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The Roles of Village Government for Rural Water Infrastructure Development

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Abstract: ***Raw water supplyin the rural area still relies on the natural resources (classical), i.e.groundwater, springs, and local water supply company (LWSC) with distribution service10%, consequently, the village community experience vulnerability of water supplyin dry season.Therefore, it is neededto provide a sustainable water supply through concern for new water paradigm with water sensitive city (WSC) approach. This research aimsto design adynamics model of village roles in the development of raw water supply infrastructure with a concern for new water paradigm. The analysisusesdynamics system with Powersim version 2.5a. The simulation results reveal: (a) with business as usual scenario the raw water supply of Bendungan village is only sufficient for 10 years in the future, i.e. in 2025. The condition is very vulnerable, because the raw water supply is less than the water demand, (b) with concern for water scenario through infrastructure: retention basin, domestic wastewater treatment (DWT), and industry wastewater treatment (IWT), raw water supply increase 72% tthat is from 10 to 55 years in 2070, and (c) with capacity building scenario of community members and village government officials, especially on their understanding of raw water supply through training, extension, and assistanceto build and manage the water infrastructure, raw water supply will increase again to 11%, that is from 55 - 62 years i.e. in 2077.***

Keywords: infrastructure, concern of water, raw water

1. Introduction

Up to now, the villageis still marginalized and less empowered, because it's governmentviews with narrow perspective due to the low quality of human resources. Their roles are only limited to administrative services, such as the administration of Identity Card (KTP), the payment of Land and Building Tax (PBB), marriage certificate, and others. Theirpotency is less empowered, even though, base on Law (UU No. 6/ 2014) [1]. The villagecommunity roles could bestrengthened, because the village community is a unit of legal community, which is authorized to regulate and manage the governmental activities and the interests of local communities, based on community initiatives, rights of origin, and / or traditional rights recognized and respected in Indonesian Governmental system (NKRI).

As a result of the past policy, it has an impact on the slowing of development in various sectors; one of them is the clean water sector. The clean water supply in rural areas still relies on natural resource availability such as river, wells, dam/retention basin and others. Consequently, access to clean water is still low at 44.8%, and that has been served with new pipelineonly reached 8.60 % [2] in [3], impact of the rural communities is relatively vulnerable to the water availability both in terms of potency and access, becousnatural variations in water supply determine the raw water demand of rural communities [4], The phenomenon was reinforced by the MDGs report which stated that the proportion of households with sustainable access to adequate drinking water sources in rural areas is 44.96% whereas the target is 65.81% [5].

In addition, the problem of infrastructure development in raw water supply such as water reservoirs, retention basins, and infiltration wells has not been well implemented, with the classic reason of limited funding.Therefore it is needed to develop rural water infrastructure through human resources capacity improvement in the form of socialization consisting of: training, extension, and assistance.

The problem of raw water supply in rural areas is also experienced by the Bendungan Village in CiawiSub-District, Bogor District, Indonesia, where, based on the water balance analysis, Bendungan village would experience a water crisis (vulnerable to water availability), i.e. vulnerability for 6 months in one year. Various efforts have been conducted by the government, both central and local governments, NGOs, as well as communities themselves, individually and communally. However, they are still using conventional or classical methods, among others, by building project-oriented clean water facilities and infrastructures. The activity has not involved the village government officialsand local community members, so the result is less optimum. For that reason, dynamics model research is needed to increase the village community roles in raw water supply through integrated infrastructure development withconcern for new water paradigm using water sensitive city approach.

The conceptual thinking of concern for new waterwith water sensitive city approach where the village as a catchment area (water catchment) which all water is collected, both rainwater and wastewater, from domestic and non-domestic sources [6]. To obtain Water Sensitive

City with water infrastructure development scheme, there are some efforts as follows:

1. Raw water supply from rural areas: groundwater, spring, and Water Supply Local Company (WSLC)
2. Reduce grey water, i.e. the remnants of domestic and non-domestic wastewater
3. Water bodies (river, retention basin)
4. Natural drainage channels
5. Recycle of industrial waste

Of the five schemes, concern for new water paradigm facilitates the water supply not only raw water and drainage but also waste water treatment. The Water Sensitive City (WSC) approach has a paradigm whichtreats five schemes not only served as water supply, water bodies and drainage but also facilitates the provision of additional recycle and 3 R (reuse, reduce and recharge) that are integrated with similar mitigation.

Based on the WSC approach, the rural area is called concern for new water paradigm which is the application of WSC in the village.The achievement of this concern for new waterparadigm at the village level through the infrastructure development for raw water supply can meetlong-term needs. Therefore, the active roles of village government officials and local community members are needed to encourage the community not only be anobject, but also a subject. Diagrammatically, the sustainablewater supply ofconcern for new water paradigm at the village level using water sensitive city approach is describedin Figure 1.

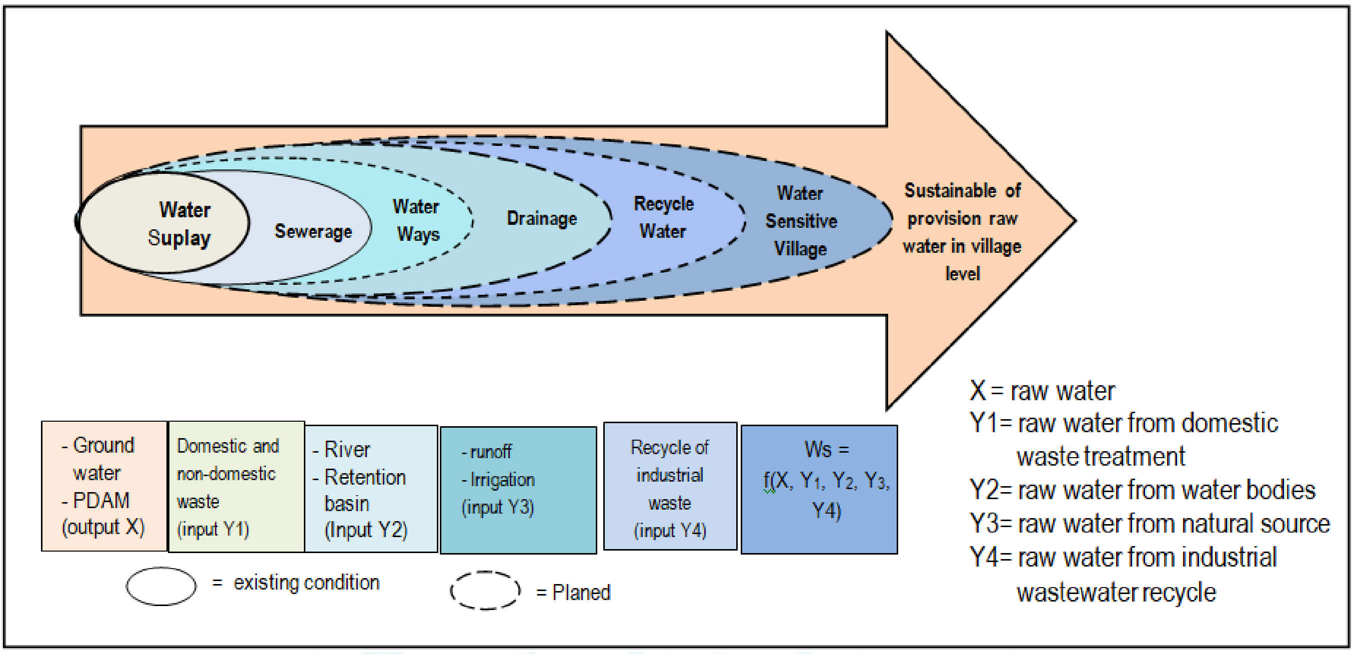


Figure 1: The concern for water supply at the village level through sustainable with Water Sensitive City (WSC) approach, modified [7]

This paper aims to design a dynamics model of village community roles in the development of rural water infrastructure with cocern for new water paradigm using water sensitive city approach.

2. Materials and Methods

a. Materials

Location selection was based on the vulnerability analysis of water resources using water balance approach from each sub-watershed of Ciliwung Hulu Watershed. Ciseuseupan Sub-Watershed was the most vulnerable sub-watershed from six sub-watersheds (Ciesek, Ciliwung Hulu, Ciasrua, Cibogo, Cisakabirus, and Ciseuseupan) in Ciliwung Hulu Watershed. From eight villages in CiseuseupanSub-Watershed, Bendungan Village is the most vulnerable area of water resources which need to be handled. The research location is illustrated in Figure 2.

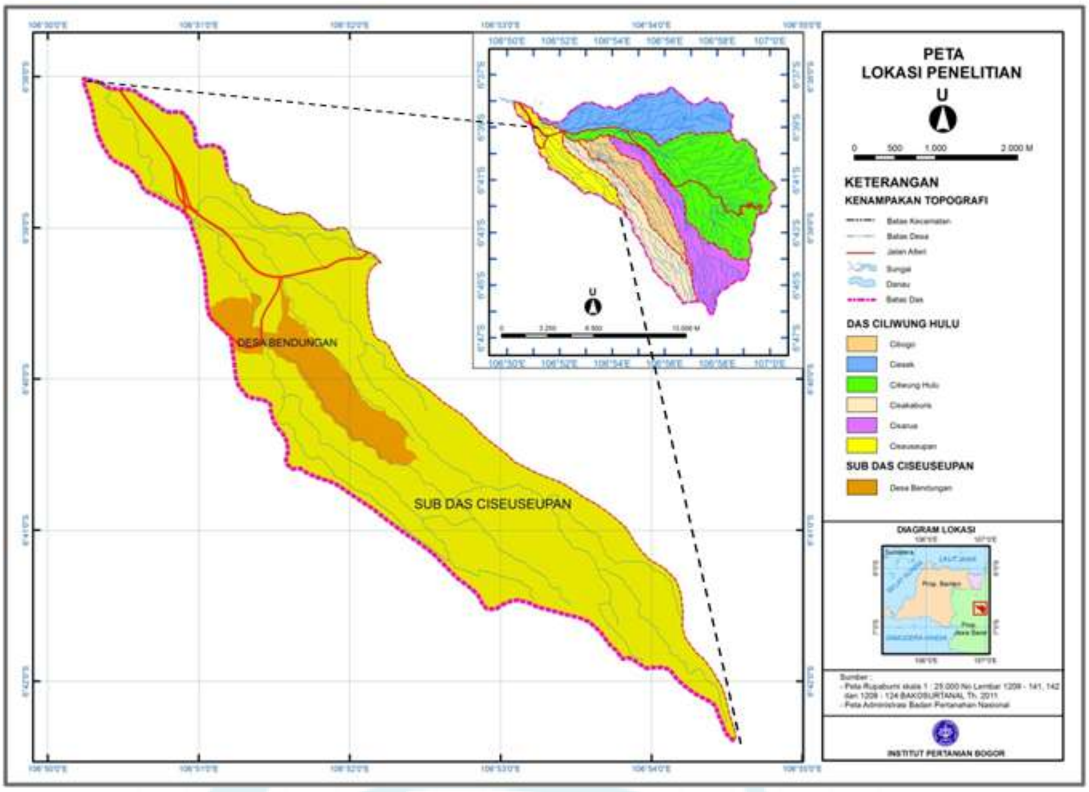


Figure 2: Bendungan Village Area, Ciawi Sub-District, CiseuseupanSub-Watershed

Research materials include secondary and primary data. Secondary data were obtained from Statistical Bureau of Ciawi Sub-District 2010 – 2015 [8], Spatial Planning of Bogor District 2016-2036 [9], rainfall records from Gadog Station during ten years (2005-2014), earth map of Ciliwung Hulu Watershed with scale 1:25.000, and other references related to water supply. Primary data were based on field observations and in-depth interviews with some experts from Public Works Agency of West Java Province, Ciawi Sub-District Office, local leaders of Bendungan Village, and lecturers of Bogor Agricultural University as expert resource or informant to validate data. The analysis uses a dynamics system approach with Powersimversion 2.5c.

b. Methods

This research follows a concern for new water paradigm to overcome the drought in the future. Furthermore, it is important to develop some infrastructures which ensure the water availability and to involve the village community roles. The research framework was described in Figure 3.

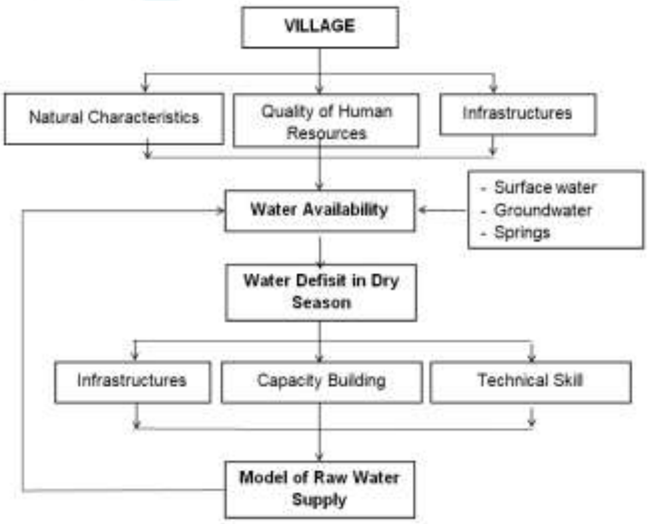


Figure 3: Framework of the capacity building of village community roles in rural water infrastructure development through concern for new water paradigm

3. Dynamics System Approach

Problem-solving using dynamics system has five steps [10] in [11], as follow:

a. Need analysis; this analysis starts with a stakeholder analysis. Generally, participant stakeholders include village government officials, community leaders, Bogor District Government, Public Works Agency of Bogor District, Ministry of Village andiagram) Development of Disadvantaged Regions, and non-governmental organizations (NGO).

b. System identification; described in an input-outputdiagram (black box diagram) which consists ofcontrolled input, uncontrolled input, desired output, and undesiredoutput. Through the mechanism of village community roles in infrastructure development with WSC scheme, an undesired output is changed into a controlled input.
c. Model compilation; consists of 2 forms, i.e. causal loop and model structure compilations. A causal loop compilation involves main factors of three sub-systems, i.e. Water supply system, water demand system, and infrastructure system (see Figure 4).

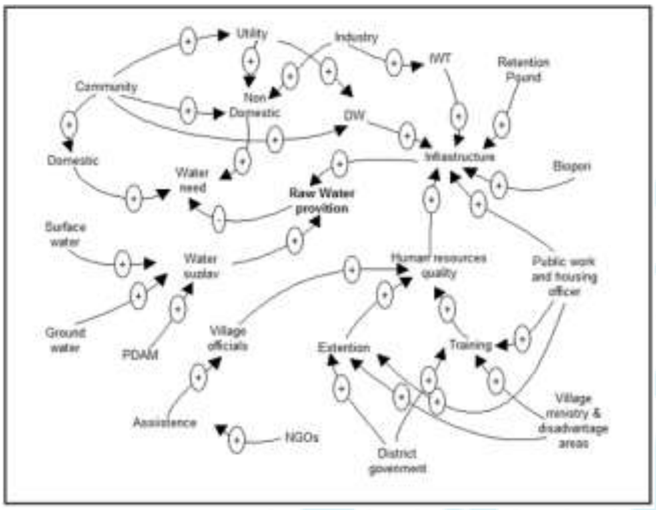


Figure 4: Causatic diagram illustrating causal loop from all factors in related to the village community roles of raw water supply

d. Model validation, to ensure the model performance in line with the current condition, start from infrastructure, water supply, to raw water needs. Performance test is to validate a model using empirical data through a statistical test with deviation standard of ten percent. Used data is a variable of main components [12]in [13]. The validation method uses Absolute Mean Error (AME) with an equation:

AME = (Si – Ai) / Ai x 100%
Si = Si / N andAi = Ai / N

Where:
S = Simulation value
A = Actual value
N = Time interval of observations

e. Simulation and Scenario

There are three scenarios in this research including:

1. Business as Usual scenario is natural scenario without interventions from governmental and corporate institutions, wher rural suplay water only come from ground water, surface water, and water suplay local corporate (WSLC=PDAM)
2. Concern for new water scenario is using Water Sensitive City approach through the development of rural raw water infrastructures, such as retention basin, DWT, andIWT. Concern of new water paradigm using water sensitive city approach has five schemes within two categories, i.e. (1) category 1 is the main source of raw water as output (X) including groundwater, springs, and Water Supply Local Company (WSLC), and (2) category 2 is supplementary source (suppletion) as input of raw water consisted of: water bodies such as river and dam (Y_1), drainage (Y_2), domesticwastewater treatment (DWT) (Y_3), andindustrial wastewater treatment (IWT) (Y_4). The equation of Water sensitive city (WSC) with five schemes is:

WSCfunction through concern of new waterparadigm

= f (X, Y_1, Y_2, Y_3, Y_4)

Where:
X = water supply
Y_1= water bodies
Y_2= natural drainage
Y_3= DWT
Y_4 = IWT

To implement the new paradigm, it is needed to build some rural water infrastructure, including:

a) Retention basin; is a reservoir for rainwater harvesting. Rainwater that falls on the ground surface is collected first before entering the drainage channel. The goal is to prevent the rainwater being quickly discharged into the drainage channel, but retained by retention basin. The retention basin is not only for water storage, but also for flood controller. Implementation of the retention basin is: each citizen association (RW) has oneretention basin with volume 400 m^3, with 20 m in length, 10 m in width, and 2 m in depth (Y_2).
b) Domestic wastewater treatment (DWT) ; i.e. the wastewater from domestic and non-domestic sources is collected communally. The assumption is that each person will produce wastewater 70% of raw water demand, while for non-domestic wastewater, it is 10% of raw water demand [14] (Y_3), assuming every neighborhood association (RT) built one DWT, with dimentions: 3 m in length, 3 m in width, and 1.5 m in depth.
c) Industry wastewater treatment (IWT) ; i.e. wastewater of industrial activities which is 10% of the industrial raw water demand [14] (Y_4) is recycled, where every industry built onesmallIWT or some similar industries make communal IWT.

3. Village community rolesare through capacity building of village community including the community training, extension, and assistance.

For playing an active roles in the village development, especially related to raw water supply, the village community should get a capacity building through socialization in the form of: training, extension and assistance conducted by cross-sectoral institutions, including Public Works Agency of Bogor District, Ministry of Village and Disadvantaged Area with village funds, Bogor District Government, and NGOs to jointly build and manage infrastructures (infrastructure approach) in the form of retention basin, DWT, and IWT. The number of type for the socialization of infrastructure development in raw water supply were presented in Table 1.

Table 1: The number of type socialization of infrastructure development in raw water supply

No.	Institution	Type of Socialization (per year)		
		Training	Extension	Assistance
1.	Bogor District Government	10	10	
2.	Public Works Agency of Bogor District	6	6	
3.	Ministry of Village and Disadvantaged Area	5	5	
4.	NGO			10

Source: Analysis results, 2016

4. Result and Discussion

a. Existing Raw Water Supply

According to watershed area, Bendungan Village is one of Ciseuseupan sub-watershed with area 1.33 km^2. This village has 11 citizen assosiatin (RW), and 48 neigborhood association (RT), inhabited by 10, 198 residents which consist of 5, 112 men and 5, 086 women in 2015. Consequently, the population density is very high, i.e. 7,668 persons / km^2, with population growth rate 0.8%. The main livelihood sources are in trade and service sectors (60%) [8].

Conceptually, the raw water supply of Bendungan Village came from the natural and man-made sources which could be classified as follow:

(1) Rural water supply consists of groundwater and water supply company sources. The groundwater extracted through 784 dug wells, 157 pump wells, and water tank from five springs of river bank [8]. Meanwhile, the water source from water supply local company is branch office of PDAM Tirta Kahuripanin Ciawi, however, their service distribution is still low, i.e. only 10% (as water output = X),

(2) Surface water came from tributary of Ciseuseupan River with perennial stream (as raw water input= Y_1),

From two raw water sources, the total supply for Bendungan Village is 5.3 x 10^5 m^3/year. When land conversion occurred, the water volume will decrease because the rainwater will stream down directly to drainage channel (gullay, river, etc). The water infiltration into the ground was estimated only 20%.consequently, water supply from surface and groundwater will also decrease.

Raw water demand for Bendungan Village was calculated a large number of 4.7 x 10^5 m^3/year, consists of:

a. Domestic water needs in 2015 for 10, 198 residents are 4.5 x 10^5 m^3/year, (clean water need is120 liters/person/day because Bendungan Village is a sub-urban area [15],
b. Non-domestic water needs include public facility with assumption 10 % of households [16]in [17], i.e. 2.2 x 10^4 m^3/year,
c. Industrial water needs are 1.8 x 10^4 m^3/year for 99 small and home industries (water standard for small industry = 180 m^3/unit/year) [15]

b. Result preparation Model and Validation Preparation Model

Based on data of raw water supply and demand in Bendungan Village, a simulation was conducted. The first step was developing a caustic diagram with the main factors of three sub-systems, i.e. supply system, water demand system, and infrastructure system.

Based on the model being compiled, then arranged the model structure. The model structure consists of three raw water sources, i.e. (1) busniss as usual condition, where raw water supply is only from surface water, groundwater, and PDAM, (2) concern for water condition where the raw water supply is through the development of rural raw water infrastructures, such as retention basin, DWT, and IWT, and (3) raw water supply involves village community rolesthrough capacity building of village community including the community training, extension, and assistance. A dynamics model structure using water sensitive city was described in Figure 5.

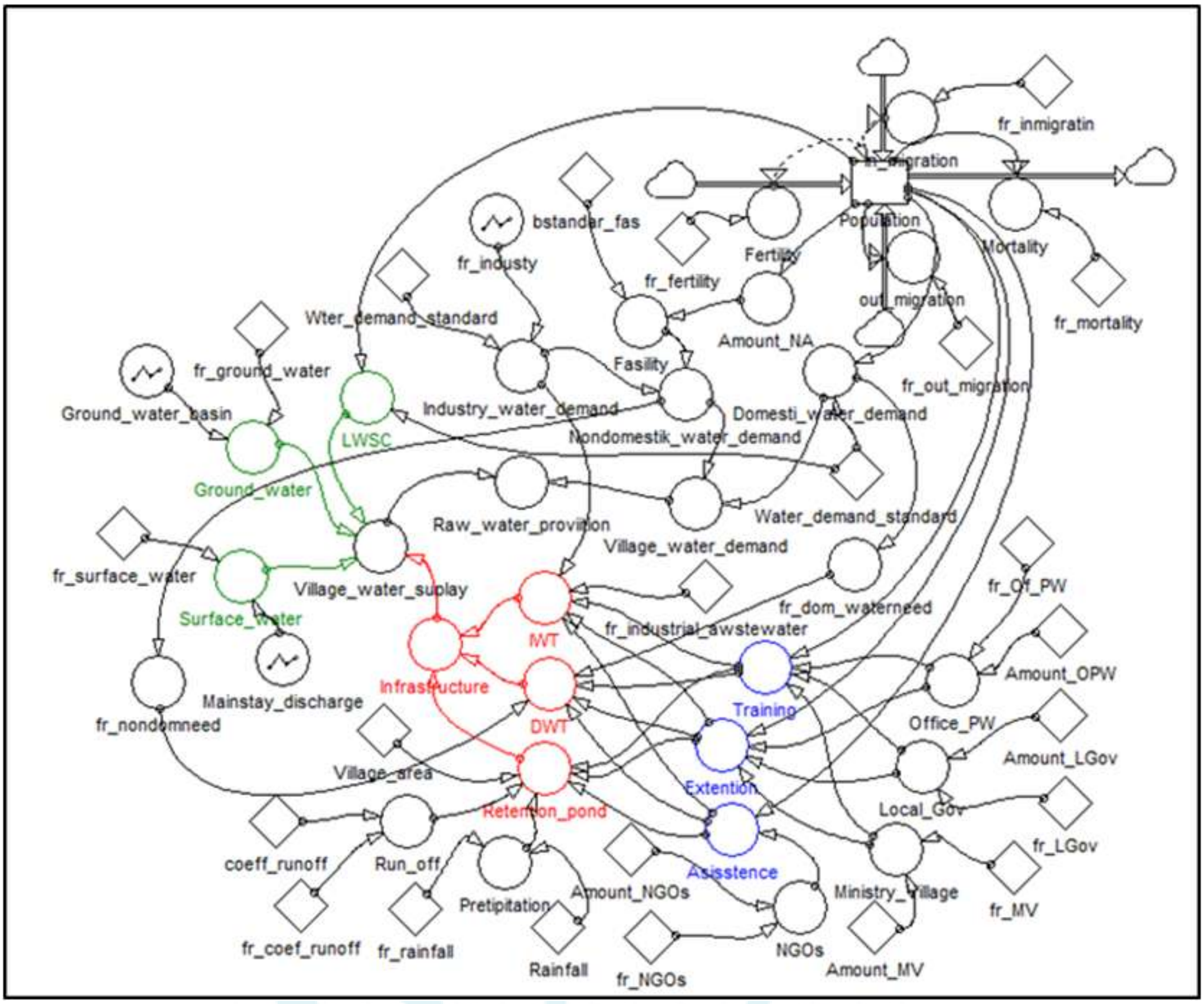


Figure 5: Dynamics model structure of village community roles in concern of new water paradigm through infrastructure development

Validation

For ensuring the model performance in line with the current condition, validation test was conducted using statistical test with maximum deviation standard 10 percent. Using Absolute Mean Error (AME) method, the results were described in Table 2, where the AME value is lower than 10%, i.e. 0.9 – 2%. Based on the value, model structures have a good performance and can be acceptedscientifically.

Table 2: Calculation of AME value in validation test of model performance

No.	Year	The Population of Bendungan Village		AME
		Actual	Simulation	
1.	2013	10, 152	10, 244	0.0091
2.	2014	10, 172	10, 323	0.0148
3.	2015	10, 198	10, 402	0.0200

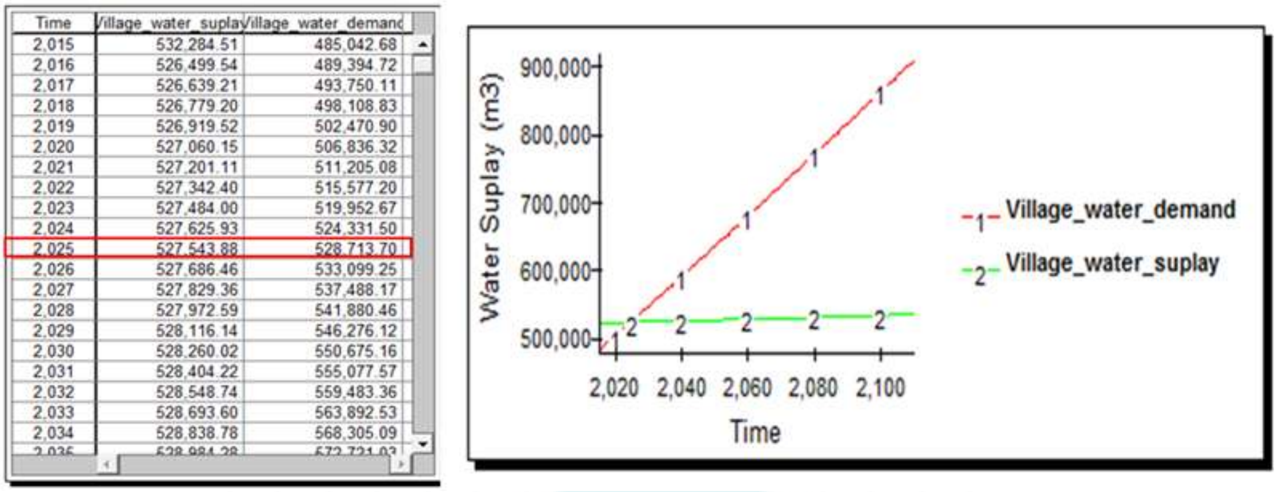
Source: Calculation Results, 2016

5. Simulation Results

1. Business as Usual

The simulation results with the dynamic system under current conditions indicate that: if the condition of raw water supply is allowed continuously without any treatment and intervention from the government or private parties, then within the next 10 years ie in 2025, the availability of raw water in Bendungan village is very vulnerable, because the water supply will be exhausted or the raw water supply is less than the water requirement. This is due to the increasing number of population following the measuring series with the growth rate of 0.8% per year which automatically the need for raw water will also increase, coupled with the lifestyle of people who trend to consumptive, while the raw water supply even more decreased, due to the transfer land function in the form of a fairly massive decline of green land cover with a rate of 1.95% per year and an increase in land use for settlements at a rate of 12.34% per year [18].. Base on the phenomenon, the surface water suplement decrease every year equal to 0.1%. Besides that, due to climate change which recently hit almost the territory of Indonesia.

Calculation results from Bussness as usualof raw water supply in Bendungan Village were described in Figure 6.

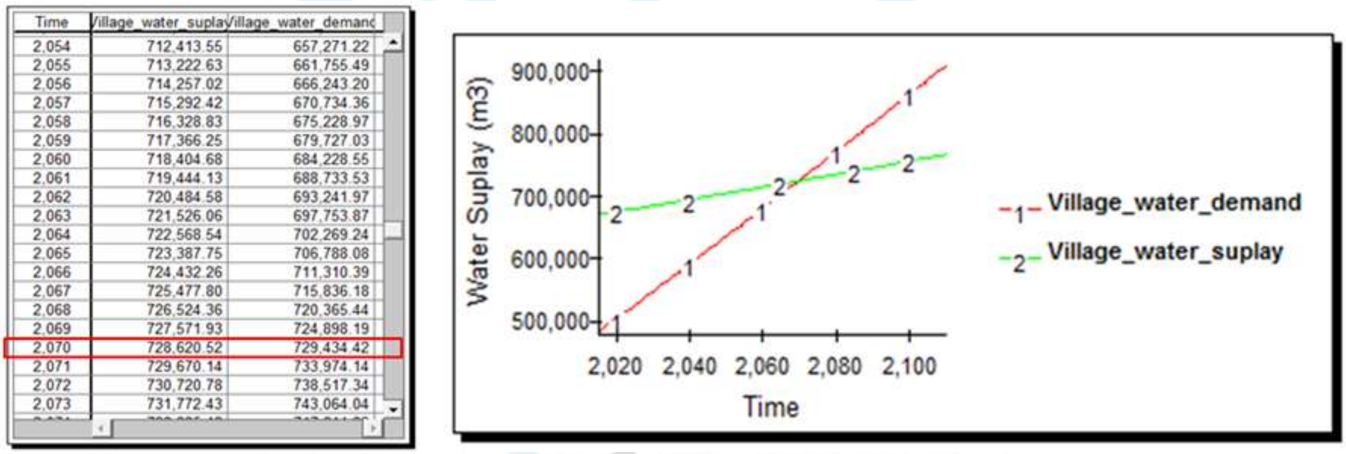


Time	Village_water_suplay	Village_water_demand
2,015	532,284.51	485,042.68
2,016	526,499.54	489,394.72
2,017	526,639.21	493,750.11
2,018	526,779.20	498,108.83
2,019	526,919.52	502,470.90
2,020	527,060.15	506,836.32
2,021	527,201.11	511,205.08
2,022	527,342.40	515,577.20
2,023	527,484.00	519,952.67
2,024	527,625.93	524,331.50
2,025	527,543.88	528,713.70
2,026	527,686.46	533,099.25
2,027	527,829.36	537,488.17
2,028	527,972.59	541,880.46
2,029	528,116.14	546,276.12
2,030	528,260.02	550,675.16
2,031	528,404.22	555,077.57
2,032	528,548.74	559,483.36
2,033	528,693.60	563,892.53
2,034	528,838.78	568,305.09

Figure 6: Simulation result of raw water supply in Bendungan Village with Busniss as usual

2. Concern of Water

Based on the concept of water sensitive city, the raw water supply in Bendungan Village is: function (f) from: water supplyof Bendungan Village (X) + water bodies (Y_1) + retention basin (Y_2) + Domestic wastewater treatment (DWT) (Y_3) + Industry wastewater treatment (IWT) (Y_4), then simulated with water demand using dynamics system. The simulation results revealed that: raw water supply would increase significantly, since it increased 72% that is from 10 years to 55 years, i.e. in 2070, where the availability and demand of raw water reached 7.3 x 10^5 m^3. The simulation results were presented in Figure 7.



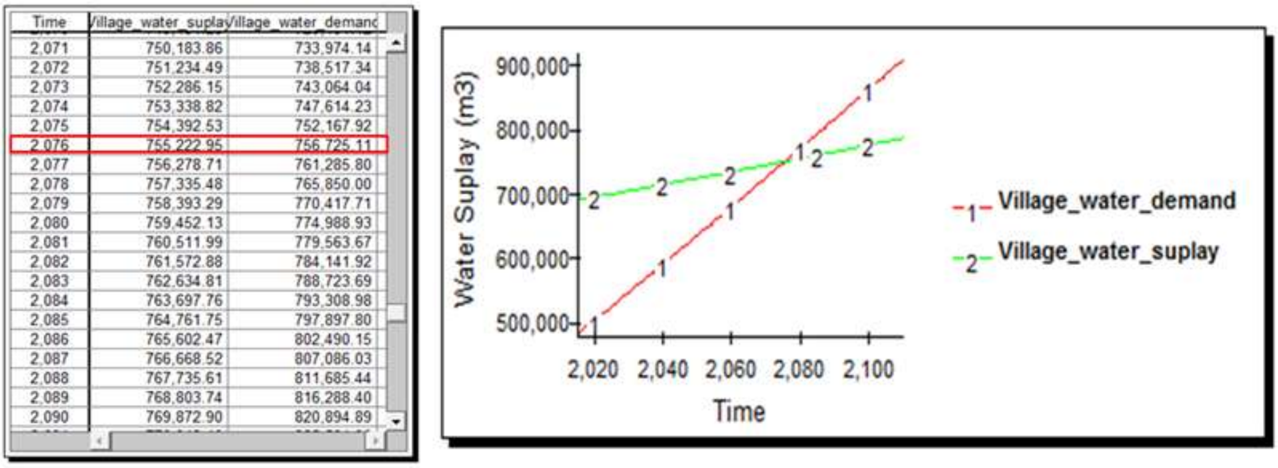
Time	Village_water_suplay	Village_water_demand
2,054	712,413.55	657,271.22
2,055	713,222.63	661,755.49
2,056	714,257.02	666,243.20
2,057	715,292.42	670,734.36
2,058	716,328.83	675,228.97
2,059	717,366.25	679,727.03
2,060	718,404.68	684,228.55
2,061	719,444.13	688,733.53
2,062	720,484.58	693,241.97
2,063	721,526.06	697,753.87
2,064	722,568.54	702,269.24
2,065	723,387.75	706,788.08
2,066	724,432.26	711,310.39
2,067	725,477.80	715,836.18
2,068	726,524.36	720,365.44
2,069	727,571.93	724,898.19
2,070	728,620.52	729,434.42
2,071	729,670.14	733,974.14
2,072	730,720.78	738,517.34
2,073	731,772.43	743,064.04

Figure 7: Simulation result of raw water supply in Bendungan Village with concern of new water paradigm

3. Village Community Roles

During the past few decades, the community rolesin village development were still low, because the program planning is always top down.After the enactment of Law (UU No. 6/2014) on the Village [1], the community members and village government officials as well as other stakeholders should play an active role in the village development.

The result of simulation revealed that: with the increase of human resources capacity, either by village government officials or community members to the raw water supply through infrastructure development and management, there is a significant increase. The water availability and demand will increase 11% that is from 55 years to62 years in 2077, i.e, 7.6 x 10^5 m^3. The simulation results were presented in Figure 8.



Time	Village_water_suplay	Village_water_demand
2,071	750,183.86	733,974.14
2,072	751,234.49	738,517.34
2,073	752,286.15	743,064.04
2,074	753,338.82	747,614.23
2,075	754,392.53	752,167.92
2,076	755,222.95	756,725.11
2,077	756,278.71	761,285.80
2,078	757,335.48	765,850.00
2,079	758,393.29	770,417.71
2,080	759,452.13	774,988.93
2,081	760,511.99	779,563.67
2,082	761,572.88	784,141.92
2,083	762,634.81	788,723.69
2,084	763,697.76	793,308.98
2,085	764,761.75	797,897.80
2,086	765,602.47	802,490.15
2,087	766,668.52	807,086.03
2,088	767,735.61	811,685.44
2,089	768,803.74	816,288.40
2,090	769,872.90	820,894.89

Figure 8: Simulation result of raw water supply in Bendungan Village through the village community roles in infrastructure development

6. Discussion

Based on the simulation results with various scenarios, several strategies can be applied as follow:

a. Infrastructuredevelopment of rural water supply, which covers:

1. Build retention basin (embung) ; where its application one citizen assosiation (RW) is one retention basin with dimention: 20 m in length, 10 min width, and 2 metersin depth which could collect rainwater 400 m^3, so Bendungan village have 11 retention basin.
2. Build domestic wastewater treatment reservoir (DWT), at the household level and communal level for public facilities (DWT), by establishing 48 DWT or one DWT in each neighborhood association (RT), with dimention: 3 m in length, 3 m in width, and 1.5 m in depth. It could be able to collect 12 m^3 of domestic wastewater.
3. Industrial household wastewater treatment reservoir (IWT) could be rovided communally for similar industries, and individuals for diverse industries.

b. Capacity building program both village government officials and the community members which covers: training and assistance should be involved or could play active roles in the water infrastructure development and management starting from planning, implementation, and even monitoring, because the community is an object in the raw water supply [19]

c. Technical skill; is conducted through assistance by NGOs to the village government officials and the community, in the hope that the community will increase its concern for the raw water infrastructure so that its service life is longer, eventually the sustainable of provision raw water in the Bendungan village.

The obstacle of this scenario is aboutconstruction cost, because to build 11 retention basins (embung) and 48domestic wastewater treatment reservoirs (DWT) will require considerable funds.However, the construction project could be implemented gradually. Implementation for thid scenarios is:

1. Starts from establishing 2 DWT and 1 retention basin (embung) every year,
2. Establishinga retention basin for the first year, then establishing DWT for the next year.

The finance of construction project can comefrom the village funds through the Ministry of Villageand Disadvantaged Areas, and villagecommunity members, or can cooperate with other institutions using CSR funds. The village community should own a sense of belongings and take care of the infrastructure.

The development constraints of rural water infrastructurescouldbe overcome when all partiesinvolved, such as the Public Works Agency of Bogor District, the Sub-District Government through, related Ministries, and NGOs. The stakeholder involvement may include training, extension, and assistance (socialization). The expectationis after getting a socialization program, the understanding quality of the community members and village government officials to raw water supply will increase and they will be able to manage the rural water infrastructures.Eventually, the durabilityof infrastructure will increase and then raw water supply will also increase.

7. Conclusion and Recommendations

a. Conclusion

1. The model of raw water supply can be used to encourage the village community roles in the development of rural water infrastructure for raw water supply with a validity level of between 0.9 and 2.0%, through 3 sub-systems: water availability, water demand, and infrastructure,
2. The application of this model with various scenarios results as follows:

a) With the business as usual method, raw water supply in rural areas (Bendungan Village) can only be up to 10 years in the future, i.e. in 2025, meaning that the raw water supply is less than the water demand.
b) With the concern of new water paradigm through a water sensitive city approach that develops

infrastructure: retention basin, DWT, and IWT, raw water supply increases 71 % that is from 10 years to 55years in the future, i.e. in 2070.

c) Through the active roles of the community members and the village government officials that have been trained anddirected with extension conducted by the Bogor District Government, Public Works Agency ofBogor District, and the Ministry of Village and Disadvantaged Areas. While assistance is only done by NGOsto build and manage rural water infrastructure, raw water supply increase 11 % that is from 55 years to 62 years, i.e. in 2077.

b. Recommendations

The application of this model with various scenarios produces the optimum scenario because it can meet the raw water demand until 2094. To achieve this scheme, there are two efforts as follow:

1. Improving the village community capacity through training, extension, and assistanceconducted by: the Bogor District Government, Public Works Agency ofBogor District, and the Ministry of Village and Disadvantaged Areas, as well as NGOs.
2. The development of rural water infrastructure covers: retention basin, DWT, and IWT.

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