THE USE OF TANDEM-X IMAGE FOR INUNDATION POTENTIAL RESEARCH BY DISCHARGE RIVER FORECAST

M Taufik, A Kurniawan, A Ishmata
Geodynamics and Environmentals Laboratory, Geomatics Departement, Sepuluh Nopember Insitute of Technology

taufik_srmd@yahoo.com , akbar@geodesy.its.ac.id , aulia.ishmata@gmail.com

Abstract. Kediri District is drained by rivers during the year, for the examples Brantas River, Bruni River, Lanang River, and Sempu River.On the rains, that areas have flood potential.
The research use Rational Method for calculate the maximum streamflows from the river. The formula is : Qmax = CIA / 360 m^3/sec. TanDEM-X satellite image can be used for determine one of maximum streamflow factor. Geographic information system used as a tool for calculate maximum streamflow parameter in a catchment areas. Run off coefficient (C) is given by land cover, slope, and soil texture parameters. The maximum rainfall (I) on Rational Method is calculated by Mononobe formula. Then, the area research is devided as some sub catchment areas. From this research, runoff coefficient value in the research area with the smallest value is 0.34 on Surat sub-catchment area and the largest is 0.6 on Lanang sub-catchment area. Values obtained debit, the smallest is 109.70 m^3/sec on Surat sub-catchment area and the largest is 221.64 m^3/sec on a Bruno sub-catchment area. The result of this research is the information of inundation potential area, ie Lanang sub-catchment area with excess of discharge river as 19.02 m^3/sec.

Keywords: Maximum streamflow, inundation, Rational Method, Mononobe Formula, TanDEM-X

1. Introduction

According to Richard (1995) on Suherlan (2001) defines the floods in the two senses, namely: 1) the overflow of river water caused by river discharge that exceeds the capacity of the river in the state of high rainfall, 2) the inundation on the lowlands that usually not flooded. Kediri region is drained by several rivers that flowduring the year, for the examples Brantas River, Bruni River, Lanang River, and Surat River, Bruno River, and others. In rainy season, that areas around the river have flood potential. Although no casualties, but this flood would be detrimental, especially for the development of this growing region. In this case, the Rational Method is one of the method that can be used to predict flood potential areas by estimate the value of the maximum discharge. Parameters required in the calculation of rational method are precipitation, elevation area, slope, soil type, and land cover. To analyze the flood by using rational method needs the data of slope and altitude region. In this research, the data are created from DEM data image of Tandem-X. Tandem-X is one of the main products of the TerraSAR satellite with a ground resolution of 12 meters.

2. Methods

2.1 Location

The location of this research is in Kediri District, East Java Province, Indonesia Country which is geographically located at coordinates between 111° 47 '05 " - 112° 18' 20" East Longitude and 7° 36 '12 " - 8° 0' 32" South Latitude especially the region of Bruni sub-catchment area, Surat sub-catchment

area, Lanang sub-catchment area, Sempu sub-catchment area, Segaran sub-catchment area, Pandansari sub-catchment area, and Bruno sub-catchment area.

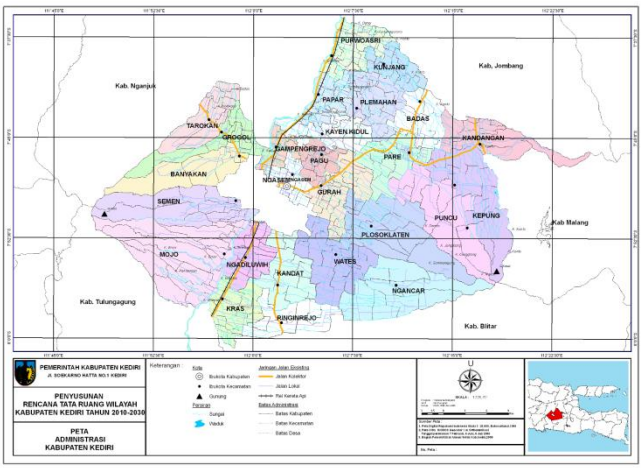

Figure 1. Research Location, Kediri District, East Java Province, Indonesia

2.2 Equipments and Data

The necessary data in this research is :

1. Kediri District DEM of TanDEM-X 2011th
2. Land Cover Map of Kediri District 2015th with the scale is 1:200000
3. Soil Type Map of Kediri District 2015th with the scale is 1:200000
4. Hydrologi Map of Kediri District 2015th with the scale is 1:200000
5. Data of Daily Rainfall of Kediri District
6. Data of River Existing Discharge of Kediri District

2.3 Research Methods

The research stepsare described in general with the following explanation:

1. Data collection phase :

   The data used in this research are:

   a. Spatial Data : Tandem-X DEM Satellite Image of Kediri District in 2011, Land Cover Map of Kediri District in 2015, Soil Type Map of Kediri District in 2015, Hydrologi Map of Kediri District in 2015
   b. Non-Spatial Data : Data of Daily Rainfall of Kediri District in 2015, Data of River Existing Discharge of Kediri District

2. Stage of data processing:

   a. Slope map processing:
      Slope Map is derived from Tandem-X satellite image. The map slope is classified into four classes, ie 0% -2%, 2% -7%, 7% -30%, and> 30%.
   b. Determination of Runoff Coefficient (C):
      Runoff coefficient values obtained from the value of the overlay of topography map, land cover map, and soil type map. The value of C has a range of between 0-1.

Table 1. Run off coefficient according to rational method.

Land Cover	Topography	Soil Texture		
		Sand	Clay	Slit
Forest	Flat	0.1	0.3	0.4
	Surging	0.25	0.35	0.5
	Hilly	0.3	0.5	0.6
Grass land	Flat	0.1	0.3	0.4
	Surging	0.16	0.36	0.55
	Hilly	0.22	042	0.6
Farm	Flat	0.3	0.5	0.6
	Surging	0.4	0.6	0.7
	Hilly	0.52	0.72	0.82
Town	Flat	distantly	moderate	congested
	Surging	0.4	0.55	0.65
	Hilly	0.5	0.65	0.8

3. Calculation of rainfall intensity:
   In the calculation of rainfall intensity, required several steps in its calculations. The first step is done to calculate the average rainfall for each sub-catchment area. Then, calculate the flow concentration time (Tc) with the height parameters obtained from the Tandem-X image. The last is calculating the maximum rainfall intensity with Mononobe formula.

4. Calculation of sub-catchment area:
   Calculation of sub-catchment area is done by the satellite imagery delineation process.

5. The calculation of the maximum discharge:
   The calculation of the maximum discharge is done for every sub-catchment area using Rational Method with the parameters such as runoff coefficient, maximum rainfall intensity and the large of sub-catchment area.

6. Analysis Process
   The analysis is done by a comparison between the data of the existing discharge and maximum discharge value calculation results in order to obtain a maximum discharge difference. This difference means that, if the value of the discharge from the calculation result is higher than the existing discharge for each stream, there will be an overflow on the river that can be an inundation.

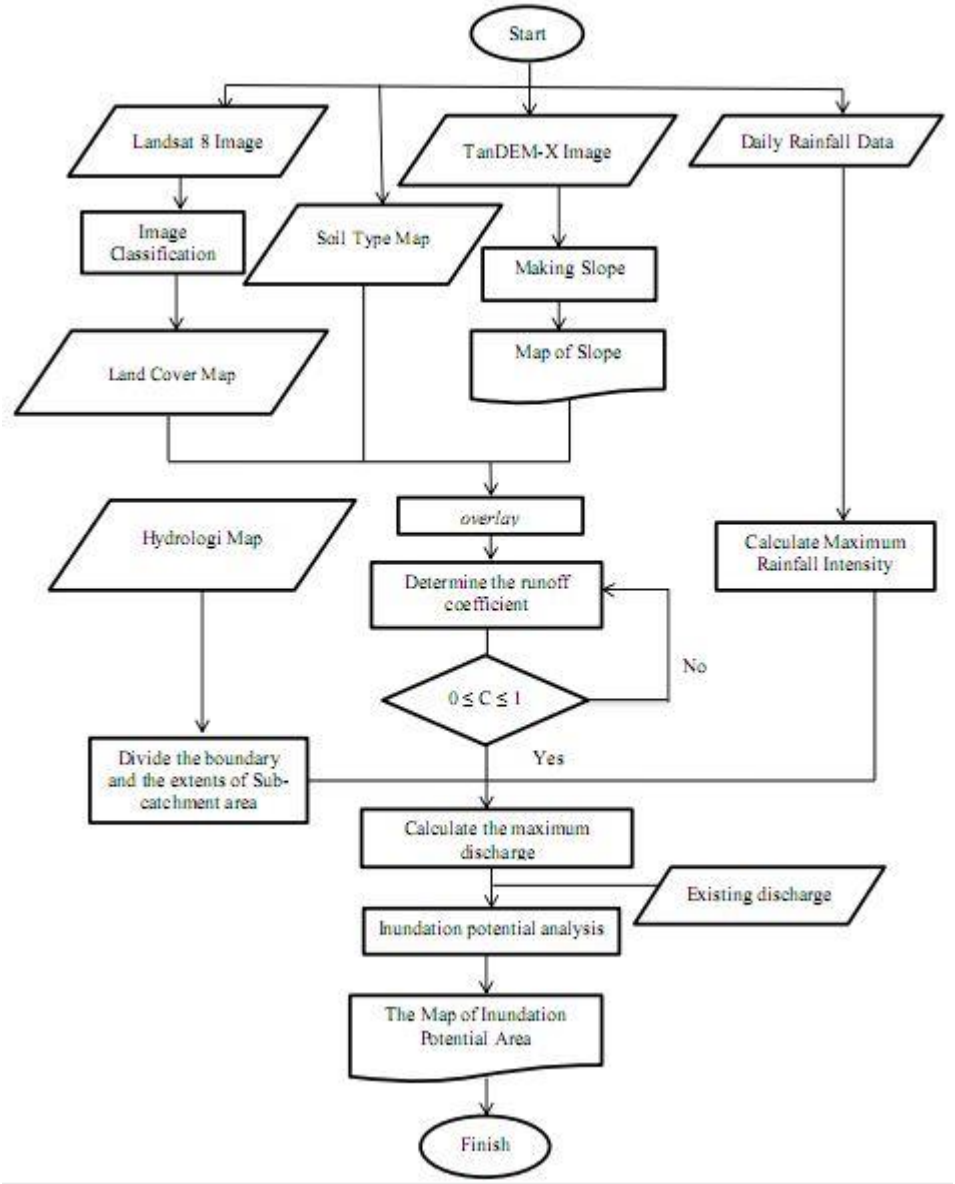

Figure 2. Processing Flowchart

3. The Results

3.1 Hydrologi Map

Hydrologi Map obtained by the process of watershed analyzed of Tandem-X image. The results obtained are oriented with the Kediri Hydrologi Map according to BAPPEDA Kediri District, as shown in the picture, there are some areas in Kediri, which is usually flooded, among other Mojo Subdistrict, NgadiluwihSubdistrict, and KrasSubdistrict. The rivers that pass through the region is Bruniriver, Surat river, Lanang River, Sempu river, Segaranriver, Pandansari river, and Brunoriver. Those rivers are the branch of the Brantas River.

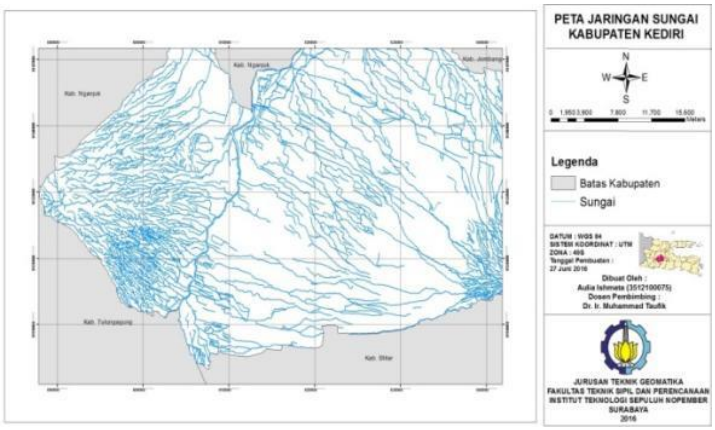

Figure 3. Hydrologi map of Kediri District

3.2 The Map of Sub-catchment area

Sub-catchment areas are divided into seven areas, namely Bruni Sub-catchment area, Surat Sub-catchment area, Lanang Sub-catchment area, Sempu Sub-catchment area, Segaran Sub-catchment area, Pandansari Sub-catchment area, and Bruno Sub-catchment area. Here is a map of the distribution of sub-catchment area research:

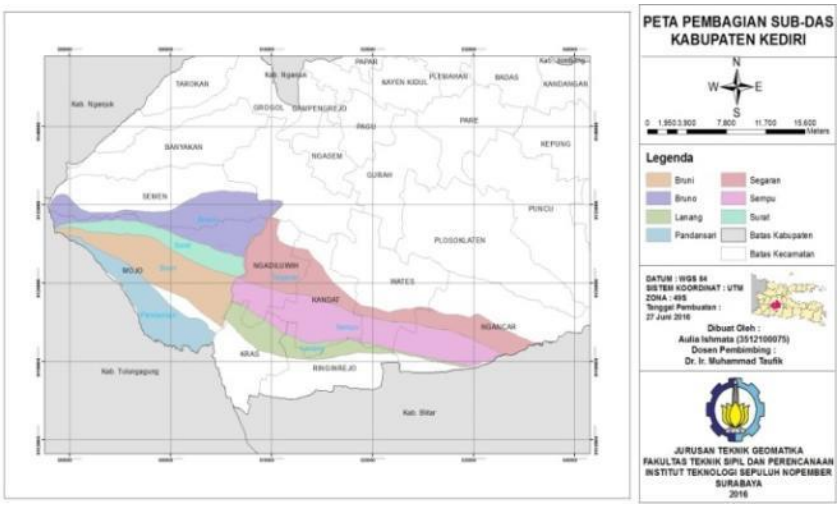

Figure 4. Map of sub-catchment area

Map of Kediri Soil Type scale 1: 50.000 were sourced from BAPPEDA (Regional Planning and Development Agency) Kediri District, there are soil types in Kediri is as follows :

Table 2. Soil Type Class

No	Soil Type	Texture
1	Regosol Coklat Kemerahan	Sand
2	Litosol Coklat Kemerahan	Sand
3	Komplek Regosol dan Litosol	Sand
No	Soil Type	Texture
4	Mediteran Coklat Kemerahan	Clay
5	Asosiasi Aluvial Kelabu & Aluvial Coklat Kelabu	Sand-Clay

From the table above, it can be seen that the kind of Alluvial soil type havethe slit soil texture. The slit soil texture is the most inundation potential because it affects the high value of the runoff coefficient.

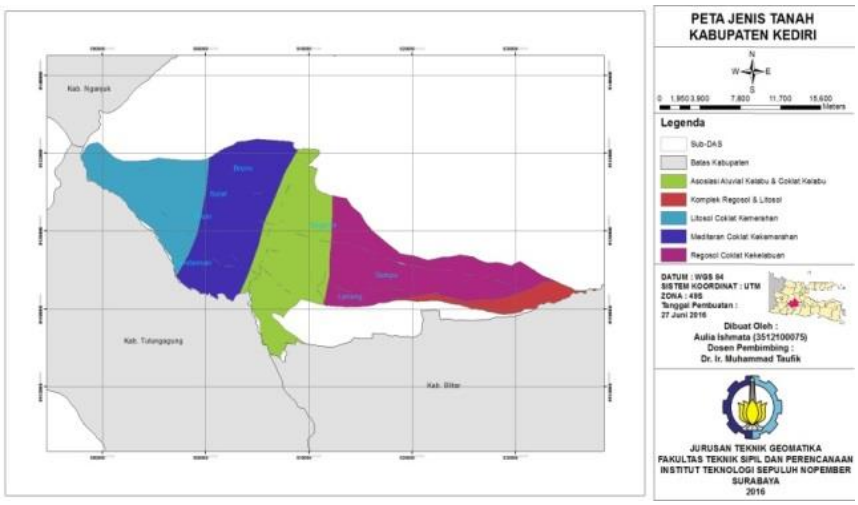

Figure 5. Map of Kediri District soil type

3.4 The Map of Kediri District Slope

Slope map images obtained from the processing of Tandem-X into a contour map and made a map of Altitude. Then, the altitude map is used for made the map Slopes which classified into four classes. Here is a contour map obtained from the image of Tandem-X:

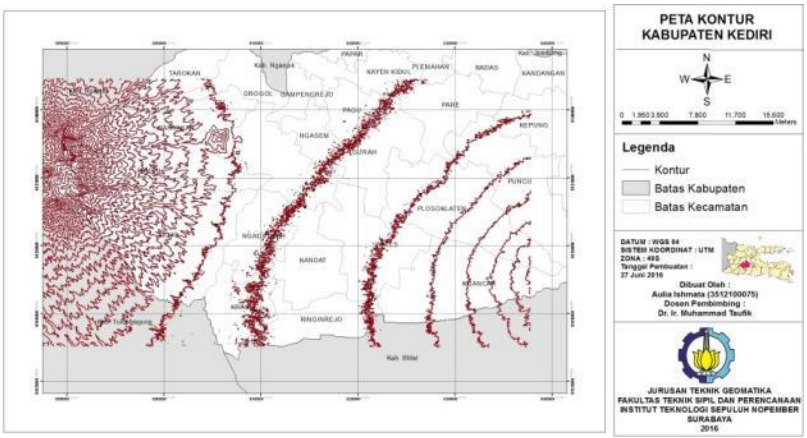

Figure 6. Contour Map of Kediri District

Here is a map of Kediri District Slopeby the processing of DEM. Basically, Kediri is a district with a varied topography that has a diverse slope. In this study, the slope is divided into four slopes i.e 0% -2%, 2% -7%, 7% -30%, and> 30%.

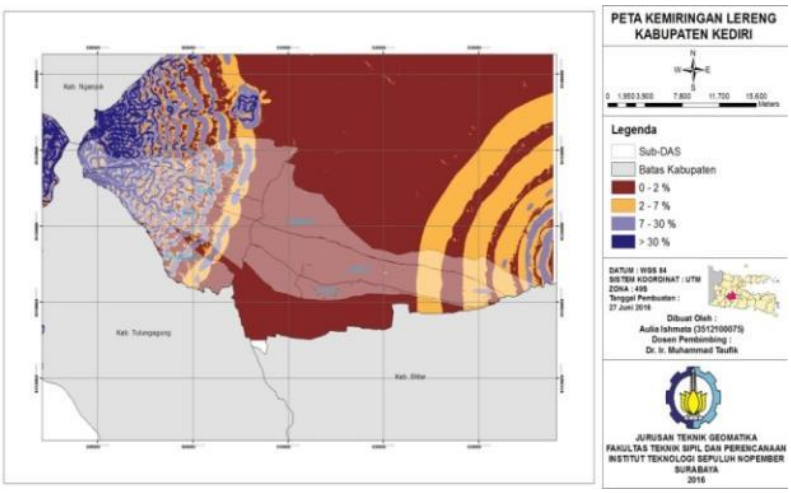

Figure 7. The slope map of Kediri District

3.5 The Land Cover Map

Here is a map of land use in the research area in Kediri, which reveal the distribution of land use in these areas.

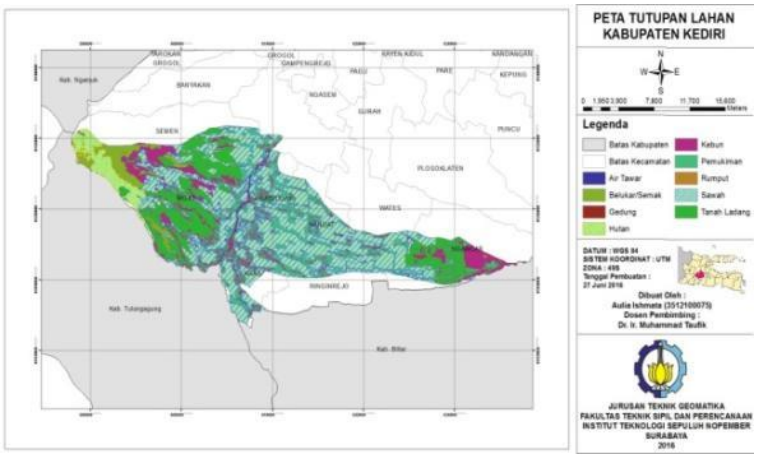

Figure 8. The land cover map in Kediri District

From the map image above, it is known that the largest land cover is dominated by rice fields and undulating flat land area.

3.6 The runoff coefficient

Runoff coefficient (C) is a number that is empirically calculated according to three parameters of cathment area, ie, land cover, soil texture, and slope. In this study, the value of C taken from Soil and Water Conservation Engineering, John Wiley & Son, 1985.

Table 3. The runoff coefficient

No	SUB-DAS	Koefisien Limpasan (C)
1	Segaran	0.45
2	Sempu	0.50
3	Bruni	0.37
4	Surat	0.34
No	SUB-DAS	Koefisien Limpasan

		(C)
5	Pandansari	0.36
6	Lanang	0.60
7	Bruno	0.36

3.7 The rainfall intensity

Rainfall intensity is defined as rainfall per unit time. In this case, you need to know the average daily rainfall in each sub-watershed.

Table 4. The rainfall in each sub-catchment area

No	Sub-DAS	Curah hujan (mm)
1	Segaran	63,2
2	Sempu	79,3
3	Bruni	82,5
4	Surat	82,5
5	Pandansari	85
6	Lanang	79,3
7	Bruno	76,33

Time of concentration (Tc) on each sub-catchment area are presented in the following table :

Table 5. Time of concentration (Tc) on each sub-catchment area

No	Sub-DAS	L (m)	D (m)	Tc (menit)
1	Segaran	29680	338	5,06
2	Sempu	73920	316	14,91
3	Bruni	22710	1575	2,05
4	Surat	16180	871	1,74
5	Pandansari	14420	417	2,03
6	Lanang	20100	125	4,73
7	Bruno	30910	1011	3,48

After obtained the value of Tc in each sub-catchment area, it can be calculated the maximum rainfall intensity for each sub-catchment area. The results are presented in the following table :

Table 6. Rainfall Intensity for each sub-catchment area

No	Sub-DAS	Rainfall intensity (mm/jam)
1	Segaran	5,38
2	Sempu	3,04
3	Bruni	11,73
4	Surat	13,09
5	Pandansari	12,07
6	Lanang	6,55
7	Bruno	7,84

3.8 Maximum Dischrage

The result of the calculation of the maximum discharge using rational methods are presented in the following table:

Table 7. Maximum discharge for each sub-catchment area

No	Sub-DAS	Q (m^3/sec)
1	Segaran	171,58
2	Sempu	113,62
3	Bruni	221,64
4	Surat	109,70
5	Pandansari	166,01
6	Lanang	119,82
7	Bruno	166,003

From the results of these calculations, it is known sub-catchment area with the largest discharge owned by Bruni sub-catchment area amounted to 221.64 m^3 / sec, and the sub-catchment area with the largest debit value owned by Surat Sub-catchment areaamounted to 109.70 m^3 / sec.

4. Analysis

After known planned discharge for each sub-catchment area, then calculate the difference with its existing capacity. From the value of the existing sub-catchment area compared with the maximum discharge can be seen sub-catchment which are safe and sub-catchment where the potentially flooded due to not being able to accommodate discharge passing.

Table 8. Value of existing discharge in each sub-catchment area

No	Sub-DAS	Q (m^3/sec)
1	Segaran	232,25
2	Sempu	459,63
3	Bruni	423
4	Surat	177,6
5	Pandansari	380,65
6	Lanang	100,8
7	Bruno	431

Table 9. The deviation between maximum discharge and existing discharge

No	Sub-DAS	Q (m^3/sec)
1	Segaran	232,25
2	Sempu	459,63
3	Bruni	423
4	Surat	177,6
5	Pandansari	380,65
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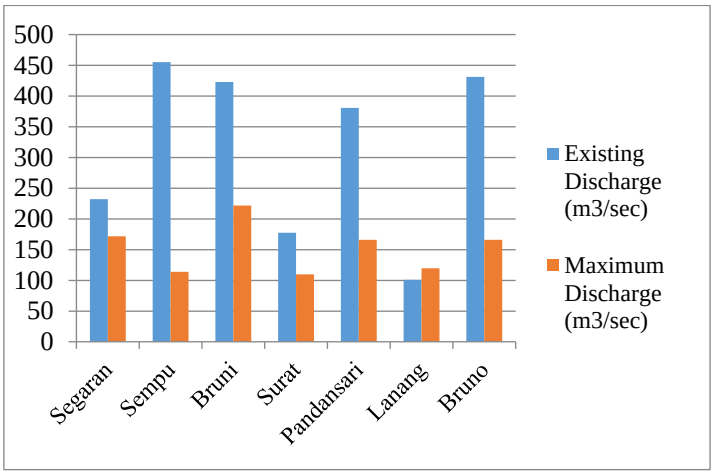

Figure 9. The comparison between maximum discharge and existing discharge

The maximum discharge value calculation results of each sub-catchment area that exceed the value of the existing flow of the river is a Lanang sub-catchment area amounted to 19.02 l m^3/sec. Thus, according to calculations by Rational Method, estimate this sub-catchment areahave the inundation potential. As for the Bruni sub-catchment area despite having the largest discharge, but not in excess of the existing capacity of the river, so the river is safe from the inundation. Here is the area that have inundation potential:

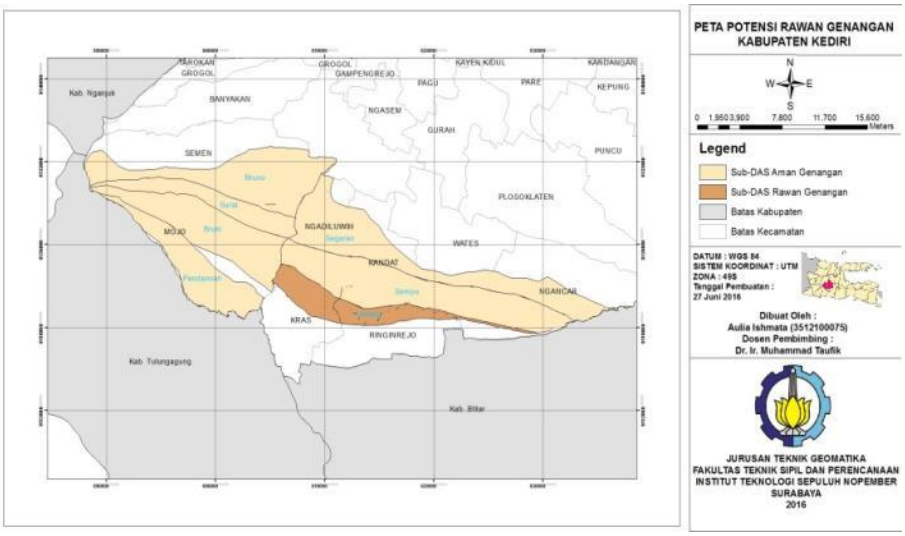

Figure 10. The potential inundation map

5. Conclusions

The results of this research conclude that:

1. From the satellite image of Tandem-X 2011 in Kediri District, obtained slope with four classes, i.e : 0% -2%, 2% -7%, 7% -30%, and > 30%.
2. The runoff coefficients obtained for each sub-catchment area are : Segaran 0.45; Sempu 0.501; Bruni 0.37; Surat 0,34; Pandansari 0.36; Lanang 0.6; Bruno 0.36.
3. The result of the maximum discharge calculation using Rational Method obtained in each sub-catchment area, namely : Bruni sub-catchment area amounted to 221.64 m^3/sec, Surat sub-catchment area amounted to 109.70 m^3/sec, Lanang sub-catchment area amounted to 119.82 m^3/sec, Sempu sub-catchment area amounted to 113.62 m^3/sec, Segaran sub-

catchment area amounted to171.58 m^3/sec, Pandansari sub-catchment area amounted to 166.01 m^3/sec, and Bruno sub-catchment area amounted to 166.003 m^3/sec.

4. The difference between the maximum discharge obtained from the calculation using the Rational Method and existing river discharge for each sub-catchment area are : Bruni sub-catchment area amounted to 201.35 m^3/sec, Surat sub-catchment area amounted to 67.90 m^3/sec, Lanang sub-catchment area amounted to -19.02 m^3/sec, Sempu sub-catchment area amounted to 346.01 m^3/sec, Segaran sub-catchment area 60.67 m^3/sec, Pandansari sub-catchment area amounted to 214.63 m^3/sec, and Bruno sub-catchment area amounted to 265 m^3/sec.

References

Ariyora,Y.K.S 2012 Pemanfaatan Data Penginderaan Jauh Dan Sistem Informasi Geografis Untuk Analisa Banjir (Studi Kasus:Banjir Provinsi Dki Jakarta). Skripsi. Teknik Geomatika, Institut Teknologi Sepuluh Nopember.

Asdak, Chay 1995*Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Yogyakarta : Gadjah Mada University Press

Badan Perencanaan Pembangunan Daerah (Bappeda) 201 *Potensi Kabupaten Kota Kediri. Provinsi Jawa Timur*.<URL: http://bappeda.jatimprov.go.id/bappeda/wp-content/uploads/potensi-kab-kota-2013/kota-kediri-2013.pdf>. Dikunjungi tanggal 20 Desember 2015 pada jam 19.00.

Bidang Cipta Karya Penyehatan Lingkungan Permukiman. 2012 *Petunjuk Teknis Definisi Operasional* Standar Pelayanan Minimal

Boiresta, F 2011 Analisa potensi Genangan Berdasarkan Data Curah Hujan Global TRMM (Tropical Rainfall Measuring Mission) (Studi kasus : Kabupaten Sampang). Skripsi. Teknik Geomatika, Institut Teknologi Sepuluh Nopember.

Handoko. 1995*Klimatologi Dasar* Jakarta: PT. Pustaka Jaya.

Hardaningrum,dkk. 2005 *Analisis Genangan Air Hujan Di Kawasan Delta Dengan Menggunakan Penginderaan Jauh dan SIG* Pertemuan Ilmiah Tahunan MAPIN XIV : Pemanfaatan Efektif Penginderaan Jauh Untuk Peningkatan Kesejahteraan Bangsa.

Hidayat, F. 2013. Pemodelan Resiko Banjir Lahar Hujan Pada Alur Kali Putih Kabupaten Magelang. Journal Undip 895-904.

Lillesand dan Kiefer 1994*Remote Sensing and Image Interpretation* New York : John Wiley&Son, Inc,.

Linsley, Kohler, dan Paulhus. 1996 *Presipitasi : Hidrologi untuk Insinyur* Diterjemahkan oleh Yandi Hermawan. Jakarta : Erlangga.

Lukman dkk. 2011. Aplikasi SIG Untuk Penyusunan Data Pokok Penunjang Evaluasi Daerah Rawan Genangan Di Surabaya. Tugas Akhir. Surabaya : Program Studi Teknik Geomatika.

Maselino, A. 2002. Modul Pelatihan Sistem Informasi Geografis.

Nugraha, A.L. 2013. Kajian Pemanfaatan Dem Srtm & Google Earth Untuk Parameter Penilaian Potensi Kerugian Ekonomi Akibat Banjir Rob *Jurnal Teknik* 343 Tahun 2013, ISSN 0852-1697.

Nugroho, S.P, Agustus 2002. Analisis Curah Hujan Dan Sistem Pengendalian Banjir Di Pantai Utara Jawa Barat Studi Kasus Bencana Banjir Periode Januari – Februari 2002 *Jurnal Sains dan Teknologi Indonesia* 4 5 hal. 114-122.

Prawito, A. 2005 Efektifitas Drainase Kota Kediri Bagian Timur – Februari 2005.Neutron 5 No1

Primayuda A, 2006Pemetaan Daerah Bahaya dan Resiko Banjir Menggunakan Sistem Informasi Geografis: studi kasus Kabupaten Trenggalek, Jawa Timur. Tugas Akhir. Bogor: Fakultas Pertanian, Institut Pertanian Bogor.

Ramdan. 2004 *Prinsip Dasar pengelolaan Daerah Aliran Sungai. Sumedang* : Fakultas Kehutanan, Universitas Winaya Mukti.

Suherlan, E., 2001 Zonasi Tingkat Kerentanan Banjir Kabupaten Bandung Menggunakan Sistim Informasi Geografis Skripsi Fakultas MIPA Institut Pertanian Bogor.

Undang-undang No 7 Tahun 2004*Tentang Sumber Daya Air* Indonesia.

Utomo 2004 Pemetaan Kawasan Berpotensi Banjir di DAS Kaligarang Semarang dengan Menggunakan Sistem Informasi Geografis Tugas Akhir Bogor: Fakultas Pertanian, Institut Pertanian Bogor.