

**International Journal of Innovative Research in Science,
Engineering and Technology***(An ISO 3297: 2007 Certified Organization)*Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Optimization of Green Openspace as Controlling Inundation in the City of Sampang

Lusiyanawati¹, Haryo Sulistyarso², Eko Budi Santoso³Student of Graduate Program of Urban Development Management, Department of Architecture, Faculty of Civil
Engineering, Institute of Technology, Sepuluh Nopember Surabaya, Indonesia¹Lecturer, Department of Urban & Regional Planning, Institute of Technology Sepuluh Nopember Surabaya,
Indonesia^{2&3}

ABSTRACT: Less optimal Green Open Space function having potency increases inundation debit in settlement area each year in Sampang Sub district. So, it is necessary for a research to be able to optimize the GOS function as an inundation control in settlement areas in Sampang city. The research method used in this research is quantitative descriptive analysis used to determine the optimization of GOS ecological functions as an catchment area in settlement in Sampang city, the scoring technique with likert scale and overlaid using Arc-GIS is used to determine the ability and natural infiltration map in Sampang city area. Conditions of air absorption in the study area comprising 181.455 Ha or 48% experienced a critical infiltration condition. The airborne infiltration condition has a critical area of 166,138 Ha or 44% of the study area. Good air recharge conditions have an area of 16.044 Ha or 4% of the study area. The generally accepted condition with a general area of 17.789 Ha is 5% of the total area of study.

KEYWORDS: Green infrastructure, Optimization, Green open space, Inundation control.

I. INTRODUCTION

Ecological unction o Green Open Space (GOS) is to be able to reduce inundation and flood as well as store water, both retained run off water and ground water by infiltration. Settlement area as a prone area of inundation is an area always facing inundation when high rain intensity. There are problems caused by high rain fall and Kemuning river overflow, namely it was recorded the height of inundation in Sampang regency in October 2016 namely by 10cm–60cm with a radius reaching 300 M, inundating the settlement area. It is also caused by the water catchment area in the form of GOS does not meet the Spatial Plan requirements between built area and catchment area in settlement area leading to create inundation. Less optimal GOS function has potency to increase the inundation debit in settlement area each year in Sampang sub district.

The effects of GOS in case of inundation control will certainly provide benefits on the water inundation control. According to the Human Housing and Settlement Office, 2016, it was recorded that the height of inundation in urban area in Sampang regency was included as inundation prone area mainly in five districts categorized as flood and inundation prone areas, namely Polagan district, Rongtengahdistrict, Gunung Sekardistrict, Karang Dalam districtand Dalpenangdistrict. Each districtfaced changes on land use on the land use in 2007 was dominated by settlement and the increasing of GOS. Role of GOS in the inundation control can also be known by the direction of required GOS area until the controlled inundation. Also, the height of rain fall by 3.582 mm/year recorded in 2016 in Sampang city indicated that it is required to conduct consideration in determination of inundation control system in settlement area.

The settlement area in Sampang city faces inundation with the height of inundation by 10cm-1m mainly in 5 districts, namely Polagan, Rongtengah, Gunung Sekar, karang Dalem and Dalpenangdistricts. It is also caused by the water

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

catchment area in the form of GOS does not meet the Spatial Plan requirements between built area and catchment area in the settlement area so that it can create inundation caused by rain intensity, type of calcareous and dry soil as well as by kemuning river overflow. There are problems concerning effects of GOS on inundation control as catchment area because of less function of GOS having potency to increase the inundation debit in settlement area each year in Sampang city. So, the question in this research is How many is the GOS demand area as natural infiltration having function as an inundation control in settlement in Sampang city.

II. LITERATURE REVIEW

Optimization on green open space can be conducted by studying on GOS functions to be optimized because of different GOS functions. The function to be used in this research is GOS ecological function as catchment area. GOS is one of the urban green infrastructures. GOS increases urban environmental quality and also maintains urban environment, as well as has benefits for life sustainability of urban people. GOS as green infrastructure uses criteria based on ecological function in which GOS can be developed to determine the area having potency as *green infrastructure* namely the catchment area that can use type of existing GOS in urban area in the forms of green area and green channels. Then, the GOS can also be as one of the catchment areas in urban area, mainly in the research study location, as well as the aspects used in the research. To create GOS optimization as inundation control, it is necessary to determine the natural infiltration condition through any influencing factors, as follow:

Tabel 2.1 Synthesis of Studies

Theory (1)	Indicator (2)	Variable (3)	Information (4)
Aspects of Green Open Space	Ecological function of public open space	• Ability of RTH Rainwater absorber • The ability of green open flood control and puddle	• Natural infiltration conditions in the study area
Aspects of Urban Settlements	Natural Factors	• Curved topography • Rainfall • Groundwater Decrease	• Slopes of Regions • Rain Water Debit • Soil Condition
	Human Factors	• Land Use • Population • Built-in Settlement Area	• Settlement Density • Total population • Land Use
Green Infrastructure Theory	Pattern of Green City's Green Security Infrastructure	• Surface Flow • Area of infiltration • Rainwater catchment area	• Groundwater Level • Absorbs water • Rainfall

Source: Analysis, 2007

Based on the above theoretical aspects can be concluded, GOS is one of the urban green infrastructure. RTH improves the quality of the city's environment and also maintains the city's environmental balance, can be beneficial for the livelihoods of urban communities. Green space as a green infrastructure using criteria in accordance with ecological function, because RTH that can be developed to be a potential area of green infrastructure that is in the form of recharge area can use the type of green open space in urban settlements in the form of green areas and green lines. Then GOS can also be one of the urban areas in the absorption area, especially in the study area.

III. RESEARCH METHODS

The analysis is conducted by resulting in natural infiltration capacity data by using scoring technique as well as overlay on supporting parameters of natural infiltration capacity in GOS Sampang city as follow:

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Table 3.1 Classification of Infiltration Based on Types of Rocks

No	Characteristics	Types of rock	Classification	Scores
(1)	(2)	(3)	(4)	(5)
1	Not Consolidated	Sediment Lava	Fast	5
2		Sediment Colluvium		
3		Sediment Alluvium		
4		Sediment Pyroclastic		
5	Consolidated	Limestone	Medium	3
6		Sand stone		
7		Volcanic Breccia		
8		Andesite		
			Very slow	1

Source: Directorate General Reforestation and Land Rehabilitation 1998, in Fahmi 2016

Table 3.2 Classification of Infiltration Based on Slope

No	Slope %	Slope	Infiltration	Score
(1)	(2)	(3)	(4)	(5)
1	<8	Flat	Large	5
2	8-15	Sloping	Rather large	4
3	15-25	Wavy	Medium	3
4	25-40	Steep	Rather small	2
5	>40	Very steep	Small	1

Source: Directorate General Reforestation and Land Rehabilitation 1998, in Fahmi 2016

Table 3.3 Classification of Infiltration Based on Types of Soil

No	Types of Soil	Infiltration	Score
(1)	(2)	(3)	(4)
1	Regosol	Large	5
2	Alluvial and Andosol	Rather large	4
3	Latosol	Medium	3
4	Mediterranean Latosol	Rather small	2
5	Grumusol	Small	1

Source: Directorate General Reforestation and Land Rehabilitation 1998, in Fahmi 2016

Table 3.4 Classification of Infiltration Based on Vegetation Density

No	Vegetation Density	Infiltration	Score
(1)	(2)	(3)	(4)
1	Almost 90% is covered both by woods or similar things	Large	4
2	Almost 50% is covered with trees and shrubs	Medium	3
3	Covering plants are in small number, there is no agricultural plans and there is a small number of natural cover	Small	2
4	There is no effective covering plan or similar things	Very small	1

Source: Toto Gunawan (1997), in Fahmi 2016

Table 3.5 Classification of Infiltration Based on Types of Rainfall

No	Classes	Rainfall (mm)	Infiltration	Score
(1)	(2)	(3)	(4)	(5)
1	I	<2500	Small	1
2	II	2500-3500	Medium	2
3	III	3500-4500	Rather large	3
4	IV	4500-5500	Large	4
5	V	>5500	Very large	5

Source: Directorate general Reforestation and Land rehabilitation 1998, in Fahmi 2016

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

The scoring tables above are used in analysis on dominant factors to be used in influencing the GOS infiltration in Sampang city. These scoring values will be used to fill in the attributes of determinant parameters of natural infiltration capacity. This process uses SIG, namely by adding each parameter attribute. The data that have been filled in with the scoring results are then overlaid using union overlay analysis to result in new data. The new data will then be added in a new field to describe the data in classification of natural infiltration capacity. The interval value of infiltration capacity uses strugess interval formula namely by dividing the highest data value and the lowest data so that it can be well-adjusted to the desired class, the Strugess interval formula :

$$K_i = (X_t - X_r) / k$$

Information

K_i = interval class

X_r = the lowest data

X_t = the highest Data

k = number of desired classes

Source: Hendrian 2013, in Hamzah 2016

$$K_i = 24 - 5/5$$

$$K_i = 3,8$$

The K_i value obtained is then used for a range of infiltration capability value by adding starting from the lowest data so that it can be known the classification results. The classification on natural infiltration value capability can be seen in Table 3.6.

Table 3.6 Classification on Natural Infiltration Capability

No	Infiltration Capability	Range of values	Notation
(1)	(2)	(3)	(4)
1	Large	21-24	a
2	Rather large	17-20	b
3	Medium	13-16	c
4	Rather small	9-12	d
5	Small	5-8	e

Source: Analysis, 2017

Condition of water infiltration is land capability condition to infiltrate rain water so that it can be aquifer recharging place. Before the use of data compilation, previously, there is assessment on land use data by providing A-E values in its attribute data based on infiltration capability according to Directorate General Reforestation and Land Rehabilitation 1998, in Fahmi, 2016.

Table 3.7 Correlation of Land Use With Infiltration Capability

No	Description of Infiltration / Catchment	Types of Land use	Notation
(1)	(2)	(3)	(4)
1	Large	Settlement, Paddy field	A
2	Rather large	Horticulture, (sloping)	B
3	Medium	Shrubs, Open Land	C
4	Rather small	Garden / Plantation	D
5	Rather	Heavy forest	E

Source: Directorate general Reforestation and Land rehabilitation 1998, in Fahmi 2016

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

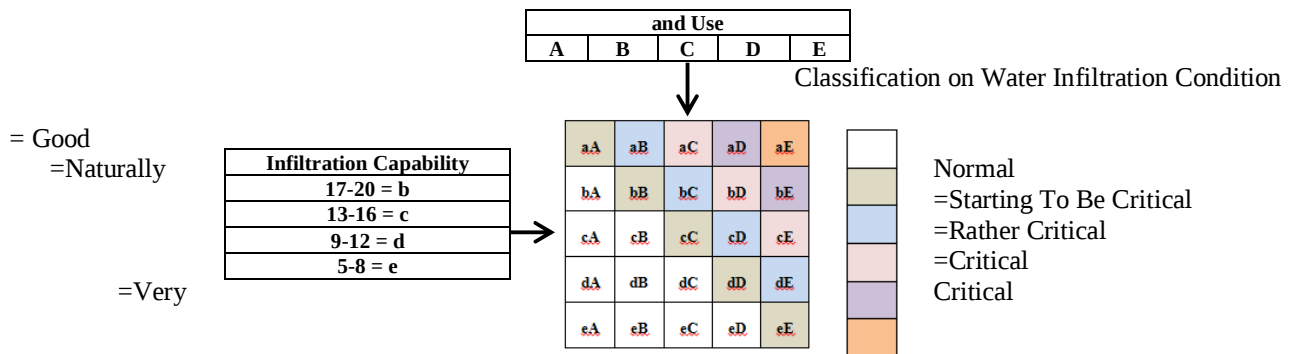


Figure 3.1 Infiltration Study Model Directorate General Reforestation and Land rehabilitation in Fahmi, 2016

IV. EXPERIMENTAL RESULTS

A. NATURAL INFILTRATION CAPABILITY

Infiltration capability is obtained by scoring on influential factors to obtain score values; this can be done by entering data obtained from the study area namely data on type of rock, slope, type of soil, vegetation density, and rainfall, so that it can be done the scoring analysis by using data on type of rock, rainfall, slope, vegetation density, and type of soil. The score values obtained in the picture above are used in the following analysis namely by entering the values into attribute data of determinant parameters of natural infiltration capability factors. This stage uses GIS applications. The data obtained will be overlaid using union overlaid analysis method. This analysis will result in new data which then it categories its data into classification of natural infiltration capability.

The catchment area condition in the study area was obtained from compilation results of infiltration capability with the regional function. The regional function is used to determine infiltration capability in each field in the study area. This analysis uses overlay technique between infiltration capability map and regional function maps.

Based on the infiltration capability according to each total scoring score, it is known that there are four classes of infiltration capability in the study area presented in table 4.1 below:

Table 4.1 Infiltration Capability of Studi Area

No	Total of Scoring	Infiltration	Area (Ha)	Percentage (%)
(1)	(2)	(3)		(4)
1	17-20	Rather large	368.985	97
2	13-16	Medium	9.736	3
3	9-12	Rather small	-	-
4	5-8	Small	-	-
	Total		381.427	100%

Source: Analysis, 2017

The infiltration capability in Sampang city area by 97% indicates that it is an area with rather large natural infiltration with an area reaching by 381.427 Ha, meanwhile 3% is an area with medium natural infiltration with an area by 9.736 Ha. So, the infiltration in inundation area in Kota city has rather large absorbency so that it can conduct optimization on the catchment area. Out of the area of inundation reaching by 381.427 Ha, there is only 3 % of the area has medium infiltration capability, namely salt pond areas in which there is no vegetation at all.

Results on natural infiltration analysis are used to determine condition of land capability to absorb rainwater so that it can be aquifer recharging place. Data on land use is obtained from Bappeda Sampang regency showing that there are 5

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

types of land use in the study area consisting of forest/ plantation, catchment, field / grass, settlement, paddy field and ponds.

Table 4.2 Land Use in Study Area

No	Total of Scoring	Infiltration	Area (Ha)	Percentage (%)
(1)	(2)	(3)		(4)
1	Forest / plantation and catchment	Rather large	16.041	5
2	Field / grass	Medium	17.788	5
3	Settlement	Rather small	181.453	48
4	Paddy field	Small	156.401	39
5	Ponds	Small	9.736	3
	Total		381.427	100

Source: Analysis, 2017

Based on classification used and result of map *overlay*, then it is obtained that the condition of catchment area in study area consists of good, naturally normal, starting to be critical, and rather critical. Compilation results between infiltration capability and land use reflect on the catchment condition in the research area and its area. In details, it can be known that condition of catchment area in the research study area namely by an area of 48% faces starting to be critical condition of catchment area. The catchment area in a good condition has an area by 4% out of the area of study area. The catchment area condition with the smallest area is in condition of naturally normal with an area of 5% out of the research study land area.

B. The Most Influential Factor on The Infiltration

Results of data processing result in four classification of infiltration capability in the research area consisting of infiltration capabilities of rather large, medium, rather small and small. There are rather large factors influencing on the infiltration capability because the rather large infiltration capability is the largest land area dominating the research area. Previous analysis results show that the scoring value serving great roles in forming rather large infiltration capability is 3 scoring value, then the most influential factors can be seen in table 4.2. showing calculation results / *counting dissolve* on the largest number of each parameter.

Table 4.3 Calculation Results on Number of each *Scoring* of Rather Large Infiltration Capability Parameters in Research Area

No.	Parameters	Scoring Values				
		1	2	3	4	5
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Types of rocks			61		
2.	Slope					60
3.	Types of soil		11		50	
4.	Vegetation Density		29	16	15	
5.	Rain fall			61		

Source: Analysis, 2017

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

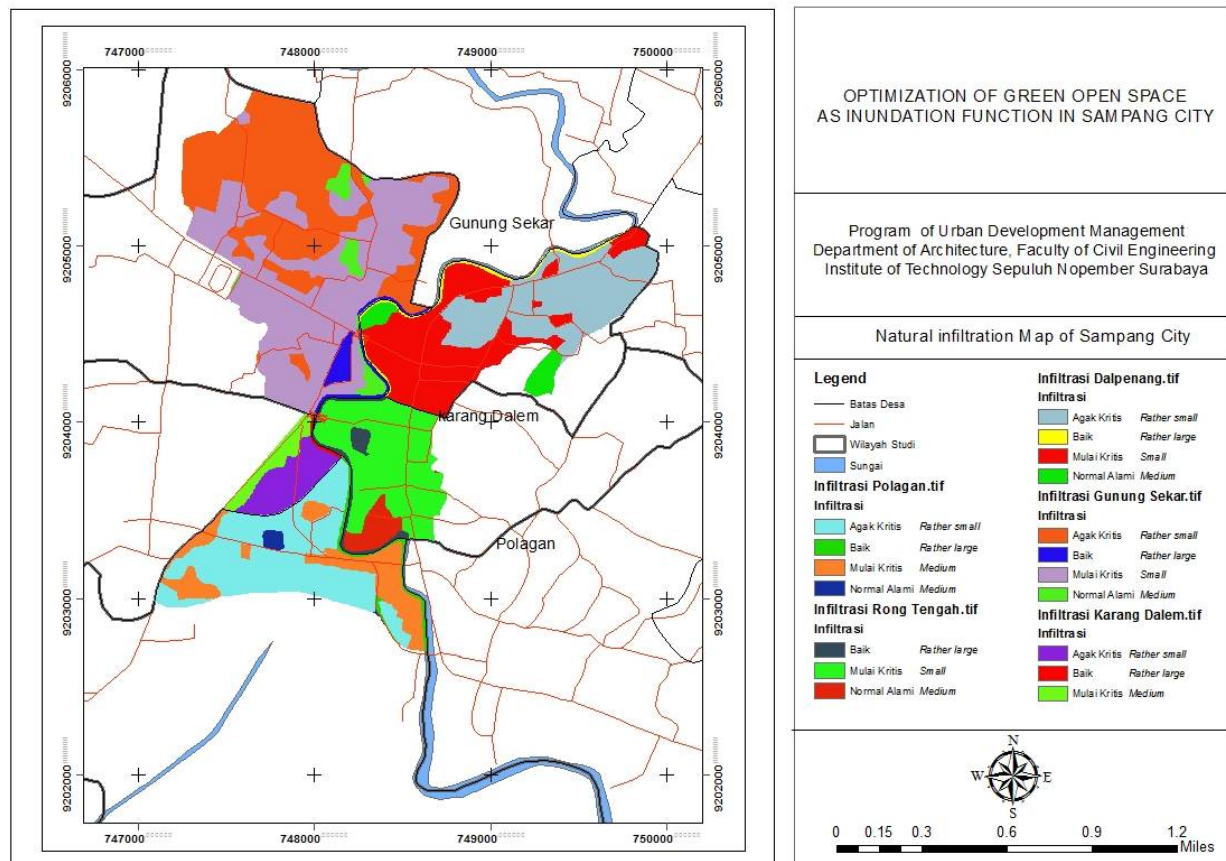


Figure 4.1 Natural Infiltration Map Sampang City

Table 4.4 Map Weighting Value Table

No.	Natural Infiltration Factors	Weights
(1)	(2)	(3)
1.	Types of rocks	5
2.	Slope	4
3.	Types of soil	3
4.	Vegetation Density	2
5.	Rain fall	5

Source: Analysis, 2017

Based on table 4.3 the calculation results on rather large infiltration capability, it is obtained that the largest number for 3 scoring value is in the parameters of types of rock, and rain fall that are considered as the most influential factors in the rather large infiltration capability area.

The research result of medium infiltration capability has an area by 9.736 Ha. The factors causing on medium infiltration capability value based on results of *counting dissolve* are obtained as follow:

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Table 4.5 Calculation Results on Number of Each Scoring of Medium Infiltration Capability Parameters in Research Area

No.	Parameters	Scoring Values				
		1	2	3	4	5
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Types of rocks			2		
2.	Slope					2
3.	Types of soil				2	
4.	Vegetation Density	2		-		
5.	Rain fall			2		

Source: Analysis, 2017

It can be seen in table 4.5 that the scoring value of each parameter is the same then the five parameters provide mutual effects on the infiltration capability in the research area.

V. CONCLUSION

Study area is an area facing constant inundation at rainy season, in which total of inundation area overall reaches 381.427 Ha with the average height by 20cm-60cm in the range of rain fall time by 1-7 hours. City square faces the inundation effects by 0.7738 Ha, city forest faces the inundation effects by 1.0317 Ha, and river borders face the inundation effects by 10,8 Ha. From the inundation effects, the GOS should be an *alternative* of catchment area in which the GOS in the study area still has large area and it can be optimized as the catchment area.

Based on the analysis results, it can be known that the condition of catchment area in the research area namely by 48% is in the condition of starting to be critical. The catchment area with rather critical condition has a land area by 44% of the research study land area. The catchment area with good condition has a land area by 4% of the study land area. And the catchment area with the smallest area is in the conditions of naturally normal with a land area by 5% of the total area of research study sites.

The high level of infiltration area facing starting to be critical condition is caused by the growth rate of built area in Sampang city. The decreasing number of open land influences on the lack of catchment area that can be used as one of the inundation control functions, then these analysis results prove that there is a small number of land area with good infiltration so that it is necessary for new GOS to be used as a catchment area in Sampang city.

REFERENCES

- [1] Dwiyanto, Agung. 2009. *Kuantitas dan Kualitas Ruang Terbuka Hijau Di Permukiman Perkotaan*. Engineering – Vol. 30 No. 2 of the year 2009: ISSN 0852-1697.
- [2] Frick, Heinz. 2006. *Arsitektur Ekologis*. Yogyakarta: Kanisius.
- [3] Fahmi, Hamzah Haz, 2016. Analisis kondisi Resapan Air Dengan Menggunakan Sistem Informasi Geografi di Kabupaten Gunungkidul. Surakarta: Universitas Muhammadiyah Surakarta.
- [4] Reader, A. 2002. *Theory in Landscape Architecture*. Philadelphia: University of Pennsylvania Press.
- [5] Molnar, Donald J. 1986. *Anatomy of A Park*. New York: McGraw-Hill inc.
- [6] Marzuki. 2002. *Metodologi Riset*. Yogyakarta: BPFE UII. Madcoms. 2002. Database.
- [7] Hakim, Rustam. 2012. *Komponen Perancangan Arsitektur Lansekap*. Jakarta: Bumi Aksara.
- [8] Depdikbud, 2008. Big Dictionary of Bahasa Indonesia Center of Language Fourth Edition. Jakarta: PT Gramedia Pustaka Utama
- [9] Sadana, Agus S. 2014. *Perencanaan Kawasan Permukiman*. Yogyakarta: Graha Ilmu.
- [10] Sugiyono. 2012. *Memahami Penelitian Kualitatif*. Bandung: Alfabeta.
- [11] Akdon dan Riduwan. 2007. *Rumus dan Data Dalam Analisis Statistika*, 2nd Ed., Bandung: Alfabeta.
- [12] Yulaelawati, dan Syihab. 2008. *Mencerdasi Bencana*. Jakarta: Grasindo.
- [13] Kodoatie, Robert J. 2013. *Rekayasa dan Manajemen Banjir Kota*. Yogyakarta: CV Andi Offset.
- [14] Spreiregen, P. D. 1965. *Urban Desing: The Architecture of Towns and Cities*. New York: McGrawHill.
- [15] Rahmawati, Agustina Dwi. 2013. Analisis Spasial Persebaran Toko Mebel di Kabupaten Jepara Profinsi Jawa Tengah. Semarang: Dipenogoro University
- [16] Badan Pusat Statistik Kabupaten Sampang. 2014. *Sampang Dalam Angka*. Sampang: BPS Kabupaten Sampang.
- [17] Dirjen Cipta Karya Bekerjasama dengan Ikatan Ahli Perencanaan Indonesia. 2015. *Kamus Tata Ruang*. Jakarta: Dirjen Cipta Karya.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

- [18] Dirjen Penataan Ruang. 2006. Ruang Terbuka Hijau (RTH) Sebagai Unsur Utama Pembentuk Kota Taman. Jakarta: Public Work Department.
- [19] Peraturan Menteri Pekerjaan Umum Nomor: 05/PRT/M/2008, *Pedoman Penyediaan dan Pemanfaatan Ruang Terbuka Hijau di Kawasan perkotaan*. Directorate General of Spatial Planning, Public Work Department.
- [20] Rencana Tata Ruang Wilayah Kabupaten Sampang-Provinsi Jawa Timur tahun 2012-2032. Sampang: BAPPEDA.
- [21] Surat Keputusan Menteri Pertanian No. 837/KPTS/UM/1980 *Tentang Kriteria dan Tata Cara Penetapan Hutan Lindung*. Jakarta.
- [22] POKJA Sanitasi Kabupaten Sampang, Tahun 2013. Program Percepatan Pembangunan Sanitasi Permukiman (PPSP). Sampang.
- [23] Peraturan Pemerintah Republik Indonesia Nomor 63 Tahun 2002, *Tentang Hutan Kota*. Republic Indonesia.
- [24] Act of the Republic Indonesia Number 1 of the year 2011, *Concerning Housing and Settlement*.
- [25] Rayuana, Ety. 2011. Hubungan Genangan Air Pasang Dengan Kelurahan Penyakit Pada Masyarakat Pesisir Pantai Desa Sei Baharu Di Kecamatan Hamparan. Thesis S2. Medan: North Sumatera University.
- [26] Kridarso, Ety R. 2012. *Dasar-dasar Permukiman dan Perkotaan*. Department of Architecture Usakti.
- [27] Isfiana, Fatmi, dan Kustiwan, Iwan. 2012. Optimalisasi Penyediaan Ruang Terbuka Hijau Privat di Kota Cimahi.
- [28] Marina dan, Maryati, Sri. 2013. Kebutuhan Ruang Terbuka Hijau Sebagai Pengendali Debit Limpasan Air di Rayon Jambangan. Surabaya. Bandung: Institut Teknologi Bandung
- [29] Danisworo, Mohammad. 1988. Konseptualisasi Gagasan dan Upaya Penanganan Proyek Peremajaan Kota: Pembangunan Kembali sebagai Fokus. Jakarta. Dalam Perencanaan Kota Indonesia.
- [30] Joga, Nirwono. 2010. Infrastruktur Hijau Kota. Kompas. <http://www.awsassets.wwf.or.id> (Accessed : 06-04-2015)
- [31] Barano. 2014. *Infrastruktur Hijau Sebagai Konsepsi Dasar Dalam Pengembangan Kawasan Terbuka Hijau*. Siswa S/ WWF ID- Anggota SUD-FI. <http://www.google.com> (Accessed: 09-11-2014).
- [32] M.si, Yulia. 2015. *Ilmu Geografi*.<http://ilmugeografi.com/ilmu-bumi/tanah/jenis-jenis-tanah>(Accessed: 20-01-2017).