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Submission date: 22-Sep-2022 08:37AM (UTC+0700)
Submission ID: 1905830915
File name: Underground-Water-with-the-Ecosystem-Ap_2016_Procedia---Soci.pdf (742.18K)
Word count: 5035
Character count: 28882

Available online at www.sciencedirect.com

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Procedia - Social and Behavioral Sciences 227 (2016) 720 – 727

Procedia
Social and Behavioral Sciences

CITIES 2015 International Conference, Intelligent Planning Towards Smart Cities, CITIES 2015, 3-4 November 2015, Surabaya, Indonesia

Conservation of underground water with the ecosystem approach to the development of the New towns in Bogor, Tangerang, Bekasi (Botabek) Region

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Abstract

The limited supply of clean water led to some residents in the city, as well as business and trade areas using underground water. Optimization of land used in the development of new towns and expanded impervious land surface, thus reducing infiltration capacity, resulting in an increased volume of runoff. The use of underground water and the reduced infiltration of rainwater resulted in a decrease in the underground water table. To maintain the underground water table and preventing land subsidence resulted from the use of underground water as raw material for clean water. The effort required is how doing underground water conservation. This paper discusses the development of new towns to assess the natural landscape as underground water conservation efforts on the development of the new town. The research method uses a quantitative approach to calculate the potential runoff using a soil conservation service, while to analyze the trend of changes in land cover using temporal spatial analysis, using descriptive analysis. The data used satellite imagery. The study found open green spaces, water bodies, and infrastructure in the form of green corridors can reduce runoff and maintain the underground water table.

Peer-review under responsibility of the organizing committee of CITIES 2015

Keywords: *Green open space, impervious surface, Landscape Ecology, Runoff, Urban Ecosystem.*

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Peer-review under responsibility of the organizing committee of CITIES 2015
doi:10.1016/j.sbspro.2016.06.138

1. Introduction

Development of new towns should be in accordance with the carrying capacity of the environment in which the city develops. "Carrying capacity is defined as the continuous load the maximum that can be imposed by humans on the environment (the Independent Commission on Population and Quality of Life, 2000). Carrying capacity of a good city is able to meet the need for clean water, clean air, food security, comfort, and safety. According to the Golani (1976) "New town is a settlement with economic independence. Ecosystem changes occurred in the area in which the city developed. In landscape ecology, urban structure consists of a matrix, is the dominant element in the form of a collection of buildings, the patch is a cluster of residential, commercial and business center, a forest park city /, lake, while the corridors in the form of roads, rivers, and pedestrian paths. "From the perspective of ecology, urban development affects the structure of the patch, resulting in changes in the size, shape, interconnectivity, and the composition of the patch experienced. It also produces a variety of disorders due to physical changes in the configuration of urban structures. Changes in land cover in urban development affect biotic diversity, primary productivity, soil quality, runoff and sedimentation. Urban activities also affect the dynamics of populations, communities, ecosystems, microclimate, air quality, and produce the urban heat island (Alberti, 2005)." According to Forman & Godron (1986) and Turner (1989) " ecological landscape be defined in various ways, but in general is the study of the structure (pattern), and the process of change. Landscape structure (pattern) can be considered as the spatial relationship between the elements of the landscape, while the landscape function or process is, the interaction between the spatial elements, and changes in the landscape is a change in the structure and function that occur through time (Hobs, 1997). Soil impervious cover increases runoff, which in turn disrupt the hydrological cycle, because of the rain that falls to the earth cannot seep into the soil, so that the ground water is not getting supplies, when underground water is used for materials clean water, shortage of underground water occurs. "The water that fell to earth in the form of rain, will experience a variety of events, evaporates into the air in the clouds condenses and falls back to earth in the form of rain. Water will be maintained while the body of water (river, lake / reservoir), and in the soil. Rainwater that falls to the ground and called infiltration and supply of underground water, rain water while others will flow on the surface of the ground (runoff), through the flow of soil, water in lakes, rivers, and the sea would evaporate and return air, this process can be referred to as the hydrology (Arsyad, 2010)."

"Following the classification of water NEA United sub habitat, including natural and artificial water bodies such as rivers, underground water lakes, marshes, ponds, trenches, canals and reservoirs. The water bodies have ecosystem services (Losco at al., 2012)."

The needs of urban green open space have ecological function, as one of the underground water system and integrated water resources. Green open spaces such as corridors and urban environment in the city park have an active role to improve air and water quality (Rao, 1997). In addition to green open space at a store of groundwater, lakes and ponds have the same functionality as the storage of rain water for the needs of the city and as a place of recreation. "Lakes and Ponds, generally defined as a body of water, which has a dependency on rainfall (Meester at al. 2005). It covers water bodies man-made or natural, (Rodriguez, 2007, p. 819)."

Based on the description above can be understood, that the ground surface is not watertight allows infiltration of rainwater, because the soil has the ability to absorb rainwater. Infiltration capacity would be better if the soil surface is covered by vegetation. Extensive vegetation covers in the form of open green space will further increase the infiltration capacity so as to reduce the flow of surface water and maintain the underground water reserves. In addition to green open spaces, lakes and ponds are natural or artificial in new towns function that can reduce runoff, thereby reducing the threat of flooding in the new towns and the surrounding area which has a lower height. The lake, with a large capacity, such as the storage of rain water, can serve as raw material for clean water for the new towns. In addition, the lake has a function to lower the air temperature micro and recreation areas, wildlife habitat, are also useful to encourage the hydrological processes. The city can be considered as an ecosystem, because there is a reciprocal relationship between the abiotic, the building is and the built environment more, and with biotic, e.g. organisms, flora and fauna, including humans in it, the relationship as a system (Newman and Jennings 2008) and according to Alberti (2008) "in the urban ecosystem, the human is dominant with the complexity and activities that make it different from the natural ecosystem."

"Ecosystem urban consists of seven elements identified as: (1) trees along the road; (2) lawn & garden; (3) the urban forest; (4) of agricultural land; (5) wetlands (6) lake / sea, and (7) rivers (Poland and Sven 1999)." Of the seven elements of urban ecosystems, agricultural land cannot be applied to the development of new towns in the region Botabek, because the land area is limited and expensive. Urban ecosystems provide useful services to new

towns, so that the ecosystem should be maintained balance. According to Sarukhan, J., and White. A (2005), the ecosystem has 4 services, among others: (1) Provisioning Service, the products provided by ecosystems directly, among others: the fresh water for consumption or production (2) Regulation services, among others: control erosion, carbon sequestration. (3) Support Services, namely, to support the provision of other ecosystem services, such as the establishment of riparian habitat for the aquifer and the water cycle, (4) social services and culture, among others: Park City, Forest City, and lakes. To achieve harmony of space, it takes the arrangement of space, which is defined as: "A system of spatial planning processes, space utilization, and control the utilization of space (Law No. 26/2007, Article 1, paragraph 5, of the spatial planning). City required to have a green open space, at least 30% of the total area of the city, such as green open space public (20%) and private (10%), with the expected green open spaces covering 30% of the total area of the city, the balance of urban ecosystems can be maintained as well as green open spaces can reduce runoff and have a good infiltration capacity so that the hydrological cycle to work. New town development should ideally be done with the ecosystem approach. “Ecosystem approach is a holistic approach to environmental management that is integrated from various disciplines such as social sciences, biology, physics and engineering. (United Nations University / Institute of Advanced Studies, 2003).”

The new town was developed with the structure and the various elements of the natural landscape, as well as landscape-made, such as: (1) Network infrastructure, such as corridors connecting, waterways and rivers, (2) green open spaces such as parks, urban forests, although the sports field, (3) body water in the form of lakes, or rivers.

The increasing complexity and high urban population, encourage the conversion of natural landscapes and artificial, thus extending the impervious soil surface and green open space narrowing, thus increasing the volume of runoff and micro air temperature rise. Population increases result in a need of water supply increases. The limited supply of clean water in the new town, encourages residents and industries utilizing underground water as raw water. The use of underground water and the shrinking of the infiltration capacity, impact on underground water deficit.

To calculate the volume of potential runoff used rainfall data in the same year with a change of land use, and soil hydrology group. On methods of soil conservation service, the calculation of runoff is influenced by soil hydrologic group divided into 4 groups, each of which has a different infiltration capacity, which is presented in tabular form the curve number (Arsyad, 2010). Provision of clean water for the development of new towns in Bogor Residence, South Tangerang City, and Bekasi Residence (Botabek), has not been fully supplied from within the city itself. The use of underground water as water supply, if it’s not accompanied by conservation, can cause a decrease in underground water. The purpose of this paper is to study the how to maintain the underground water table with the ecosystem approach to the development of a new towns that affect the sustainability of the city.

2. Methods

This research uses descriptive-analytic method, by making observations to obtain data on the object that has an influence on the quality of the environment, among others: the phenomenon of natural and man-made environment. The results of research conducted by other researchers previously used as secondary data. Analysis of data on changes in land use, density of vegetation and land cover will use temporal spatial analysis.

Obtaining research data, field observations were conducted, by recording the state of the natural and built environment, using purposive sampling (samples based on the selection of researchers as needed and interesting phenomenon). Temporal, spatial data in the form of land cover change from 1998, 2000, 2005, 2009, and 2012. 1998 began to study the data, and the commencement of construction of new towns in the region Botabek. Satellite image data obtained from the recordings made by the National Institute of Aeronautics and Space (LAPAN). To determine the amount of runoff using the Soil Conservation Service (Arsyad, 2010). In the SCS method, runoff is influenced by a group of hydrology and rainfall, land cover and awake. Data used rainfall, since 1998 up to 2012, with the source of the data, meteorological and geophysics agency. Deprivation use / land can affect the infiltration of rainwater, which is determined using the curve number (Cn). By knowing the runoff, can be calculated reservoir capacity needs and the needs of the new town green open spaces. The results of the discussion in this paper obtained the volume of runoff can be reduced by green open spaces, an artificial lake, and infrastructure, namely: vegetative drainage, roads and green corridors that are under all the extra high-voltage lines.

2.1. Research Location

The study was conducted in three new towns. The first new town, at located Sentul Bogor in Bogor Regency with an altitude of 250-801 m from above sea level, to have development area 3000 ha, the second, which is located in South Tangerang City with an altitude of 22-45 m from the above sea level, has a development area of 5600 ha and third, Cikarang Baru City in Bekasi Regency with an altitude of 25 m from the above sea level, has development area 6000 ha. The third the new towns are geographically located between the $6^{0}18'$-$6^{0}40$ 'south latitude and $106^{0}24'$-$107^{0}12'$ east longitude. The new towns have a different function, such as: tourism destinations, city services and trade, and industrial city. These three new towns have different landscapes such as geomorphology. Sentul City region with hilly topography, Serpong region with flat-undulating topography, and Cikarang Baru region with flat topography.

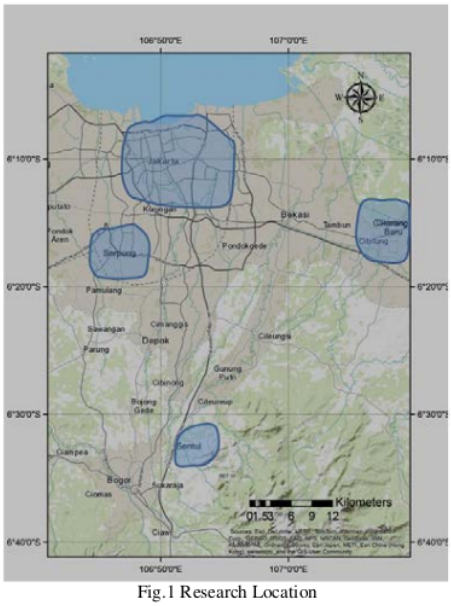

Fig.1 Research Location

3. Result and Discussion

The third new Towns have a body of water, such as lakes and rivers. Sentul City has a lake broader than the other new towns, whereas Bumi Serpong Damai Region has the largest watershed compared to the other two new towns, Cisadane watershed are 155975 ha, or 1,559.75 km2. Of all new towns, Bumi Serpong Damai Region, and Cikarang Baru Region has a source of raw water from the nearby river.

Lake in Sentul City has an area that is different, adjust topography, lakes provide regulation, rainwater, and a culture of social services as a place for recreation and education, so that an open space that is useful to "support the natural systems that have direct benefits for humans, this could be a factor climate moderation, water catchment areas, flood control, water and air pollution, as well as emissions reduction (Alabi 2009)." In addition to have a river lake Sentul City in Bogor Cikeas flowing upstream, downstream and to the Bekasi district. Other rivers that flow in Sentul City are Citeureup River, but the water flow of the river during the dry season is very little. So it cannot be used as a source of raw water.

BSD region in the flow of four rivers, are: Cisadane, Angke, Jaletreng, Ciater, and, other water bodies such as rivers, and lake / pool. Cisadane part of the watershed upstream in Bogor, which is in the middle of Bumi Serpong Damai area, and downstream in the district of Tangerang, while Watershed Angke culminates in Bogor, Angke

River in Serpong is the middle and downstream in the city. According to Asdak (1995), the watershed is divided into 3 parts, the area upstream, midstream, and downstream. The development plan ideal of the urban forest on the river border line width of 100 m, along the watershed to the area of BSD City, could hamper the flow rate of the river, and increase the infiltration capacity of water bodies, so as to reduce the threat of flooding in downstream areas. Utilization of the border line and the time, Cisadane Angke as forest / park, in addition to reducing the threat of flooding in the lower areas (Downstream), may also be useful as water conservation efforts on the ground. Jaletreng river flows in the middle of a city park 2, cluster housing, the river is a small river, and is used as drainage in the area of BSD City. River Jaletreng change the shape of the river, by simplifying the flow of the river, which was originally winding, become straight, this difference can be seen in the results of sensing google earth before and after 2006. Modification of this flow can accelerate the flow of the river, with the ultimate goal in Cisadane River, so water in Jaletereng rapidly shrinking. Results modifications get more land that can be developed into housing. In contrast to the principles of conservation, meandering river water naturally slow down the flow, but the large water infiltration that occurs, so that the greater the groundwater stored in the area around the river (Asdak 1995).

Conserving riparian Cisadane and Angke needs to be done, especially to prevent the conversion of areas of riparian. Structuring the demarcation line of the river is still tolerable as far as to the development of forest botanical/gardens city. “The development of the banks of the river should avoid impervious surface more than 10%, of the total river bank. Development that exceeds 10% can result in damage to the environment as expressed by Arnold & Gibbson (1996), Schueler (1992), that “the extent of impervious surface on the river riparian line impact, and degrade the quality of the environment. (Flinker, 2010).” Corridor with the shape of the watershed, providing service provision, as a raw material supplier to clean water. To protect the river conditions determining riparian river is very important to protect the river, "city developers and planners must try to control the volume of runoff on new development by developing low-impact. Development of low impact, including measures to preserve natural areas, as a very sensitive area such as hydrology and land border line that has a good infiltration capacity. (US-EPA 2003), thus “Cities should protect and restore critical ecosystems as the main water source. This will provide a lower cost, more efficient water supply system and resilient. (Mafuta, C., Formo, RK, Nellemann, C, and Li, F. eds, 2011).”

At under land along extra high voltage line has potential as a green corridor which can function as a control water runoff, with the rainwater that falls on all the highways or the area around the extra high voltage lines. Road as a corridor that connects the patch has the potential for providing ecosystem services by controlling runoff of rainwater that falls on the road surface. This can occur by designing a road as a green corridor by raising the road surface elevation higher than the shoulders and median middle of the road that has been optimized infiltration capacity with vegetative method. The patch is an interactive space in which living creatures, including humans. Forms such as patches, cluster housing, forest park / city and lake. in addition to connecting and uniting patch in new towns, roads makes it possible to support and maintain the underground water, by means of rainwater that falls on the road surface such as roads, pedestrian and bicycle paths flowed into the shoulder of the road by means of elevation of the road surface made higher than in the shoulder. Green open spaces and water bodies in the patch have the ecosystem services that increase the infiltration capacity so as to maintain the water level underground. Of the three studies found new towns drainage in the two cities using vegetative methods or natural methods, which allow rain water infiltration, can occur. In principle, the water flow in the drainage vegetative slow drain allows rainwater can get into the soil so that it can help the conservation of underground water. “Vegetative methods of slowing the flow of water, so that the infiltration capacity enlarges, it can be proved by Manning equation (Arsyad, 2010).”

Meteorological and geophysical measurement results climatological station, Dramaga and Pondok Betung, there is a difference in the amount of precipitation in Sentul, Serpong and Cikarang Baru Region (Table 1).

Table 1.Land Development of the New towns

Object	Sentul	Serpong	Cikarang Baru
	General Condition (Development of the Cities)		
Development Year	1995	1989	1984
Function	Tourist destinations	City of Services and trade	Industrial Cities
Large	3000 ha	6000 ha	5600 ha
Altitude from above sea level	175-810 m	22-45 m	10-25 m
Geohydrology	Scarce underground water Low permeability	Underground water there Permeability good	Underground water there good permeability
Rainfall	During from 1992 to 2012, the	During the period from 1992 up to	During the period 1992 up to

	trend of increased 0,125 mm with the highest rainfall occurred in 2005, with an average rainfall of 466 mm/month during the year, and the lowest in 1997 with a rainfall of 89 mm	2012 the trend was increased 0.094 mm with the highest rainfall occurred in the 1992 annual average of 298 mm/month the year and the lowest occurred in 2011, with a rainfall of 93 mm.	2012 the trend increased by 0.067 mm, with the highest rainfall in 2010 with an average rainfall of 224 mm/month the year and the lowest occurred in 2003, with a rainfall of 92 mm.

Sources: processed authors

Optimizing the development of land, causing widespread impervious land surface, while the green open space narrowing, leading to reduced infiltration capacity, and increase the volume of runoff (Table 4). Changes in regional, agricultural and rural areas will affect the ecosystem in the area being developed, "Changes in land cover affect biotic diversity, soil quality, runoff (Alberti, 2005)."

Table 2. Land Cover in New towns Region

	Sentul			Serpong			Cikarang Baru		
Years	Open green space (ha)	Built area (ha)	Water body (ha)	Green open space (ha)	Built area (ha)	Water body (ha)	Green open space (ha)	Built area (ha)	Water body (ha)
1998	5440.8	169	36.20	5663	197.00	191	6798.69	1473.48	23.94
2000	5416	212	32.60	6113	629.00	209	6487.29	1787.94	23.94
2005	5154.45	479.34	32.21	5430	5430.00	138	4659.21	3633.21	3.69
2009	4947.2	687.3	25.50	1858	1858.00	132.64	3585.00	4707.00	3.89
2012	4752.74	888	20.26	2668	2668.00	123	2896.00	5395.05	3.69

Sources: Satellite image, 1998, 2000, 2005, and 2012 data.

The third development of new urban areas built from 1998 until this research is still ongoing, so the impervious surface area will be wider than the green open spaces and water bodies. This condition may increase the volume of runoff when it rains arrive. The low building coverage ratio will increase the capacity of infiltration that allow surface runoff will be reduced, with the expected rain water infiltration of underground water level can be maintained. According to Rao, (1997), the need for open space, particularly green open spaces in urban areas are ecologically very important.

Table 3. Ecosystem of New towns

Object of study and Location	Sentul	Serpong	Cikarang Baru
Patch			
Water bodies	Lakes/*ponds*,	Ponds,	Ponds
City Park/forest	Location at Slope> 25%, main road, and public park	Location at public park	Location at public park in housing cluster plan
Housing garden	There is in each cluster	There is in each cluster	There is in each cluster
Corridor			
Water bodies	Flow two rivers: Cikeas, and Citeurep.	Four river flow: Cisadane, Angke, Ciater, and Jalentreng	Flow two rivers: Cilemah Abang, and Kanal Tarum Barat
Green open space Corridor	Along secondary arterial roads, secondary collector, local roads, and in the cluster of houses.	Along the secondary road artery, the secondary collector, local roads, in residential clusters, and along the extra high voltage land lines	Along the secondary road artery, the secondary collector, local roads, in residential clusters, and along the extra high voltage land lines

Sources: processed authors

"Open space is a provider of underground water systems and integrated water resources. The open space in the form of environmental corridors and large garden has an active role in the urban areas to improve air and water quality. The ecosystem approach to the development of new towns, in an effort to achieve a sustainable city, "emphasizing land use and management conservation of biotic components in the system, such as population, community, emphasis on biodiversity (Carmel and Naveh, 2002)." Raw material availability of clean water and a comfortable air is a major factor in the city, so that the land has a slope of > 25%, with the shape of the hill or valley is not developed, preserved with vegetation so it can control erosion, lowering the air temperature, and increase the capacity of infiltration. Calculation of potential surface water runoff in the new towns writer using SCS method, given the land use diversity in new towns:

"Methods of the Soil Conservation Service (SCS) surface flow (Q) depend on the amount of rainfall (P) and the volume of savings available to hold water (S). Actual Detention (F) is the difference between rainfall and runoff. Furthermore, a rain water volume at the beginning of the rainy called initial abstraction (Ia) does not occur runoff. This SCS method of calculating the surface flow uses an index called Runoff Curve Number (CN). Numbers starting joint influences of land condition, hydrology, and water content beforehand. Determination of the amount of this CN uses a CN table, which is a matrix of land use / treatment / hydrology with soil hydrology group. (Attachment 4). Calculation of potential surface water runoff in the new town writer using SCS, given the diversity of land covers new town. (Arsyad, 2010).

Table. 4. Runoff Potential in 3 New towns Region

Year	Sentul			Serpong			Cikarang Baru		
	Run off	Rainfall/ month	Built Area (ha)	Run off	Rainfall/ month	Built Area (ha)	Run off	Rainfall/ month	Built Area (ha)
1998	14,699,200	333	169	10,564,000.	220	197	12,692,880.	201	1,478.43
2000	8,406,580	216	212.73	7,992,500.	177	629	7,798,240.	137	1,787.94
2005	22,398,740	465	479.34	11,328,500.	225	1,382	7,300,480.	124	3,633.21
2009	9,986,340	239	668.8	6,394,000.	143	1,757	9,789,200.	153	4,707
2012	8,011,640	203	907.49	9,452,000	187	2,668	7,051,600	113	5,395.95

Sources: Authors Analysis

Based on Table 4 can be seen, that rainfall has a major influence on water runoff, as well as land cover, the wider built environment, the greater the runoff. To control the runoff to benefit the conservation of underground water, the presence of green open space and lakes is needed. Needs open space, especially in urban green open space is very important ecologically. "Open space is a provider of underground water systems and integrated water resources, open spaces such as corridors and large park environment in urban constellation active role improving air and water quality (Rao, 1997)." Urban forest, as a green open space has its benefits, among others: 1) be able to withstand the rate of erosion, especially in areas with a slope of> 25%, 2) provide additional water capacities 3) enhancing infiltration (Asdak, 1995). In addition to the green open space at a store of groundwater, lakes and ponds have the same functionality as the storage of rain water for the needs of the city and as a place of recreation. Likewise, lake or pond as an ecosystem, which is located in the city have service rules, which accommodate runoff so as to reduce the potential for flooding, in addition to regulation of services, the lake also has a service culture, recreation and education.

4. Conclusion

The volume of runoff is affected by the extent of land surface impervious and green open space narrowing. The use of underground water as raw material for clean water may have an impact on the underground water table decrease with a long time will cause land subsidence. Underground water conservation can be done with some effort, such as: In cluster housing an underground water conservation by utilizing (1) Neighborhood Park, (2) natural drainage. The volume of runoff is affected by the extent of land surface impervious and green open space narrowing. The use of underground water as raw material for clean water may have an impact on the underground water table decrease with a long time will cause land subsidence. On a scale of cities, the conservation of underground water utilizing (1) a green open space in the corridor road shoulder like vehicles, cyclists, and pedestrians (2) river corridors, utilizing the border line of the river (3) along the corridor land tract extra high voltage, (4) patch, such as lakes/ ponds, and City park/forest.

Acknowledgment

A special thanks for The Meteorology & Geophysics Agency (BMKG) which has assisted in providing the data on rainfall, National Aeronautics and Space Agency (LAPAN) which has provided the satellite imagery data, to help to obtain the data of imagery satellite, and also last but not least special appreciation to interviewees Mr. Ir. Pranawa, and Ir. Arie Ganie as a sources of information about new urban development in Indonesia.

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