x_{12}) of 0.319 with significant level and negative correlation of 0.234 for variable circularity ratio Rc (x_{13}).

4.2 Caracteristic of Lambidaro sub-Basin

The morphometric characteristics of the Lambidaro watershed are shown in Fig. 3. Land

utilization in the Lambidaro sub-basin is dominated by shrubs, trees, fields and forests ranging from 72%, settlements ranging from 4.74% to potentially changing land use, such as for settlement development. Settlement construction mainly occurs in right Lambidaro (Lambidaro-2) sub-watershed close to the main road / outer shaft of Palembang City (Musidua bridge). As part of left Lambidaro (Lambidaro-1) sub-basin is dominated by bushes and swamps. The sub-watershed of Lambidaro river has varying altitude less than 10 m msl in estuary area up to 36 m in upstream area. The percentage of the slope is dominated by 0-3% and more than 8% with a maximum height of 36 msl in the upstream area. River conditions are still natural, especially in part of left Lambidaro, while some rivers in part of right Lambidaro sub-basin have been normalized by cliff reinforcement.

With the condition of land use, slope, flow density and soil type, the range of runoff coefficient in Lambidaro sub-basin shows the runoff coefficient value of 0.66. This means that 34% of the total rainfall falls on the Lambidaro river sub-basin can still be infiltrated (see Figure 3).

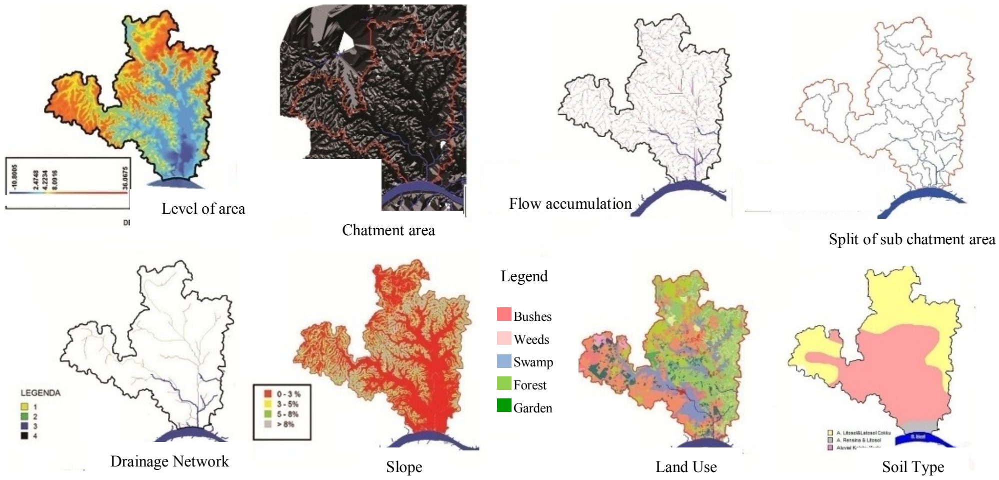

Fig. 3 Caracteristic of morfometry Lambidaro sub-basin

4.3 Hydrodynamic model of Lambidaro watershed

The simulation of the Duflow-ArcGIS model was conducted on the Lambidaro watershed. Schematic of the water system based on DEM extraction with flow patterns that resulted in sub-basin and drainage line boundaries to illustrate runoff on the floodwaters was constructed first (Figure 4). The Lambidaro sub-basin network scheme was built by entering the cross-profile data as well as extending the channels per segment based on the measurement results in the field. Channel width ranges from 11 - 18 m. The boundary conditions for the Duflow model consist of upper boundary conditions such as runoff from upstream Lambidaro watershed and downstream boundary conditions, such as water levels at the mouth of the Lambidaro river. The rainfall hydrology parameter was taken from the analysis of the distribution of maximum daily rainfall by Gumbell method for a 25-year period of 163 mm/day. The weighted C values of each Lambidaro sub-basin were calculated from the results of spatial analysis of land use, slope, soil type and flow density per sub-watershed as shown in Fig.4b. The water level in certain segments of drainage network of Lambidaro watershed is shown in Figure 4c. The results of the hydrodynamic modeling, the existing conditions of the Lambidaro sub-watershed were approached with a 25-year return period scenario.

The water level on each segment was then transformed into the DEM sub of the Lambidaro sub-basin, and interpolated by the ArcGIS procedure to obtain the inundation distribution that will occur for the 25-year anniversary scenario. The results of the analysis of the distribution of inundation of Lambidaro sub-basin were classified into six classifications, namely: (1) unlogged areas; (2) flooded with altitude less than 0.25 m; (3) altitude 0.25 - 0.5 m; (4) Altitude of 0.5-0.75 m; (5) altitude of 0.75-1 m and (6) heights of more than 1 m. The result of hydrodynamic modeling using Duflow model was followed by analysis of inundation distribution that will occur with 25 year period return scenario seen as in Figure 4d. The flooded areas of the Lambidaro sub-basin are the areas of flow accumulation and from field observations are low areas with a slope of 0-3% with the type of land use in swamp dominance. The calibration of this model is shown by the high suitability of inundation that occurs in the field with R^2= 0.869.

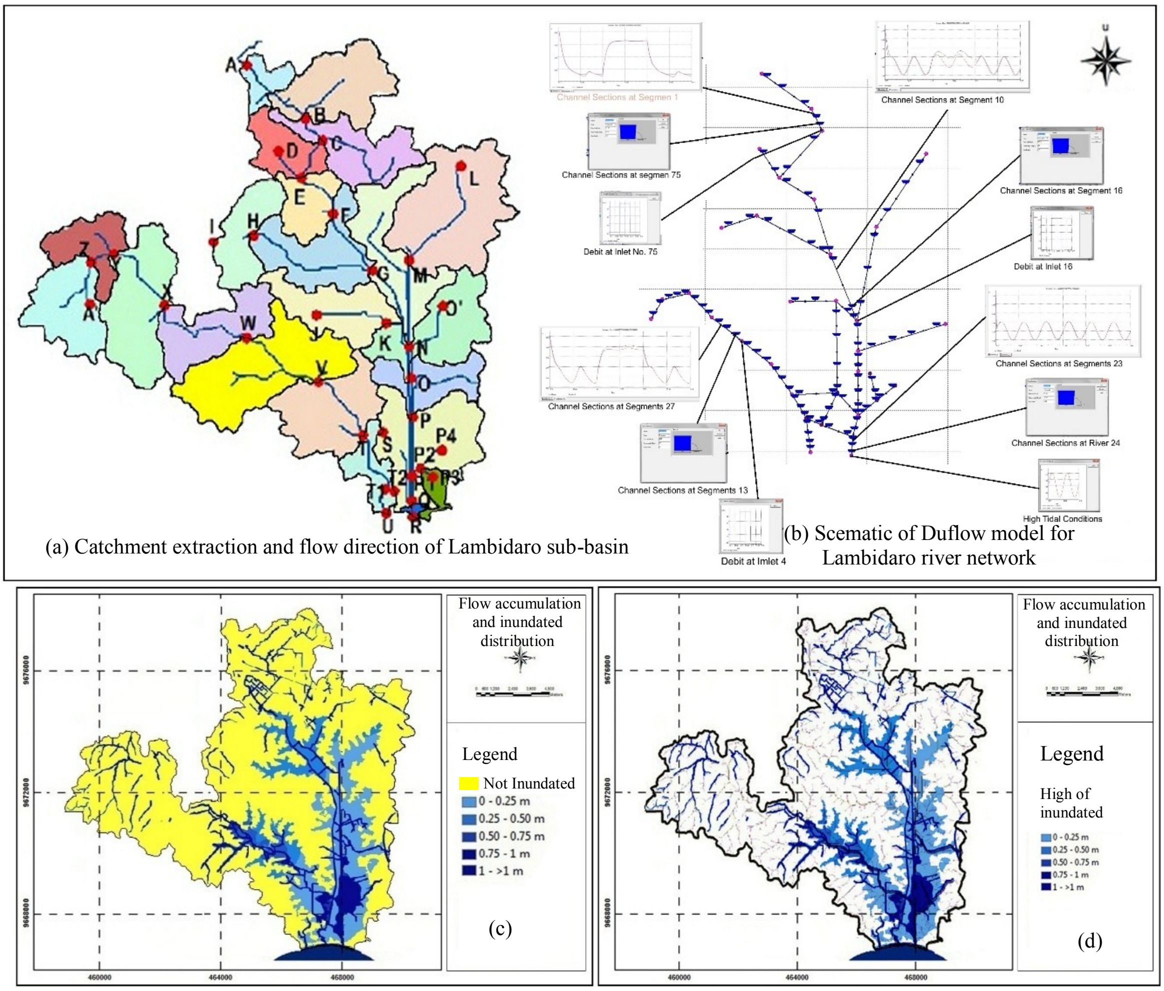

Fig. 4 Drainage network flood simulation of Lambidaro sub-basin: (a) Chatment extraction and flow direction of Lambidaro sub-basin (b) Scematic and drainage network; (c) distribution of inundation due to land use change; (d) the puddle area is assembled with flow accumulation

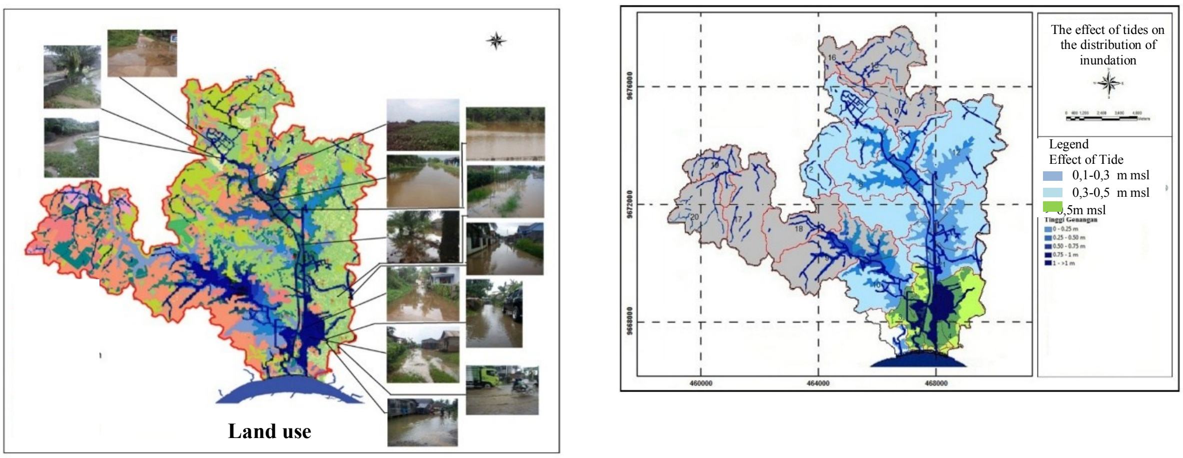

Fig. 5 Distribution of inundation is arranged with Lambidaro sub-waters upstream, middle and downstream

The influence of inundation in the upper Lambidaro watershed is 756.81 ha, 2821,6 ha, and downstream 513,23 ha. As for the part of left Lambidaro sub-watershed, the upstream area of 1854.5 ha, middle 380.5 ha and downstream 131.1 ha. The distribution of inundation stacked with Lambidaro sub-basin can be seen in Figure 5.

4.4 Land use change scenarios

Zoning scenario to see the effect of land use change on the inundation distribution that will occur in Lambidaro sub-basin. Land use change scenario is made as many as 5 scenarios, namely:

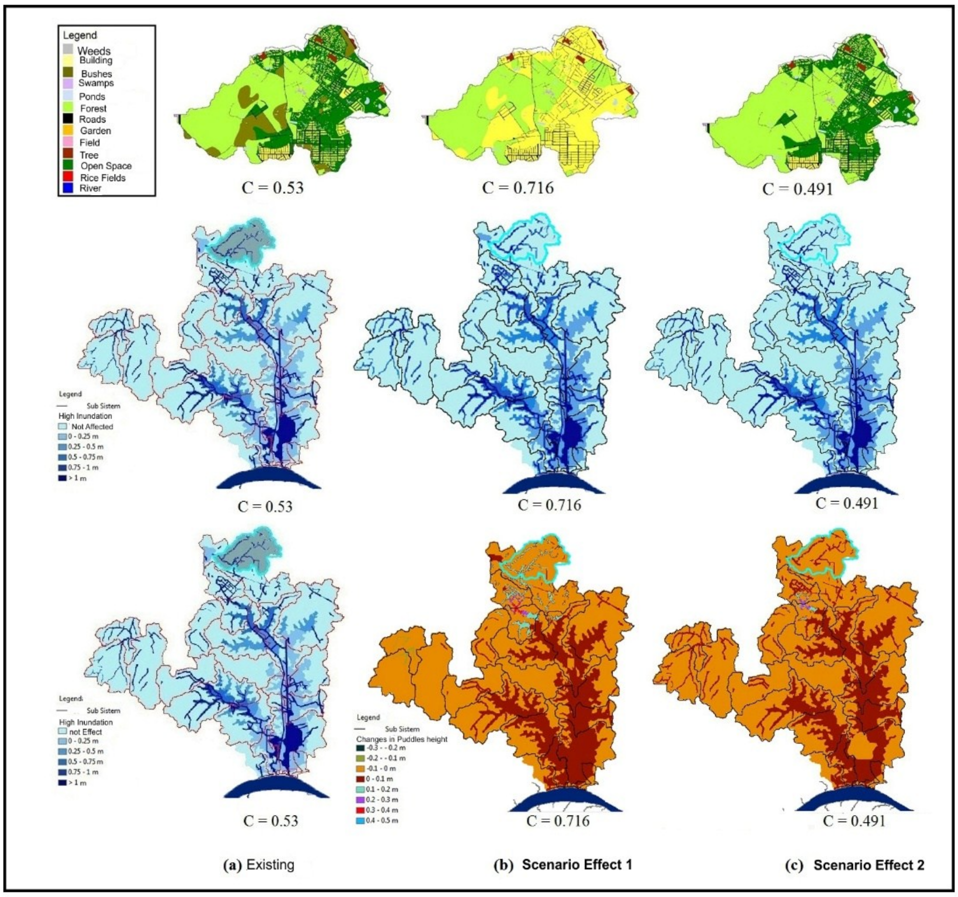

Fig. 6 Effects of land use change of Lambidaro upstream basin

(1) The first scenario is changing the type of land use area that is still possible to be converted into a green area (urban forest, park) so it can decrease the value of *C*.
(2) The second scenario is changing the type of land utilization of Lambidaro-2 sub-basin of the right section that may still be converted into a settlement (see the current city development) resulting in an increase in the value of *C*.
(3) The third scenario is similar to the first scenario is only done on the part of Lambidaro-1 sub-basin.
(4) The fourth scenario is the same as the second scenario and is only done on the part of Lambidaro-1 sub-basin.
(5) The fifth scenario is changing land use with different *C* values ranging from 0.2 to 0.9

Some of the effects of land use change scenarios on upstream, mid and downstream sub-watersheds are minimizing and increasing the value of the runoff coefficient *C* per sub-watershed were done to reduce and increase the inundation shown in Fig.6.

5. CONCLUSION

1. There is a strongly significant relationship between runoff and river length, watershed area, perimeter watershed, average *Rb*, flow density, texture ratio, roughness number Rn.
2. There is a strong relationship between runoff and concentration time (*Tc*).
3. The correlation is strong enough on the Frequency of flow and Relief with the forest area
4. The effect of land-use change with several scenarios made in the Lambidaro sub-basin proves that if land use change is not well controlled, the extent of the inundation will extend from downstream, middle to upstream

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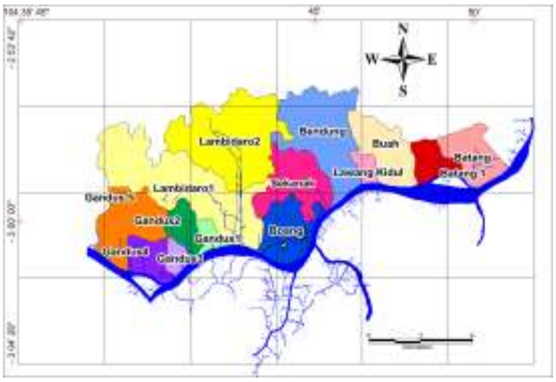

Fig.1 Lambidaro sub-basin at Musi downstreem sub-basin area

3. METHODOLOGY

To anticipate the amount of runoff water, due to inappropriate land allocation, a multicriteria analysis is needed in every decision of land allocation. Land Allocation Management System (SIMAL) is a watershed analysis system developed using GIS or Geographic Information System (GIS) using land use change parameters, morphometry, and hydrometry of DAS [8].

3.1 Research Site

The study material is to explain the effect of surface runoff on land use change, the location of the study is the Lambidaro sub-basin (Figure 1), which is one of 16 sub-basins that form the drainage system of Palembang which discharges into the Musi River, through the city of Palembang. With an area of 65.42 Km2.

3.2 Research Data

The data used in this research are river hydrometry data, longitudinal cross-section (l) and river cross (b), river bed invert (ls), watershed area (A) and density (r). While spot height data and land use are needed to analyze the infiltration coefficient (c) and time concentration (Tc). And the ever-changing dynamic data is the rainfall data (R) needed to calculate the rain intensity (I) in each sub-watershed.

3.3 Research Methods

The method used in this research is using hydrology model and Geographic Information System (GIS). The hydrodynamic model Duflow was used to calculate the amount of runoff, which

would also be used to track flood flow in rivers [11].

The hydrodynamic analysis was performed on selected river sub-systems that have been obtained from the results of cluster analysis. This analysis utilizes the 1D (Duflow) non-steady flow model with the maximum rainfall intensity conditions of the 25th anniversary period of the previous hydrological analysis results as well as the results of tidal observation forecasting at the sub-systems of selected river sub-systems. The first stage in the hydrodynamic analysis was by establishing a scheme of the hydrodynamic network in sub-watershed adapted to the results through terrain morphology and terrain processing analysis on ArcGIS-ARC Hydro and field conditions, then incorporating the dimensions of water structure, cross section, boundary conditions (tidal, rain Results of hydrological analysis) and flow discharge. After calculation of each segment/cross section will be obtained some hydraulic parameters such as flood water level, water flow rate, channel flow and water level in river and channel were obtained.

The inundation distribution occurring in the sub-river system was obtained by combining the results of hydrodynamic analysis and spatial analysis. The water level in the river and the channel was interpolated to obtain the distribution of water level in the selected river subsystem. Then the distribution of water level is arranged with the topographic condition of river sub system in the form of DEM 5m x 5m so as to obtain the distribution of classified high pools that occur in each selected river sub-system with 25th anniversary period.

With several scenarios of land use change, it can be seen how much the changes in inundation height due to land use change in the selected sub-system. This scenario was used as a way to see the condition of the sub-system of a river which in turn will influence the pattern of river environmental control that will be done. The first scenario is to change the type of land use so that the value of *C* tends to decrease which became an indicator of the condition of the river subsystem becomes better. The second scenario was changing the type of land use so that the value of *C* tends to increase, this condition could explain that river subsystem had a condition that was considered to be disturbed.

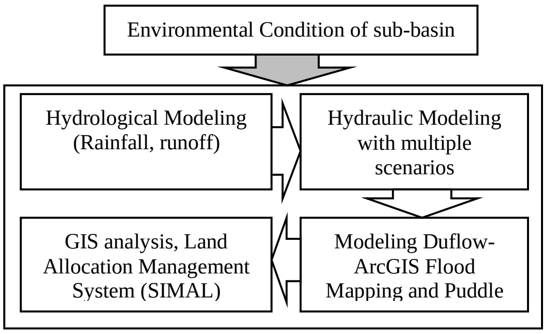

Fig. 2 Flow Chart of research methods

4. RESULTS AND DISCUSSION

4.1 Correlation Between Surface Run-off with Morphometric Characteristic Variable

This correlation was analyzed to address the problem of spatial relationships between land use and sub-basin morphometry and its effect on the extent of surface runoff. The strong correlation between independent variables (characteristic of sub-basin morphometry) and the dependent variable of runoff (Q), is seen through Pearson correlation value. Correlation values range from -1,000 to 1,000. The value of -1.000 shows a very strong but negative correlation, while the value of 1,000 indicates a very strong correlation/very closely directed positively.

The results of the analysis (at 99% confidence level) obtained the correlation value between variables very high runoff (*Q*) ranges from 0.849 to 0.999 with variable length of river order (x_1), river length (x_2), watershed (x_3), roving watershed (x_4) , average *Rb*(x_5), Flow density (x_6), texture ratio (x_8), Roughness number *Rn* (x_{10}).

This means that there is a strongly significant relationship between runoff and long river order, river length, basin area, perimeter watershed, average Rb, flow density, texture ratio, roughness number Rn. While the value of strong correlation is seen between runoff with *Tc* concentration time of 0.629. This means at a significance level of 5% or a 95% confidence level, there is a strong relationship between runoff and concentration time (*Tc*). The correlation value is strong enough at flow frequency (x_7), relief (x_9) and green area (forest, tree, shrub, yard, rice field, field, garden) (x_{14}). The low correlation value between runoff and variable flow coefficient C (x_{12}) of 0.319 with significant level and negative correlation of 0.234 for variable circularity ratio Rc (x_{13}).

4.2 Caracteristic of Lambidaro sub-Basin

The morphometric characteristics of the Lambidaro watershed are shown in Fig. 3. Land

utilization in the Lambidaro sub-basin is dominated by shrubs, trees, fields and forests ranging from 72%, settlements ranging from 4.74% to potentially changing land use, such as for settlement development. Settlement construction mainly occurs in right Lambidaro (Lambidaro-2) sub-watershed close to the main road / outer shaft of Palembang City (Musidua bridge). As part of left Lambidaro (Lambidaro-1) sub-basin is dominated by bushes and swamps. The sub-watershed of Lambidaro river has varying altitude less than 10 m msl in estuary area up to 36 m in upstream area. The percentage of the slope is dominated by 0-3% and more than 8% with a maximum height of 36 msl in the upstream area. River conditions are still natural, especially in part of left Lambidaro, while some rivers in part of right Lambidaro sub-basin have been normalized by cliff reinforcement.

With the condition of land use, slope, flow density and soil type, the range of runoff coefficient in Lambidaro sub-basin shows the runoff coefficient value of 0.66. This means that 34% of the total rainfall falls on the Lambidaro river sub-basin can still be infiltrated (see Figure 3).

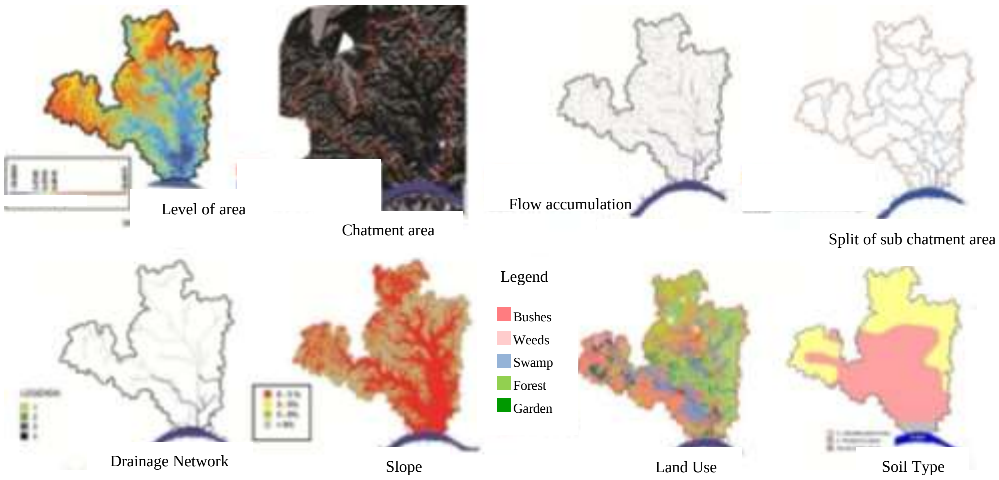

Fig. 3 Caracteristic of morfometry Lambidaro sub-basin

4.3 Hydrodynamic model of Lambidaro watershed

The simulation of the Duflow-ArcGIS model was conducted on the Lambidaro watershed. Schematic of the water system based on DEM extraction with flow patterns that resulted in sub-basin and drainage line boundaries to illustrate runoff on the floodwaters was constructed first (Figure 4). The Lambidaro sub-basin network scheme was built by entering the cross-profile data as well as extending the channels per segment based on the measurement results in the field. Channel width ranges from 11 - 18 m. The boundary conditions for the Duflow model consist of upper boundary conditions such as runoff from upstream Lambidaro watershed and downstream boundary conditions, such as water levels at the mouth of the Lambidaro river. The rainfall hydrology parameter was taken from the analysis of the distribution of maximum daily rainfall by Gumbell method for a 25-year period of 163 mm/day. The weighted C values of each Lambidaro sub-basin were calculated from the results of spatial analysis of land use, slope, soil type and flow density per sub-watershed as shown in Fig.4b. The water level in certain segments of drainage network of Lambidaro watershed is shown in Figure 4c. The results of the hydrodynamic modeling, the existing conditions of the Lambidaro sub-watershed were approached with a 25-year return period scenario.

The water level on each segment was then transformed into the DEM sub of the Lambidaro sub-basin, and interpolated by the ArcGIS procedure to obtain the inundation distribution that will occur for the 25-year anniversary scenario. The results of the analysis of the distribution of inundation of Lambidaro sub-basin were classified into six classifications, namely: (1) unlogged areas; (2) flooded with altitude less than 0.25 m; (3) altitude 0.25 - 0.5 m; (4) Altitude of 0.5-0.75 m; (5) altitude of 0.75-1 m and (6) heights of more than 1 m. The result of hydrodynamic modeling using Duflow model was followed by analysis of inundation distribution that will occur with 25 year period return scenario seen as in Figure 4d. The flooded areas of the Lambidaro sub-basin are the areas of flow accumulation and from field observations are low areas with a slope of 0-3% with the type of land use in swamp dominance. The calibration of this model is shown by the high suitability of inundation that occurs in the field with R^2= 0.869.

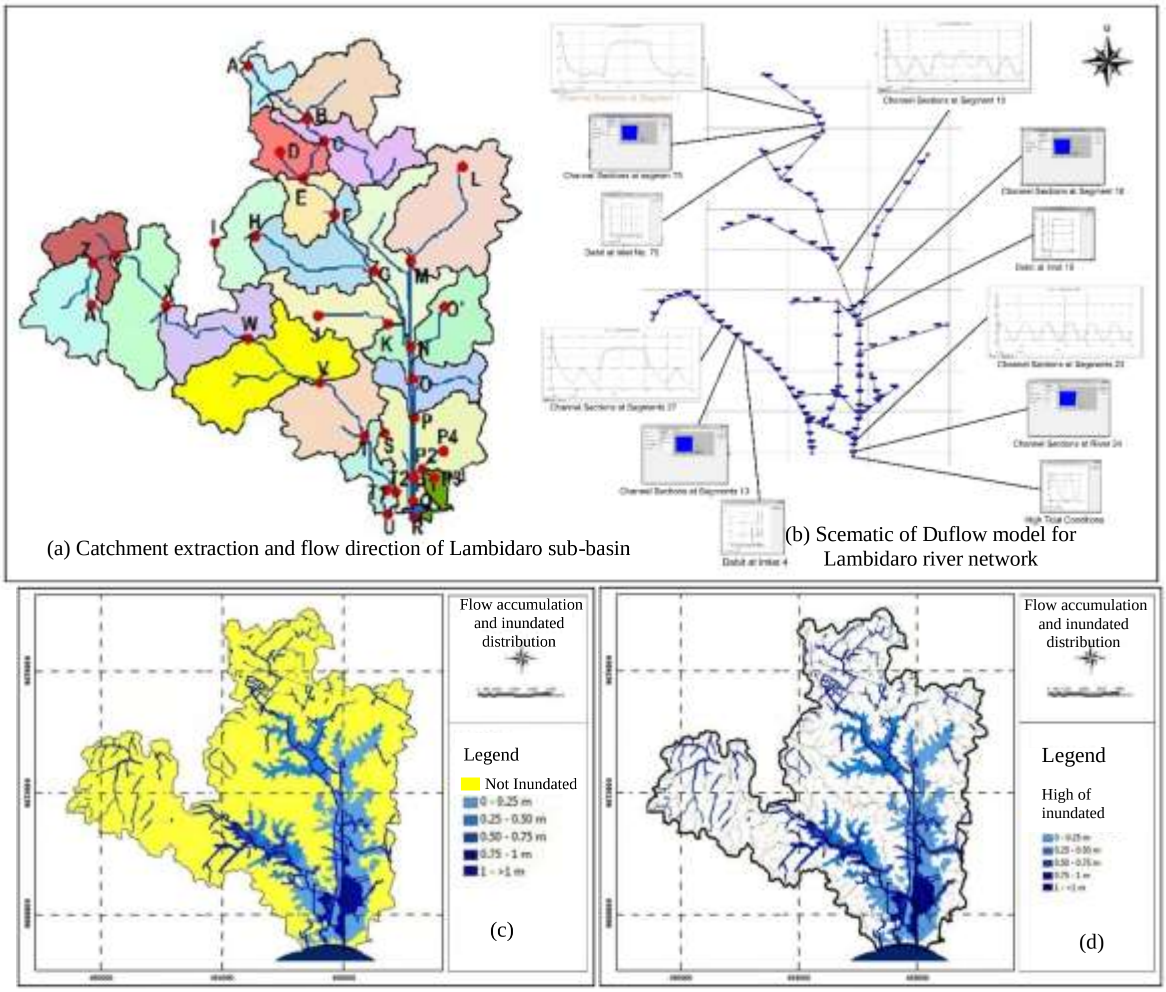

Fig. 4 Drainage network flood simulation of Lambidaro sub-basin: (a) Chatment extraction and flow direction of Lambidaro sub-basin (b) Scematic and drainage network; (c) distribution of inundation due to land use change; (d) the puddle area is assembled with flow accumulation

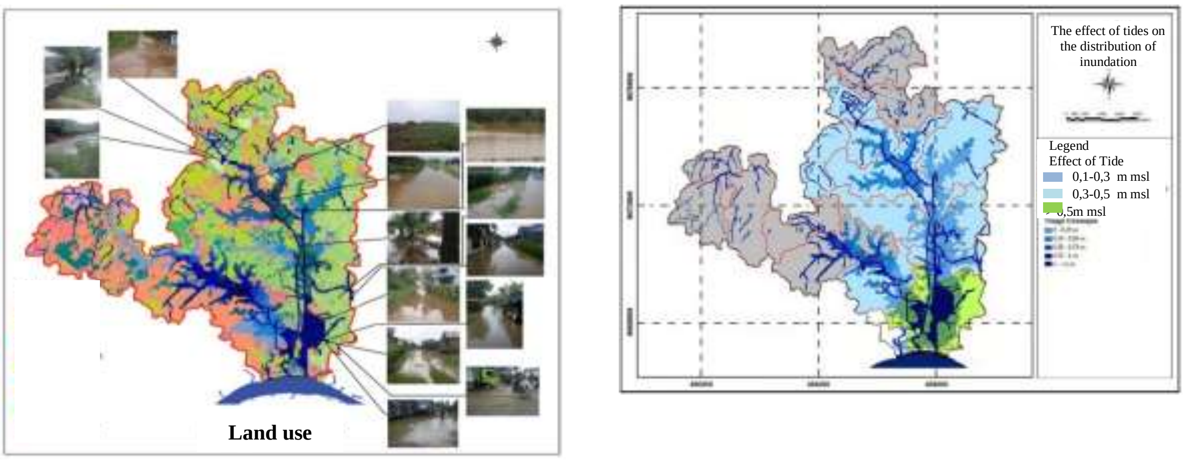

Fig. 5 Distribution of inundation is arranged with Lambidaro sub-waters upstream, middle and downstream

The influence of inundation in the upper Lambidaro watershed is 756.81 ha, 2821,6 ha, and downstream 513,23 ha. As for the part of left Lambidaro sub-watershed, the upstream area of 1854.5 ha, middle 380.5 ha and downstream 131.1 ha. The distribution of inundation stacked with Lambidaro sub-basin can be seen in Figure 5.

4.4 Land use change scenarios

Zoning scenario to see the effect of land use change on the inundation distribution that will occur in Lambidaro sub-basin. Land use change scenario is made as many as 5 scenarios, namely:

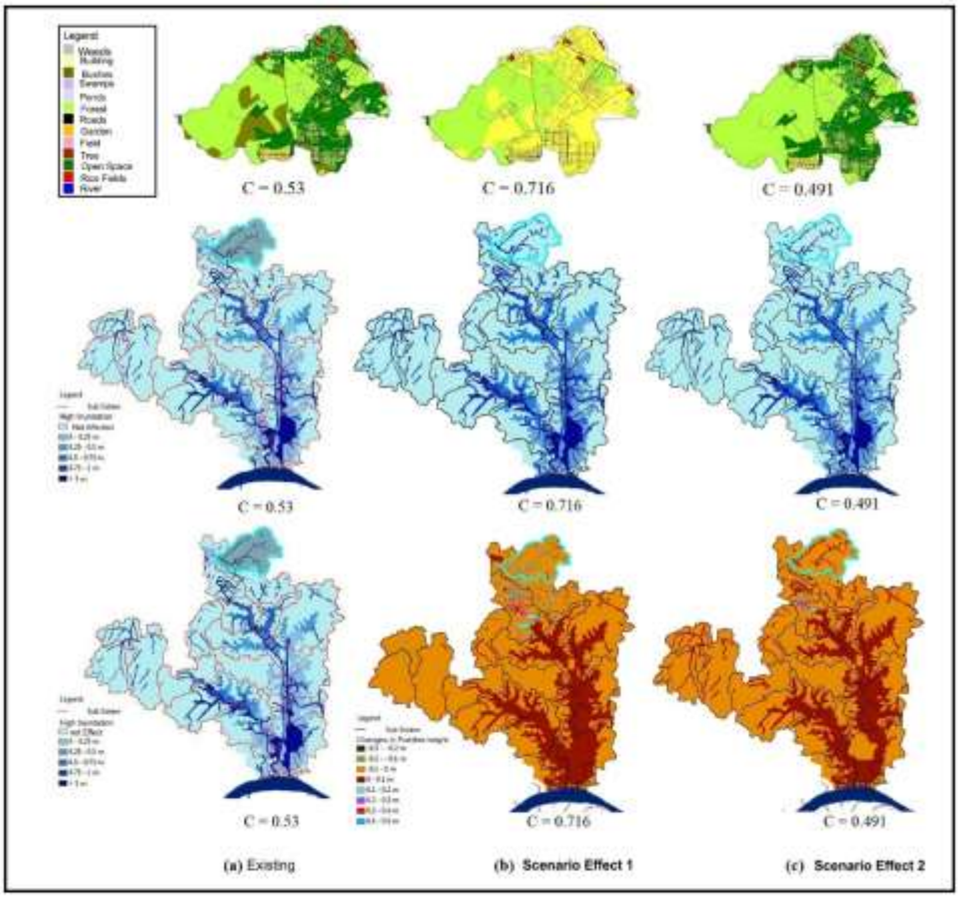

Fig. 6 Effects of land use change of Lambidaro upstream basin

(1) The first scenario is changing the type of land use area that is still possible to be converted into a green area (urban forest, park) so it can decrease the value of *C*.
(2) The second scenario is changing the type of land utilization of Lambidaro-2 sub-basin of the right section that may still be converted into a settlement (see the current city development) resulting in an increase in the value of *C*.
(3) The third scenario is similar to the first scenario is only done on the part of Lambidaro-1 sub-basin.
(4) The fourth scenario is the same as the second scenario and is only done on the part of Lambidaro-1 sub-basin.
(5) The fifth scenario is changing land use with different *C* values ranging from 0.2 to 0.9

Some of the effects of land use change scenarios on upstream, mid and downstream sub-watersheds are minimizing and increasing the value of the runoff coefficient *C* per sub-watershed were done to reduce and increase the inundation shown in Fig.6.

5. CONCLUSION

1. There is a strongly significant relationship between runoff and river length, watershed area, perimeter watershed, average *Rb*, flow density, texture ratio, roughness number Rn.
2. There is a strong relationship between runoff and concentration time (*Tc*).
3. The correlation is strong enough on the Frequency of flow and Relief with the forest area
4. The effect of land-use change with several scenarios made in the Lambidaro sub-basin proves that if land use change is not well controlled, the extent of the inundation will extend from downstream, middle to upstream

ACKNOWLEDGMENTS

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INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING

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ABSTRACT: It is necessary to analyze the conditions of the watershed hydrometry, the type of land use, the duration and the time of rain, the tidal height, which is modeled spatially, in order to support in decision making for spatial management and water management. Palembang Metropolitan City is one of the major cities on the island of Sumatra, which is regionally included in the Musi Watershed area. Hydrologically Palembang City is located at the mouth of the Musi river, with an altitude of less than 20 m above the mean sea level. When the maximum rainfall occurs in the watershed Area, Palembang City will be affected by tidal water, and runoff on the sub-watershed in Palembang city can not be flowed through the main channel within Palembang City, due to the tide of Musi river water. This study aims to show the relationship between watershed hydrometry, land use change management, rain intensity, and tidal influences on the watershed area, with various scenarios that will affect the runoff discharge and distribution of inundation that occur in the watershed area. Taking a case study of the Lambidaro sub-basin, in the Palembang City area, all sub-basin parameters that have been tested were modeled by a using duflow to calculate the extent of runoff and flood flow tracking in the river. The inundation distribution occurring in the sub watershed was obtained by combining the results of hydrodynamic analysis and spatial analysis. Based on the results obtained it is concluded that there is a strong spatial relationship between land use and sub-basin morphometry and its effect on the extent of surface runoff.

Keywords: *Land Use Change, flooding and pudles, Run-off, spatial management*

1. INTRODUCTION

Land use changes in some areas of the city in Indonesia is so fast, due to rapid urbanization and industrial development. These changes are almost entirely done by reclamation of swamps, the utilization of river banks, and conversion of forest land and agricultural land. The impact of changes in land use has changed the patterns of water drainage in sub-basin areas that exist in urban areas. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff [1].

Human activities have caused very significant impact on water quantity, water quality and aquatic ecology. As the result, the dangers of flooding, household and industrial waste, which, after accumulating for a long time, are unlikely to return to normal or require enormous costs for recovery.

Run-off problems with peak flood and inundation characteristics are influenced by several factors, such as urbanization, unsuitable landfill, tidal effects, as well as sedimentation and river-flow pollutants from upstream areas and other small rivers that form the sub-watersheds in the area [2].

Flow management capability, run-off mitigation, infiltration and water quality all have relevance to land use conditions. Furthermore, the connection between the water management system and spatial planning is one of the important keys that must be done if they want to play a role in reducing the danger of flooding. However, in reality in every spatial arrangement, the two systems, namely spatial planning and water management have never been integrated. On this basis, an analysis of hydro topographic conditions, type of land cover, duration and time of rain, tidal height, are modeled using spatial analysis, in order to support decision making for spatial management and water management [3].

2. CITY DEVELOPMENT AND FLOOD PROBLEM IN SOUTH SUMATERA AREA

Similar to the development of several regions in Indonesia, the province of South Sumatra has the development of cities that is very significant. It can be seen from the population growth which averagely reached 1.44% with the population of 7,481,200 in 2010 [4] of which, 1,468,000 are in Palembang (19.62%). If the average population growth in South Sumatera remains at 1.88%, then it is estimated that in 2030, the population in South Sumatera province will reach 10,166,760 people and 18.97% will be in Palembang City.

With such a large population growth, there will be concentration of population in big cities in South Sumatera Province especially in Palembang City, which will cause expansion of land use for

various urban activities. The expansion that will change the various functions of the water reservoir land, is transformed into a developed one,and will neglect the watershed ecosystem.

Based on data from BMKG (2010), the highest rainfall in South Sumatera Province is 18 - <34.87 mm/day and the peak rainfall in November, and the lowest rainfall <18 mm/day, occurs every in May-August. Surface water is difficult to predict in relation to space and time distribution . While the AWLR which is used to record water level in several locations along the river has not worked properly. This has caused much constraints to predict the occurrence of peak flood and areas that will occur. In October (2016), the city of Lubuk Linggau, and several sub-districts in Musi Rawas district have experienced floods, the city of Sekayu and several sub-districts in Musi Banyuasin regency in September (2016), Inderalaya city and several sub-districts in Ogan Ilir Regency (October, 2016), Kayu Agung city and several sub-districts in Ogan Komering Ilir regency, Pangkalan Balai City and several sub-districts in Banyuasin regency, and Palembang City itself always experiences flood in every rainy season with high intensity.

Efforts to control floods have been undertaken by several cities that often experience floods every year. In Jakarta City floodway canal and biopore has been made and in Semarang City, a polder system has been also built. But all of them have not yet shown that the problem of annual floods can be overcome. All flood control systems, must depart from existing watershed ecosystem conditions. From these conditions, It requires new analysis by simulation to determine the flood discharge with each return period, which finally can be used to determine the appropriate drainage system in the area [5]. Thus a specific approach through more useful and accurate techniques is necessary. Transforming data into a Geographic Information System using Multicriteria Spatial Analysis in decision making [6] can be used as a policy and technical combination solution and technical, and also as a model in presenting the watershed environmental conditions for better data quality and analysis [7].

2.1 Case Study

As an example of frequent inundation in the Lambidaro sub-basin especially in the downstream area and around the floodplain, during the rainy season and high tides is Lambidaro sub basin with an area of 65.25 km2 is a sub watershed which has different morphometric characteristics from other sub watersheds. Based on the drainage pattern it is divided into two sub-watersheds namely part of left Lambidaro (Lambidaro-1) Sub-watershed and part of right Lambidaro (Lambidaro-2) sub-watershed which leads to the Musi river.

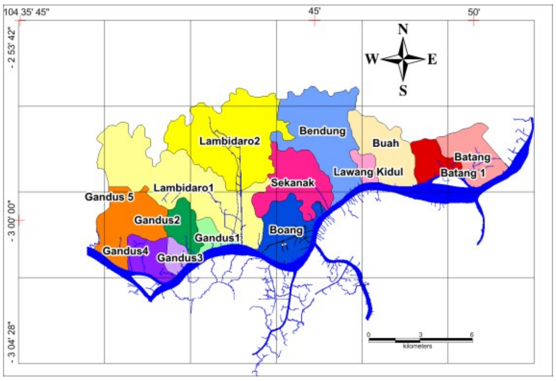

Fig.1 Lambidaro sub-basin at Musi downstreem sub-basin area

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To anticipate the amount of runoff water, due to inappropriate land allocation, a multicriteria analysis is needed in every decision of land allocation. Land Allocation Management System (SIMAL) is a watershed analysis system developed using GIS or Geographic Information System (GIS) using land use change parameters, morphometry, and hydrometry of DAS [8].

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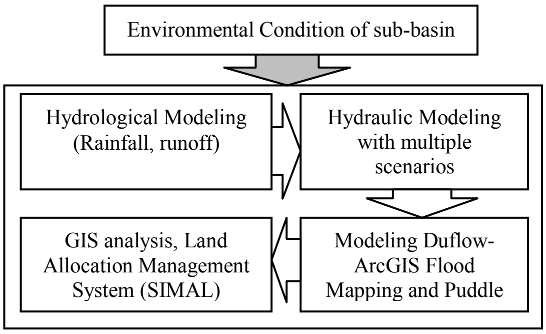


Fig. 2 Flow Chart of research methods

4. RESULTS AND DISCUSSION

4.1 Correlation Between Surface Run-off with Morphometric Characteristic Variable

This correlation was analyzed to address the problem of spatial relationships between land use and sub-basin morphometry and its effect on the extent of surface runoff. The strong correlation between independent variables (characteristic of sub-basin morphometry) and the dependent variable of runoff (Q), is seen through Pearson correlation value. Correlation values range from -1,000 to 1,000. The value of -1.000 shows a very strong but negative correlation, while the value of 1,000 indicates a very strong correlation/very closely directed positively.

The results of the analysis (at 99% confidence level) obtained the correlation value between variables very high runoff (*Q*) ranges from 0.849 to 0.999 with variable length of river order (x_1), river length (x_2), watershed (x_3), roving watershed (x_4) , average *Rb*(x_5), Flow density (x_6), texture ratio (x_8), Roughness number *Rn* (x_{10}).

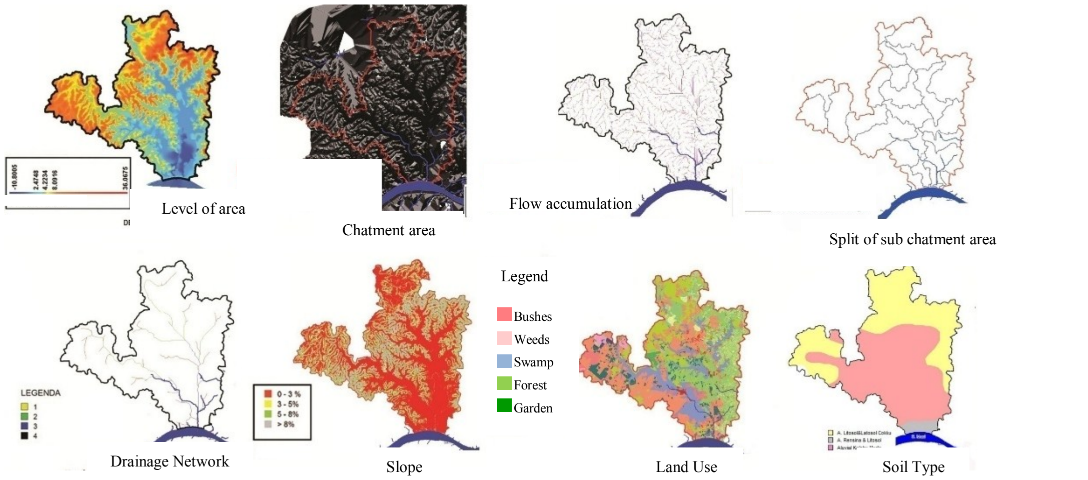
This means that there is a strongly significant relationship between runoff and long river order, river length, basin area, perimeter watershed, average Rb, flow density, texture ratio, roughness number Rn. While the value of strong correlation is seen between runoff with *Tc* concentration time of 0.629. This means at a significance level of 5% or a 95% confidence level, there is a strong relationship between runoff and concentration time (*Tc*). The correlation value is strong enough at flow frequency (x_7), relief (x_9) and green area (forest, tree, shrub, yard, rice field, field, garden) (x_{14}). The low correlation value between runoff and variable flow coefficient C (x_{12}) of 0.319 with significant level and negative correlation of 0.234 for variable circularity ratio Rc (x_{13}).

4.2 Caracteristic of Lambidaro sub-Basin

The morphometric characteristics of the Lambidaro watershed are shown in Fig. 3. Land

utilization in the Lambidaro sub-basin is dominated by shrubs, trees, fields and forests ranging from 72%, settlements ranging from 4.74% to potentially changing land use, such as for settlement development. Settlement construction mainly occurs in right Lambidaro (Lambidaro-2) sub-watershed close to the main road / outer shaft of Palembang City (Musidua bridge). As part of left Lambidaro (Lambidaro-1) sub-basin is dominated by bushes and swamps. The sub-watershed of Lambidaro river has varying altitude less than 10 m msl in estuary area up to 36 m in upstream area. The percentage of the slope is dominated by 0-3% and more than 8% with a maximum height of 36 msl in the upstream area. River conditions are still natural, especially in part of left Lambidaro, while some rivers in part of right Lambidaro sub-basin have been normalized by cliff reinforcement.

With the condition of land use, slope, flow density and soil type, the range of runoff coefficient in Lambidaro sub-basin shows the runoff coefficient value of 0.66. This means that 34% of the total rainfall falls on the Lambidaro river sub-basin can still be infiltrated (see Figure 3).



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The water level on each segment was then transformed into the DEM sub of the Lambidaro sub-basin, and interpolated by the ArcGIS procedure to obtain the inundation distribution that will occur for the 25-year anniversary scenario. The results of the analysis of the distribution of inundation of Lambidaro sub-basin were classified into six classifications, namely: (1) unlogged areas; (2) flooded with altitude less than 0.25 m; (3) altitude 0.25 - 0.5 m; (4) Altitude of 0.5-0.75 m; (5) altitude of 0.75-1 m and (6) heights of more than 1 m. The result of hydrodynamic modeling using Duflow model was followed by analysis of inundation distribution that will occur with 25 year period return scenario seen as in Figure 4d. The flooded areas of the Lambidaro sub-basin are the areas of flow accumulation and from field observations are low areas with a slope of 0-3% with the type of land use in swamp dominance. The calibration of this model is shown by the high suitability of inundation that occurs in the field with R^2= 0.869.

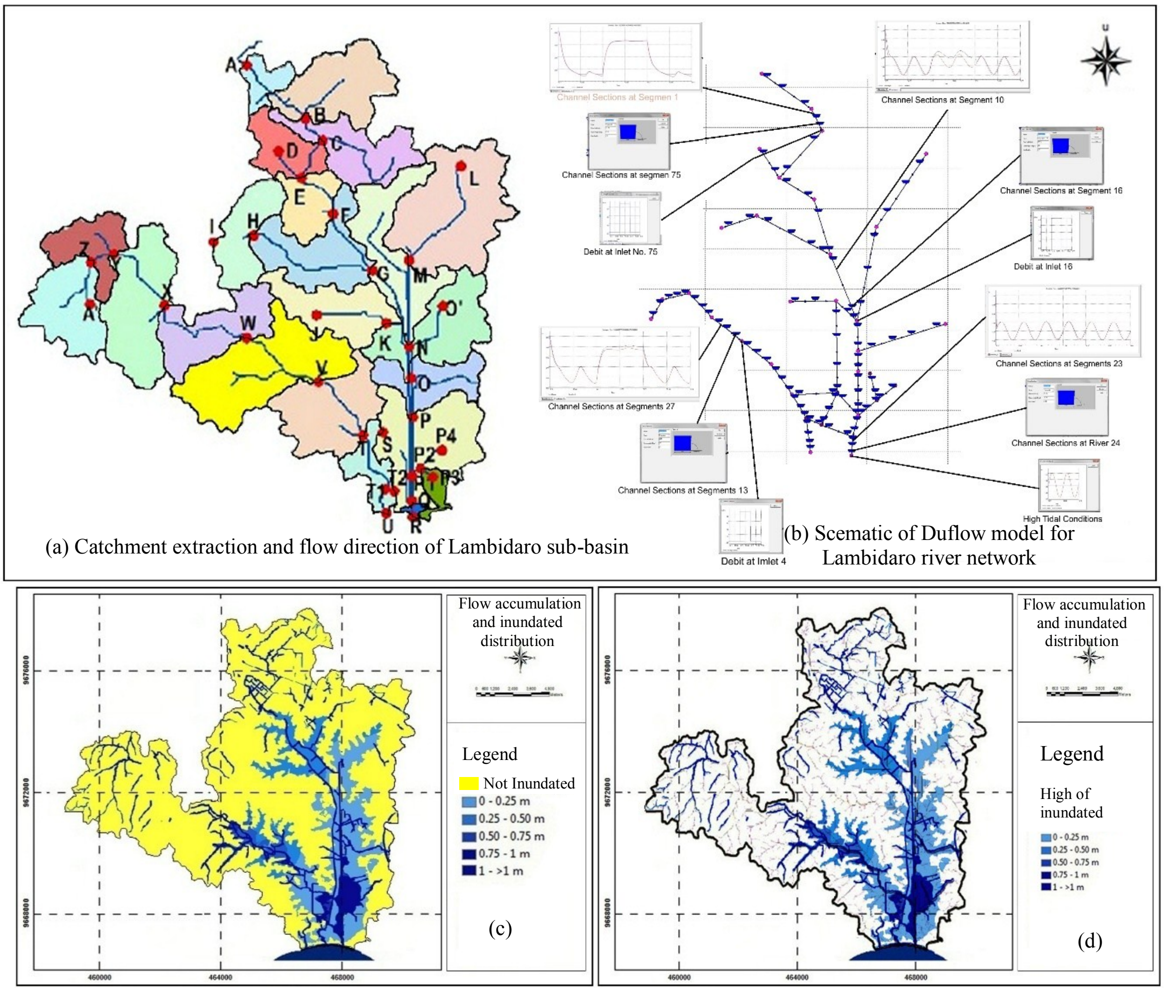

Fig. 4 Drainage network flood simulation of Lambidaro sub-basin: (a) Chatment extraction and flow direction of Lambidaro sub-basin (b) Scematic and drainage network; (c) distribution of inundation due to land use change; (d) the puddle area is assembled with flow accumulation

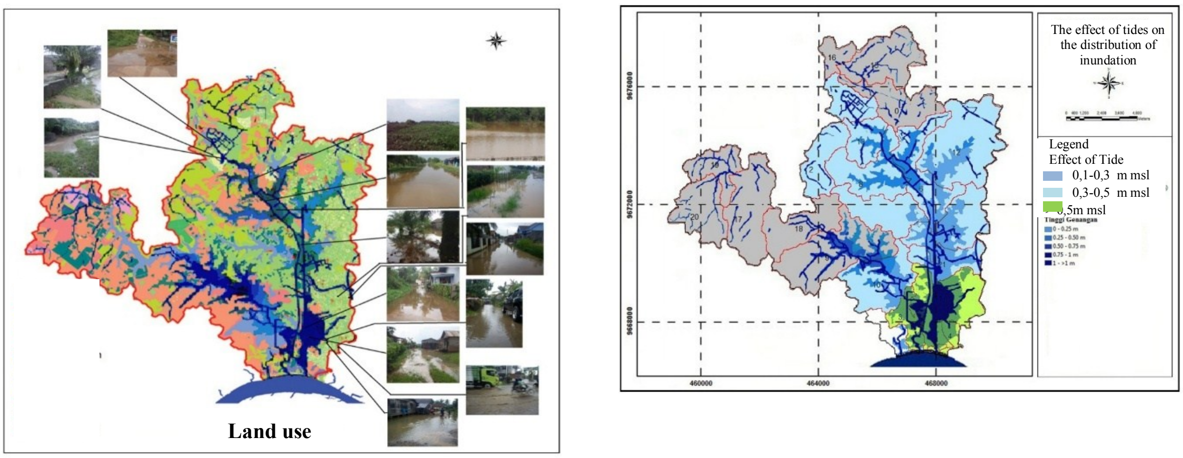

Fig. 5 Distribution of inundation is arranged with Lambidaro sub-waters upstream, middle and downstream

The influence of inundation in the upper Lambidaro watershed is 756.81 ha, 2821,6 ha, and downstream 513,23 ha. As for the part of left Lambidaro sub-watershed, the upstream area of 1854.5 ha, middle 380.5 ha and downstream 131.1 ha. The distribution of inundation stacked with Lambidaro sub-basin can be seen in Figure 5.

4.4 Land use change scenarios

Zoning scenario to see the effect of land use change on the inundation distribution that will occur in Lambidaro sub-basin. Land use change scenario is made as many as 5 scenarios, namely:

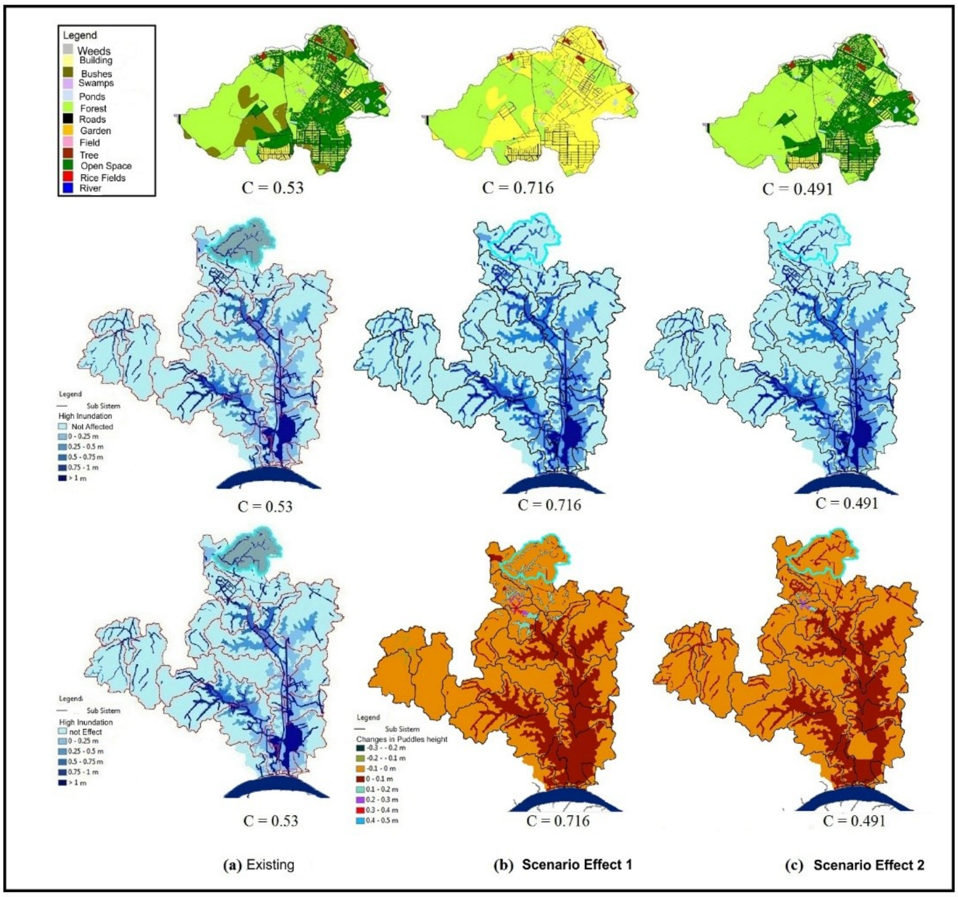

Fig. 6 Effects of land use change of Lambidaro upstream basin

(1) The first scenario is changing the type of land use area that is still possible to be converted into a green area (urban forest, park) so it can decrease the value of *C*.
(2) The second scenario is changing the type of land utilization of Lambidaro-2 sub-basin of the right section that may still be converted into a settlement (see the current city development) resulting in an increase in the value of *C*.
(3) The third scenario is similar to the first scenario is only done on the part of Lambidaro-1 sub-basin.
(4) The fourth scenario is the same as the second scenario and is only done on the part of Lambidaro-1 sub-basin.
(5) The fifth scenario is changing land use with different *C* values ranging from 0.2 to 0.9

Some of the effects of land use change scenarios on upstream, mid and downstream sub-watersheds are minimizing and increasing the value of the runoff coefficient *C* per sub-watershed were done to reduce and increase the inundation shown in Fig.6.

5. CONCLUSION

1. There is a strongly significant relationship between runoff and river length, watershed area, perimeter watershed, average *Rb*, flow density, texture ratio, roughness number Rn.
2. There is a strong relationship between runoff and concentration time (*Tc*).
3. The correlation is strong enough on the Frequency of flow and Relief with the forest area
4. The effect of land-use change with several scenarios made in the Lambidaro sub-basin proves that if land use change is not well controlled, the extent of the inundation will extend from downstream, middle to upstream

ACKNOWLEDGMENTS

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INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING

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ABSTRACT: It is necessary to analyze the conditions of the watershed hydrometry, the type of land use, the duration and the time of rain, the tidal height, which is modeled spatially, in order to support in decision making for spatial management and water management. Palembang Metropolitan City is one of the major cities on the island of Sumatra, which is regionally included in the Musi Watershed area. Hydrologically Palembang City is located at the mouth of the Musi river, with an altitude of less than 20 m above the mean sea level. When the maximum rainfall occurs in the watershed Area, Palembang City will be affected by tidal water, and runoff on the sub-watershed in Palembang city can not be flowed through the main channel within Palembang City, due to the tide of Musi river water. This study aims to show the relationship between watershed hydrometry, land use change management, rain intensity, and tidal influences on the watershed area, with various scenarios that will affect the runoff discharge and distribution of inundation that occur in the watershed area. Taking a case study of the Lambidaro sub-basin, in the Palembang City area, all sub-basin parameters that have been tested were modeled by a using duflow to calculate the extent of runoff and flood flow tracking in the river. The inundation distribution occurring in the sub watershed was obtained by combining the results of hydrodynamic analysis and spatial analysis. Based on the results obtained it is concluded that there is a strong spatial relationship between land use and sub-basin morphometry and its effect on the extent of surface runoff.

Keywords: *Land Use Change, flooding and pudles, Run-off, spatial management*

1. INTRODUCTION

Land use changes in some areas of the city in Indonesia is so fast, due to rapid urbanization and industrial development. These changes are almost entirely done by reclamation of swamps, the utilization of river banks, and conversion of forest land and agricultural land. The impact of changes in land use has changed the patterns of water drainage in sub-basin areas that exist in urban areas. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff [1].

Human activities have caused very significant impact on water quantity, water quality and aquatic ecology. As the result, the dangers of flooding, household and industrial waste, which, after accumulating for a long time, are unlikely to return to normal or require enormous costs for recovery.

Run-off problems with peak flood and inundation characteristics are influenced by several factors, such as urbanization, unsuitable landfill, tidal effects, as well as sedimentation and river-flow pollutants from upstream areas and other small rivers that form the sub-watersheds in the area [2].

Flow management capability, run-off mitigation, infiltration and water quality all have relevance to land use conditions. Furthermore, the connection between the water management system and spatial planning is one of the important keys that must be done if they want to play a role in reducing the danger of flooding. However, in reality in every spatial arrangement, the two systems, namely spatial planning and water management have never been integrated. On this basis, an analysis of hydro topographic conditions, type of land cover, duration and time of rain, tidal height, are modeled using spatial analysis, in order to support decision making for spatial management and water management [3].

2. CITY DEVELOPMENT AND FLOOD PROBLEM IN SOUTH SUMATERA AREA

Similar to the development of several regions in Indonesia, the province of South Sumatra has the development of cities that is very significant. It can be seen from the population growth which averagely reached 1.44% with the population of 7,481,200 in 2010 [4] of which, 1,468,000 are in Palembang (19.62%). If the average population growth in South Sumatera remains at 1.88%, then it is estimated that in 2030, the population in South Sumatera province will reach 10,166,760 people and 18.97% will be in Palembang City.

With such a large population growth, there will be concentration of population in big cities in South Sumatera Province especially in Palembang City, which will cause expansion of land use for

various urban activities. The expansion that will change the various functions of the water reservoir land, is transformed into a developed one,and will neglect the watershed ecosystem.

Based on data from BMKG (2010), the highest rainfall in South Sumatera Province is 18 - <34.87 mm/day and the peak rainfall in November, and the lowest rainfall <18 mm/day, occurs every in May-August. Surface water is difficult to predict in relation to space and time distribution . While the AWLR which is used to record water level in several locations along the river has not worked properly. This has caused much constraints to predict the occurrence of peak flood and areas that will occur. In October (2016), the city of Lubuk Linggau, and several sub-districts in Musi Rawas district have experienced floods, the city of Sekayu and several sub-districts in Musi Banyuasin regency in September (2016), Inderalaya city and several sub-districts in Ogan Ilir Regency (October, 2016), Kayu Agung city and several sub-districts in Ogan Komering Ilir regency, Pangkalan Balai City and several sub-districts in Banyuasin regency, and Palembang City itself always experiences flood in every rainy season with high intensity.

Efforts to control floods have been undertaken by several cities that often experience floods every year. In Jakarta City floodway canal and biopore has been made and in Semarang City, a polder system has been also built. But all of them have not yet shown that the problem of annual floods can be overcome. All flood control systems, must depart from existing watershed ecosystem conditions. From these conditions, It requires new analysis by simulation to determine the flood discharge with each return period, which finally can be used to determine the appropriate drainage system in the area [5]. Thus a specific approach through more useful and accurate techniques is necessary. Transforming data into a Geographic Information System using Multicriteria Spatial Analysis in decision making [6] can be used as a policy and technical combination solution and technical, and also as a model in presenting the watershed environmental conditions for better data quality and analysis [7].

2.1 Case Study

As an example of frequent inundation in the Lambidaro sub-basin especially in the downstream area and around the floodplain, during the rainy season and high tides is Lambidaro sub basin with an area of 65.25 km2 is a sub watershed which has different morphometric characteristics from other sub watersheds. Based on the drainage pattern it is divided into two sub-watersheds namely part of left Lambidaro (Lambidaro-1) Sub-watershed and part of right Lambidaro (Lambidaro-2) sub-watershed which leads to the Musi river.

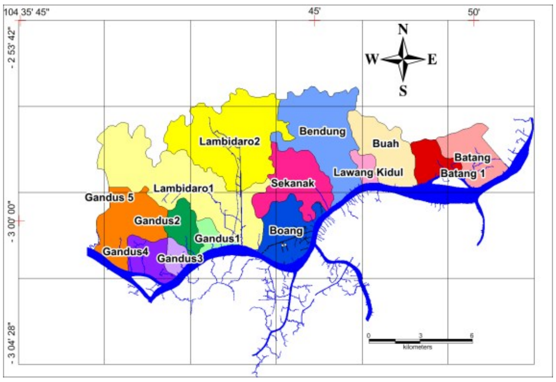

Fig.1 Lambidaro sub-basin at Musi downstreem sub-basin area

3. METHODOLOGY

To anticipate the amount of runoff water, due to inappropriate land allocation, a multicriteria analysis is needed in every decision of land allocation. Land Allocation Management System (SIMAL) is a watershed analysis system developed using GIS or Geographic Information System (GIS) using land use change parameters, morphometry, and hydrometry of DAS [8].

3.1 Research Site

The study material is to explain the effect of surface runoff on land use change, the location of the study is the Lambidaro sub-basin (Figure 1), which is one of 16 sub-basins that form the drainage system of Palembang which discharges into the Musi River, through the city of Palembang. With an area of 65.42 Km2.

3.2 Research Data

The data used in this research are river hydrometry data, longitudinal section (l) and river cross-section (b), river bed invert (ls), watershed area (A) and density (r). While spot height data and land use are needed to analyze the infiltration coefficient (c) and time concentration (Tc). And the ever-changing dynamic data is the rainfall data (R) needed to calculate the rain intensity (I) in each sub-watershed.

3.3 Research Methods

The method used in this research is using hydrology model and Geographic Information System (GIS). The hydrodynamic model Duflow was used to calculate the amount of runoff, which

would also be used to track flood flow in rivers [11].

The hydrodynamic analysis was performed on selected river sub-systems that have been obtained from the results of cluster analysis. This analysis utilizes the 1D (Duflow) non-steady flow model with the maximum rainfall intensity conditions of the 25th anniversary period of the previous hydrological analysis results as well as the results of tidal observation forecasting at the sub-systems of selected river sub-systems. The first stage in the hydrodynamic analysis was by establishing a scheme of the hydrodynamic network in sub-watershed adapted to the results through terrain morphology and terrain processing analysis on ArcGIS-ARC Hydro and field conditions, then incorporating the dimensions of water structure, cross section, boundary conditions (tidal, rain results of hydrological analysis) and flow discharge. After calculation of each segment/cross section will be obtained some hydraulic parameters such as flood water level, water flow rate, channel flow and water level in river and channel were obtained.

The inundation distribution occurring in the sub-river system was obtained by combining the results of hydrodynamic analysis and spatial analysis. The influence of the tides in the main river entering the subchannel of the river system is measured in height and the area of distribution so as to obtain the distribution of water level in the river subsystem. Then the distribution of water level is compiled with the topographic condition of the sub-system of the relevant river based on 0.5-meter contour interval so as to obtain the distribution of the classified high pools that occur in each selected river sub-system with the 25th anniversary of rainfall intensity.

With several scenarios of land use change, it can be seen how much the changes in inundation height due to land use change in the selected sub-system. This scenario was used as a way to see the condition of the sub-system of a river which in turn will influence the pattern of river environmental control that will be done. The first scenario is to change the type of land use so that the value of *C* tends to decrease which became an indicator of the condition of the river subsystem becomes better. The second scenario was changing the type of land use so that the value of *C* tends to increase, this condition could explain that river subsystem had a condition that was considered to be disturbed.

The disruption of the sub-system condition of the river is caused by the increase of water runoff caused by the decrease of surface soil absorption capacity to water, thus increasing the volume of surface water flow if the surface condition of the soil is almost largely a wake up area

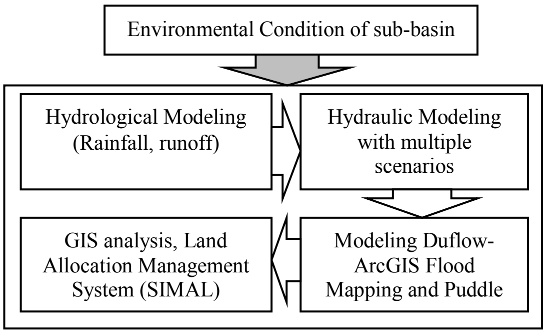

Fig. 2 Flow Chart of research methods

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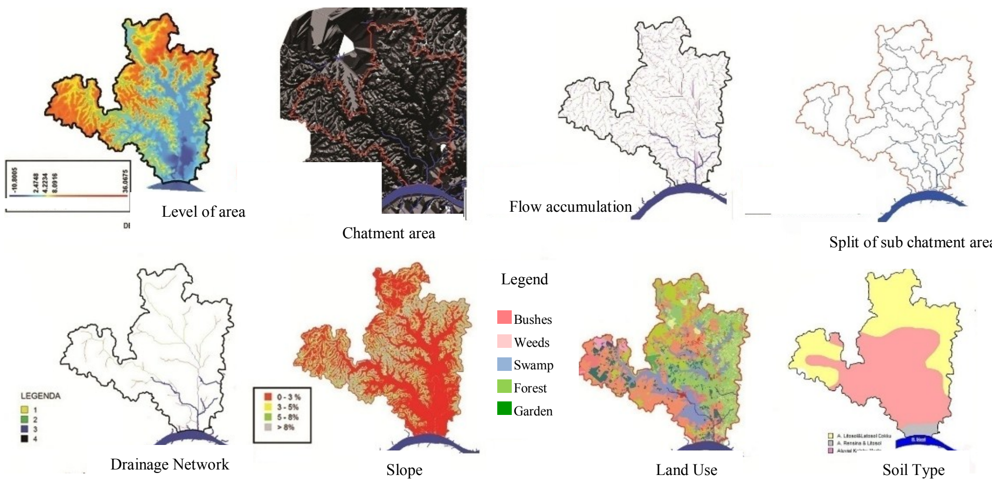

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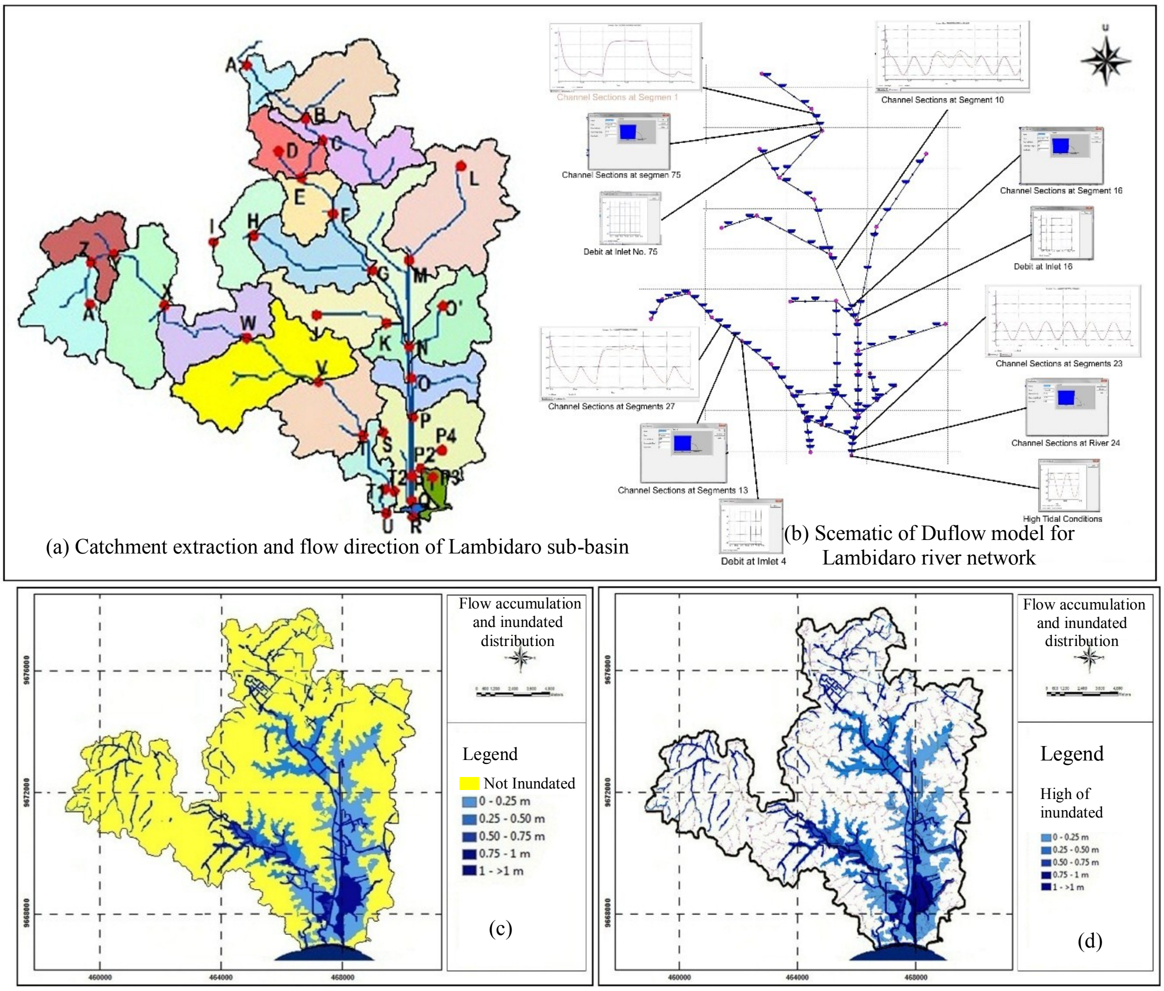

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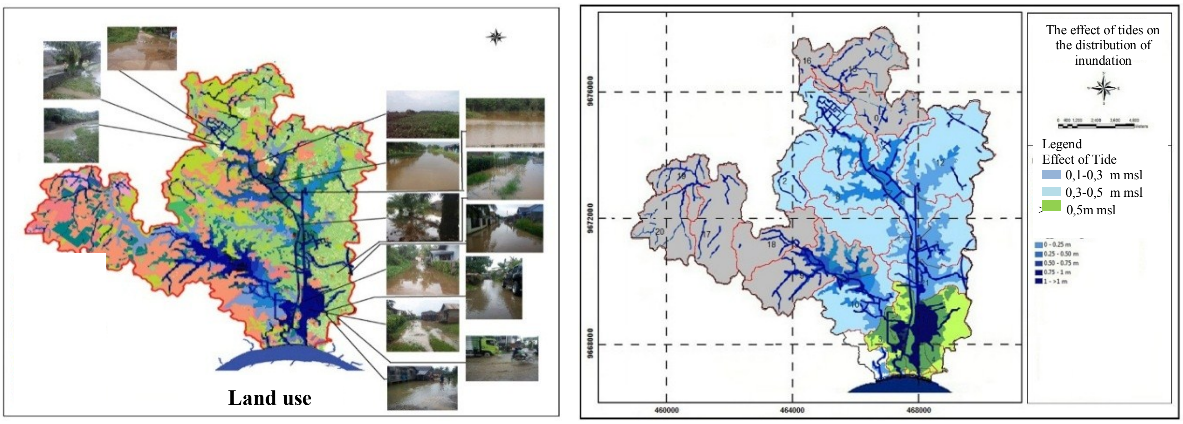

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The influence of inundation can be seen in Figure 5, the upper Lambidaro watershed is 756.81 ha, 2821.6 ha, and downstream 513.23 ha. As for the part of left Lambidaro sub-watershed, the upstream area of 1,854.5 ha, middle 380.5 ha and downstream 131.1 ha.

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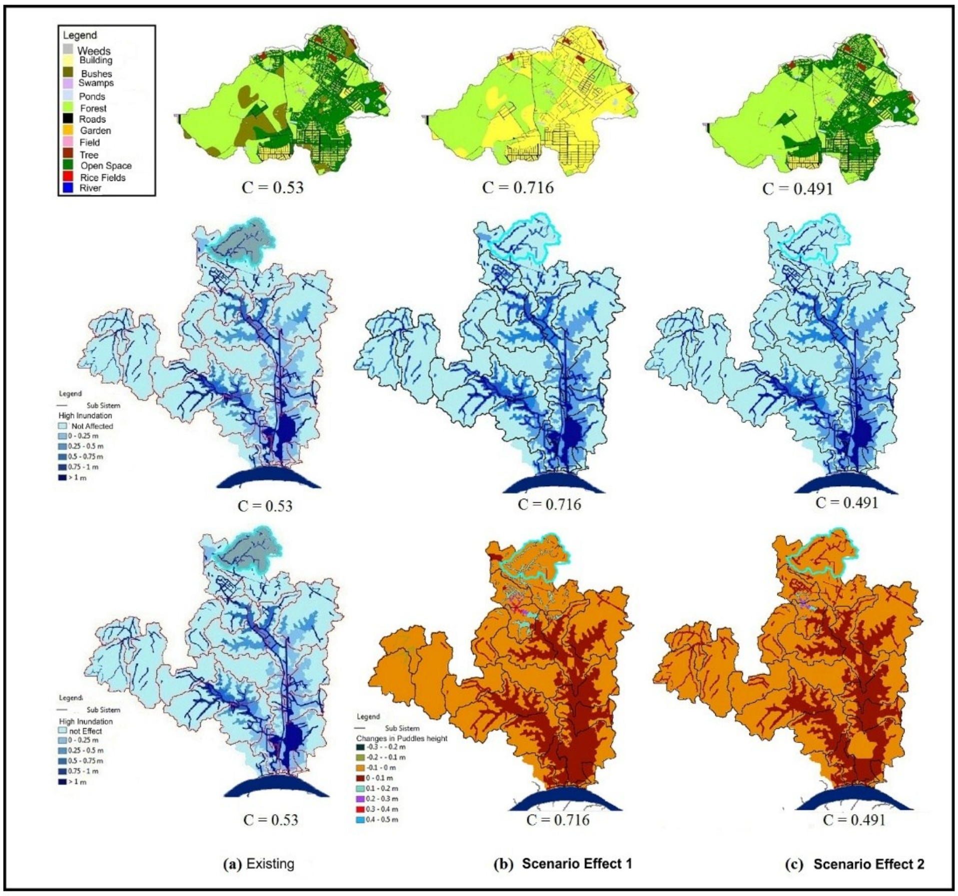

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5. CONCLUSION

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2. There is a strong relationship between runoff and concentration time (*Tc*).
3. The correlation is strong enough on the Frequency of flow and Relief with the forest area
4. The effect of land-use change with several scenarios made in the Lambidaro sub-basin proves that if land use change is not well controlled, the extent of the inundation will extend from downstream, middle to upstream

ACKNOWLEDGMENTS

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INTEGRATION OF SURFACE WATER MANAGEMENT IN URBAN AND REGIONAL SPATIAL PLANNING

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ABSTRACT: It is necessary to analyze the conditions of the watershed hydrometry, the type of land use, the duration and the time of rain, the tidal height, which is modeled spatially, in order to support in decision making for spatial management and water management. Palembang Metropolitan City is one of the major cities on the island of Sumatra, which is regionally included in the Musi Watershed area. Hydrologically Palembang City is located at the mouth of the Musi river, with an altitude of less than 20 m above the mean sea level. When the maximum rainfall occurs in the watershed Area, Palembang City will be affected by tidal water, and runoff on the sub-watershed in Palembang city can not be flowed through the main channel within Palembang City, due to the tide of Musi river water. This study aims to show the relationship between watershed hydrometry, land use change management, rain intensity, and tidal influences on the watershed area, with various scenarios that will affect the runoff discharge and distribution of inundation that occur in the watershed area. Taking a case study of the Lambidaro sub-basin, in the Palembang City area, all sub-basin parameters that have been tested were modeled by a using duflow to calculate the extent of runoff and flood flow tracking in the river. The inundation distribution occurring in the sub watershed was obtained by combining the results of hydrodynamic analysis and spatial analysis. Based on the results obtained it is concluded that there is a strong spatial relationship between land use and sub-basin morphometry and its effect on the extent of surface runoff.

***Keywords**: Land Use Change, flooding and pudles, Run-off, spatial management*

1. INTRODUCTION

Land use changes in some areas of the city in Indonesia is so fast, due to rapid urbanization and industrial development. These changes are almost entirely done by reclamation of swamps, the utilization of river banks, and conversion of forest land and agricultural land. The impact of changes in land use has changed the patterns of water drainage in sub-basin areas that exist in urban areas. The main effects of changes in drainage patterns are flooding and puddles as a result of excessive runoff [1].

Human activities have caused very significant impact on water quantity, water quality and aquatic ecology. As the result, the dangers of flooding, household and industrial waste, which, after accumulating for a long time, are unlikely to return to normal or require enormous costs for recovery.

Run-off problems with peak flood and inundation characteristics are influenced by several factors, such as urbanization, unsuitable landfill, tidal effects, as well as sedimentation and river-flow pollutants from upstream areas and other small rivers that form the sub-watersheds in the area [2].

Flow management capability, run-off mitigation, infiltration and water quality all have relevance to land use conditions. Furthermore, the connection between the water management system and spatial planning is one of the important keys that must be done if they want to play a role in reducing the danger of flooding. However, in reality in every spatial arrangement, the two systems, namely spatial planning and water management have never been integrated. On this basis, an analysis of hydro topographic conditions, type of land cover, duration and time of rain, tidal height, are modeled using spatial analysis, in order to support decision making for spatial management and water management [3].

2. CITY DEVELOPMENT AND FLOOD PROBLEM IN SOUTH SUMATERA AREA

Similar to the development of several regions in Indonesia, the province of South Sumatra has the development of cities that is very significant. It can be seen from the population growth which averagely reached 1.44% with the population of 7,481,200 in 2010 [4] of which, 1,468,000 are in Palembang (19.62%). If the average population growth in South Sumatera remains at 1.88%, then it is estimated that in 2030, the population in South Sumatera province will reach 10,166,760 people and 18.97% will be in Palembang City.

With such a large population growth, there will be concentration of population in big cities in South Sumatera Province especially in Palembang City, which will cause expansion of land use for

various urban activities. The expansion that will change the various functions of the water reservoir land, is transformed into a developed one,and will neglect the watershed ecosystem.

Based on data from BMKG (2010), the highest rainfall in South Sumatera Province is 18 - <34.87 mm/day and the peak rainfall in November, and the lowest rainfall <18 mm/day, occurs every in May-August. Surface water is difficult to predict in relation to space and time distribution . While the AWLR which is used to record water level in several locations along the river has not worked properly. This has caused much constraints to predict the occurrence of peak flood and areas that will occur. In October (2016), the city of Lubuk Linggau, and several sub-districts in Musi Rawas district have experienced floods, the city of Sekayu and several sub-districts in Musi Banyuasin regency in September (2016), Inderalaya city and several sub-districts in Ogan Ilir Regency (October, 2016), Kayu Agung city and several sub-districts in Ogan Komering Ilir regency, Pangkalan Balai City and several sub-districts in Banyuasin regency, and Palembang City itself always experiences flood in every rainy season with high intensity.

Efforts to control floods have been undertaken by several cities that often experience floods every year. In Jakarta City floodway canal and biopore has been made and in Semarang City, a polder system has been also built. But all of them have not yet shown that the problem of annual floods can be overcome. All flood control systems, must depart from existing watershed ecosystem conditions. From these conditions, It requires new analysis by simulation to determine the flood discharge with each return period, which finally can be used to determine the appropriate drainage system in the area [5]. Thus a specific approach through more useful and accurate techniques is necessary. Transforming data into a Geographic Information System using Multicriteria Spatial Analysis in decision making [6] can be used as a policy and technical combination solution and technical, and also as a model in presenting the watershed environmental conditions for better data quality and analysis [7].

2.1 Case Study

As an example of frequent inundation in the Lambidaro sub-basin especially in the downstream area and around the floodplain, during the rainy season and high tides is Lambidaro sub basin with an area of 65.25 km2 is a sub watershed which has different morphometric characteristics from other sub watersheds. Based on the drainage pattern it is divided into two sub-watersheds namely part of left Lambidaro (Lambidaro-1) Sub-watershed and part of right Lambidaro (Lambidaro-2) sub-watershed which leads to the Musi river.

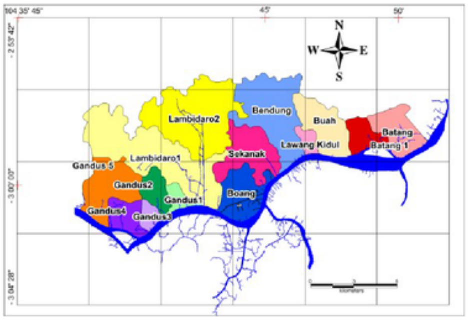

Fig.1 Lambidaro sub-basin at Musi downstreem sub-basin area

3. METHODOLOGY

To anticipate the amount of runoff water, due to inappropriate land allocation, a multicriteria analysis is needed in every decision of land allocation. Land Allocation Management System (SIMAL) is a watershed analysis system developed using GIS or Geographic Information System (GIS) using land use change parameters, morphometry, and hydrometry of DAS [8].

3.1 Research Site

The study material is to explain the effect of surface runoff on land use change, the location of the study is the Lambidaro sub-basin (Figure 1), which is one of 16 sub-basins that form the drainage system of Palembang which discharges into the Musi River, through the city of Palembang. With an area of 65.42 Km2.

3.2 Research Data

The data used in this research are river hydrometry data, longitudinal section (*l*) and river cross-section (*b*), river bed invert (*Is*), watershed area (*A*) and density (*r*). While spot height data and land use are needed to analyze the infiltration coefficient (*c*) and time concentration (*Tc*). And the ever-changing dynamic data is the rainfall data (*R*) needed to calculate the rain intensity (*I*) in each sub-watershed.

3.3 Research Methods

The method used in this research is using hydrology model and Geographic Information System (GIS). The hydrodynamic model Duflow was used to calculate the amount of runoff, which

would also be used to track flood flow in rivers [11].

The hydrodynamic analysis was performed on selected river sub-systems that have been obtained from the results of cluster analysis. This analysis utilizes the 1D (Duflow) non-steady flow model with the maximum rainfall intensity conditions of the 25th anniversary period of the previous hydrological analysis results as well as the results of tidal observation forecasting at the sub-systems of selected river sub-systems. The first stage in the hydrodynamic analysis was by establishing a scheme of the hydrodynamic network in sub-watershed adapted to the results through terrain morphology and terrain processing analysis on ArcGIS-ARC Hydro and field conditions, then incorporating the dimensions of water structure, cross section, boundary conditions (tidal, rain results of hydrological analysis) and flow discharge. After calculation of each segment/cross section will be obtained some hydraulic parameters such as flood water level, water flow rate, channel flow and water level in river and channel were obtained.

The inundation distribution occurring in the sub-river system was obtained by combining the results of hydrodynamic analysis and spatial analysis. The influence of the tides in the main river entering the subchannel of the river system is measured in height and the area of distribution so as to obtain the distribution of water level in the river subsystem. Then the distribution of water level is compiled with the topographic condition of the sub-system of the relevant river based on 0.5-meter contour interval so as to obtain the distribution of the classified high pools that occur in each selected river sub-system with the 25th anniversary of rainfall intensity.

With several scenarios of land use change, it can be seen how much the changes in inundation height due to land use change in the selected sub-system. This scenario was used as a way to see the condition of the sub-system of a river which in turn will influence the pattern of river environmental control that will be done. The first scenario is to change the type of land use so that the value of *C* tends to decrease which became an indicator of the condition of the river subsystem becomes better. The second scenario was changing the type of land use so that the value of *C* tends to increase, this condition could explain that river subsystem had a condition that was considered to be disturbed.

The disruption of the sub-system condition of the river is caused by the increase of water runoff caused by the decrease of surface soil absorption capacity to water, thus increasing the volume of surface water flow if the surface condition of the soil is almost largely a wake up area

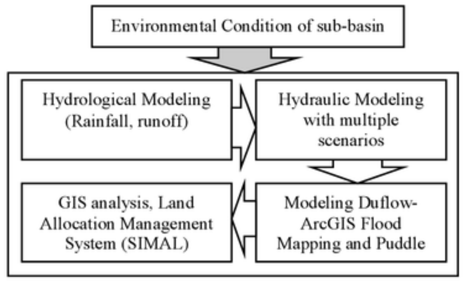

Fig. 2 Flow Chart of research methods

4. RESULTS AND DISCUSSION

4.1 Correlation Between Surface Run-off with Morphometric Characteristic Variable

This correlation was analyzed to address the problem of spatial relationships between land use and sub-basin morphometry and its effect on the extent of surface runoff. The strong correlation between independent variables (characteristic of sub-basin morphometry) and the dependent variable of runoff (Q), is seen through Pearson correlation value. Correlation values range from -1,000 to 1,000. The value of -1.000 shows a very strong but negative correlation, while the value of 1,000 indicates a very strong correlation/very closely directed positively.

The results of the analysis (at 99% confidence level) obtained the correlation value between variables very high runoff (*Q*) ranges from 0.849 to 0.999 with variable length of river order (x_1), river length (x_2), watershed (x_3), roving watershed (x_4) , average $Rb(x_5)$, Flow density (x_6), texture ratio (x_8), Roughness number *Rn* (x_{10}).

This means that there is a strongly significant relationship between runoff and long river order, river length, basin area, perimeter watershed, average Rb, flow density, texture ratio, roughness number Rn. While the value of strong correlation is seen between runoff with *Tc* concentration time of 0.629. This means at a significance level of 5% or a 95% confidence level, there is a strong relationship between runoff and concentration time (*Tc*). The correlation value is strong enough at flow frequency (x_7), relief (x_9) and green area (forest, tree, shrub, yard, rice field, field, garden) (x_{14}). The low correlation value between runoff and variable flow coefficient C (x_{12}) of 0.319 with significant level and negative correlation of 0.234 for variable circularity ratio Rc (x_{13}).

4.2 Caracteristic of Lambidaro sub-Basin

The morphometric characteristics of the Lambidaro watershed are shown in Fig. 3. Land

utilization in the Lambidaro sub-basin is dominated by shrubs, trees, fields and forests ranging from 72%, settlements ranging from 4.74% to potentially changing land use, such as for settlement development. Settlement construction mainly occurs in right Lambidaro (Lambidaro-2) sub-watershed close to the main road / outer shaft of Palembang City (Musidua bridge). As part of left Lambidaro (Lambidaro-1) sub-basin is dominated by bushes and swamps. The sub-watershed of Lambidaro river has varying altitude less than 10 m msl in estuary area up to 36 m in upstream area. The percentage of the slope is dominated by 0-3% and more than 8% with a maximum height of 36 msl in the upstream area. River conditions are still natural, especially in part of left Lambidaro, while some rivers in part of right Lambidaro sub-basin have been normalized by cliff reinforcement.

With the condition of land use, slope, flow density and soil type, the range of runoff coefficient in Lambidaro sub-basin shows the runoff coefficient value of 0.66. This means that 34% of the total rainfall falls on the Lambidaro river sub-basin can still be infiltrated (see Figure 3).

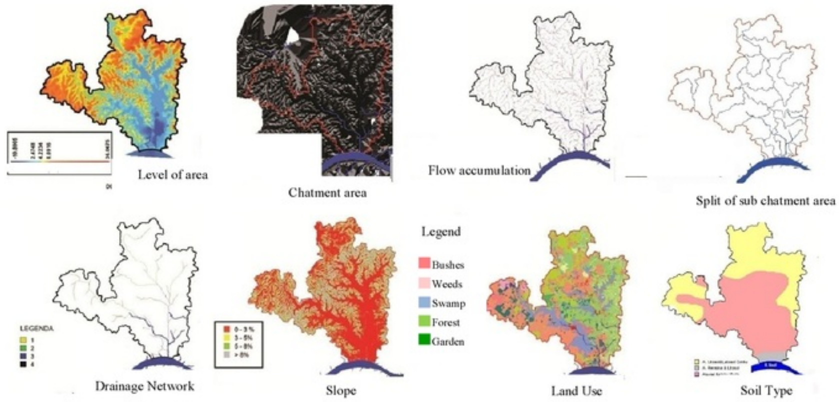

Fig. 3 Caracteristic of morfometry Lambidaro sub-basin

4.3 Hydrodynamic model of Lambidaro watershed

The simulation of the Duflow-ArcGIS model was conducted on the Lambidaro watershed. Schematic of the water system based on DEM extraction with flow patterns that resulted in sub-basin and drainage line boundaries to illustrate runoff on the floodwaters was constructed first (Figure 4). The Lambidaro sub-basin network scheme was built by entering the cross-profile data as well as extending the channels per segment based on the measurement results in the field. Channel width ranges from 11 - 18 m. The boundary conditions for the Duflow model consist of upper boundary conditions such as runoff from upstream Lambidaro watershed and downstream boundary conditions, such as water levels at the mouth of the Lambidaro river. The rainfall hydrology parameter was taken from the analysis of the distribution of maximum daily rainfall by Gumbell method for a 25-year period of 163 mm/day. The weighted C values of each Lambidaro sub-basin were calculated from the results of spatial analysis of land use, slope, soil type and flow density per sub-watershed as shown in Fig.4b. The water level in certain segments of drainage network of Lambidaro watershed is shown in Figure 4c. The results of the hydrodynamic modeling, the existing conditions of the Lambidaro sub-watershed were approached with a 25-year return period scenario.

The water level on each segment was then transformed into the DEM sub of the Lambidaro sub-basin, and interpolated by the ArcGIS procedure to obtain the inundation distribution that will occur for the 25-year anniversary scenario. The results of the analysis of the distribution of inundation of Lambidaro sub-basin were classified into six classifications, namely: (1) unlogged areas; (2) flooded with altitude less than 0.25 m; (3) altitude 0.25 - 0.5 m; (4) Altitude of 0.5-0.75 m; (5) altitude of 0.75-1 m and (6) heights of more than 1 m. The result of hydrodynamic modeling using Duflow model was followed by analysis of inundation distribution that will occur with 25 year period return scenario seen as in Figure 4d. The flooded areas of the Lambidaro sub-basin are the areas of flow accumulation and from field observations are low areas with a slope of 0-3% with the type of land use in swamp dominance. The calibration of this model is shown by the high suitability of inundation that occurs in the field with R^2= 0.869.

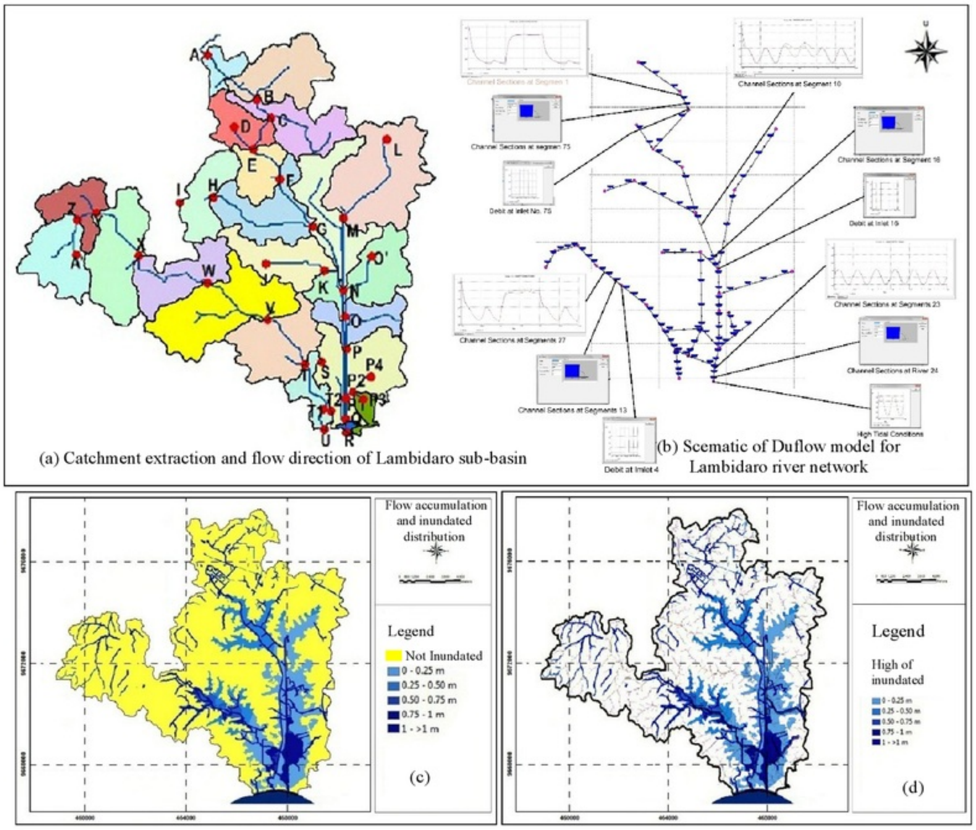

Fig. 4 Drainage network flood simulation of Lambidaro sub-basin: (a) Chatment extraction and flow direction of Lambidaro sub-basin (b) Scematic and drainage network; (c) distribution of inundation due to land use change; (d) the puddle area is assembled with flow accumulation

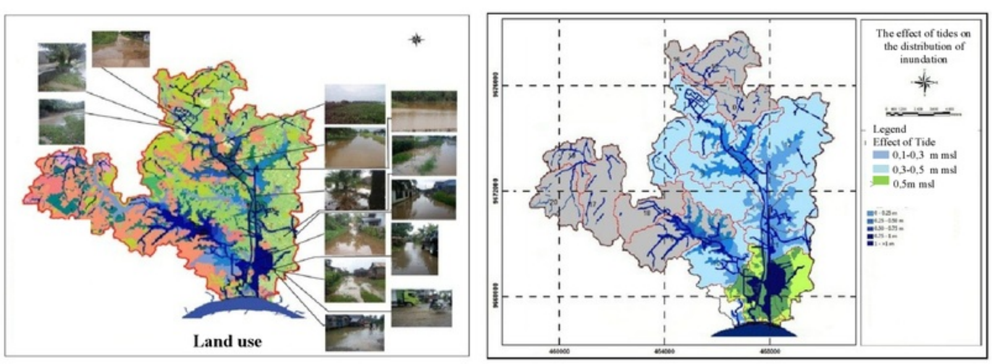

Fig. 5 Distribution of inundation is arranged with Lambidaro sub-waters upstream, middle and downstream

The influence of inundation can be seen in Figure 5, the upper Lambidaro watershed is 756.81 ha, 2821.6 ha, and downstream 513.23 ha. As for the part of left Lambidaro sub-watershed, the upstream area of 1,854.5 ha, middle 380.5 ha and downstream 131.1 ha.

4.4 Land use change scenarios

Zoning scenario to see the effect of land use change on the inundation distribution that will occur in Lambidaro sub-basin. Land use change scenario is made as many as 5 scenarios, namely:

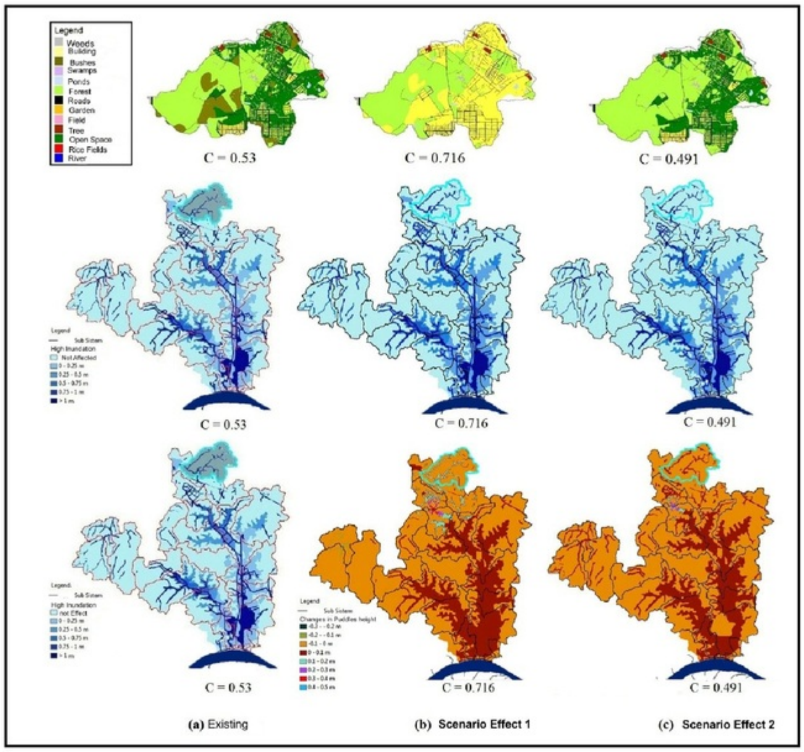

Fig. 6 Effects of land use change of Lambidaro upstream basin

(1) The first scenario is changing the type of land use area that is still possible to be converted into a green area (urban forest, park) so it can decrease the value of *C*.
(2) The second scenario is changing the type of land utilization of Lambidaro-2 sub-basin of the right section that may still be converted into a settlement (see the current city development) resulting in an increase in the value of *C*.
(3) The third scenario is similar to the first scenario is only done on the part of Lambidaro-1 sub-basin.
(4) The fourth scenario is the same as the second scenario and is only done on the part of Lambidaro-1 sub-basin.
(5) The fifth scenario is changing land use with different *C* values ranging from 0.2 to 0.9

Some of the effects of land use change scenarios on upstream, mid and downstream sub-watersheds are minimizing and increasing the value of the runoff coefficient *C* per sub-watershed were done to reduce and increase the inundation shown in Fig.6.

5. CONCLUSION

1. There is a strongly significant relationship between runoff and river length, watershed area, perimeter watershed, average *Rb*, flow density, texture ratio, roughness number Rn.
2. There is a strong relationship between runoff and concentration time (*Tc*).
3. The correlation is strong enough on the Frequency of flow and Relief with the forest area
4. The effect of land-use change with several scenarios made in the Lambidaro sub-basin proves that if land use change is not well controlled, the extent of the inundation will extend from downstream, middle to upstream

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