# ENVIRONMENTAL MANAGEMENT OF RECHARGE AREA CASE STUDY: EXISTING IMPACT OF ARTIFICIAL RECHARGE IN CIESEK SUB-WATERSHED, CILIWUNG WATERSHED, BOGOR REGENCY, WEST JAVA PROVINCE

Syampadzi Nurroh[1], Slamet Suprayogi[2], and R. Suharyadi[2]
[1]Environmental Science, Graduate School Universitas Gadjah Mada
[2]Faculty of Geography Universitas Gadjah Mada

The research have three purpose regarding to environmental management of recharge area. The first purpose in study environmental management of recharge area is that analyzed of impact artificial recharge of decreasing runoff in research area (one of priority watershed, Ciliwung watershed, Indonesia) and also water balance within modified method; the second purpose is that analyzed of social component regarding knowledge and willingness society in mitigation for protection environment of recharge area; and the third of purpose is that concept analyzed for strategic environmental recharge area. Environmental management of recharge area are treating in regarding abiotic component, this component is analyzed by quantitative description method of hydrology models; scoring method; and geography information system also remote sensing. Regarding to actual recharge artificial endorsement that used for quantitative description method of water balance and potential recharge artificial potential. In regarding biotic component, this component is analyzed by qualitative description method of observation and journal's reference. Regarding to social component, this component is analyzed by qualitative description method of society willingness Index.

Based on input result of the analyzed for environmental management that conclusion are quality of recharge area in study area, classified in good nature category is 4,34%; 43,36% in normal nature; 34,26% in starting damaged; 16,97% in less damaged; and 1,07% in strong damaged. Those number of percent are effected regarding to runoff coefficient 0,14 which precipitation through is to be surface runoff (14%) and exchange of stored water is 9% (400 mm/year). Actual capable of artificial recharge (ΔIRP ) is 9,1% or 50 mm (2013) and 12% or 78 mm (2014) regarding to total runoff volume and component of water balance through passed with impervious area (5,84%) spread to evapotranspiration (27%); runoff (14%); shallow infiltration (31%); and deep infiltration (28%). The main of concept analyzing of strategic environmental recharge area can approach by technical method and institutional method, regarding to approach technical with increasing artificial recharge units and regarding to approach institutional method within given fund incentive by government program or corporate social responsibility in private sector for protection recharge area, environmental management in land and water conservation in starting damaged till Strong damaged of quality recharge area, this strategic is established for economic and ecology balance sustainability.

Keywords: environmental management, recharge area, artificial recharge, water balance and Runoff

**INTRODUCTION**

Regarding to environmental management how to maintain relationship between interrelationship abiotic component, biotic component, and culture component, those matter have correlation with landscape by covering of ecosystem. Watershed ecosystem one of part of them which having purpose to keep, stroll, sink and streaming form precipitation by differences high level slope to down level and water bodies. That condition called recharge area.

Whereas area of research have issue strategic regarding for aiming the function of management and controlling at the space of protection area and conservation water and land which issued as watershed priority management in Indonesia. In the area research is included in B-4 (RTRW, Bogor District), that pattern of low paving area; wet/dry agriculture; plantation system, fisheries, animal husbandry, and agroindustry also forest product limited. Rachmawati (2013), the problem are decreasing area of forest as 1286 ha and have been increasing settlement area by 2300,179 ha during the last five year.

Those problem as basic for protection quality of recharge area and keep function of hydrology system in the area research, one of the solution problem of the management environmental with technical approach by *artificial recharge* in settlement area then how worth that is existing impact for them to increase infiltration rate ad decrease runoff. Value of the artificial recharge can be assessed it by hydrology model with quantitative description method approach. The goal of artificial recharge powerless is influenced by social component who is society in the area research. Also government and stakeholder with all intention for quality recharge area. How influence is that assessment, can be divine by methods qualitative description approach. Overall, the research can be identify of the problem in social, economic and culture in the area research.

## How To Research

This study of management environmental of recharge area environmental management of recharge area are treating in regarding abiotic component, this component is analyzed by quantitative description method of hydrology models; scoring method; and geography information system also remote sensing. Regarding to actual recharge artificial endorsement that used to quantitative description method of water balance and potential artificial recharge. In regarding biotic component, this component is analyzed by qualitative description method of observation and journal's reference. Regarding to social component, this component is analyzed by qualitative description method of Society Willingness Index. This data are given in **Table 1.** regarding to data and variable also method which is used in the research.

**Table 1.** Data and variable which is using in the research

| No | Data | Variable | Statement | Method |
|---|---|---|---|---|
| 1 | Quality of recharge area | Precipitation | Isohyet method | Weighting and Scoring method |
| | | Type soil | USDA classification | |
| | | Slope | Ci: 12,5 meter; Scale 1: 50.000 | |
| | | Landuse | scale 1: 50.000 | |
| 2 | Hydrology | | | |
| a | Evapotranspiration | Precipitation | mm/day | Penman Model |
| | | temperature | $^{o}C$ | |
| | | Speed wind | m/s | |
| | | Sun Radiation | $MJ/m^2/day$ | |
| b | Runoff | Precipitation | mm/day | SCS-CN Model |
| | | Landuse | scale 1: 50.000; Citra Geo-Eye | |
| | | Type soil | USDA classification | |
| | Runoff | Precipitation | mm/day | Units Hydrograp h |
| | | recharge maximum | $m^3$/second | |
| | | Time to peak | hour | |
| | | Time of base | hour | |
| | | Intention Precipitation | hour | |
| | | Intention maximum | Mm | |
| c | *Water balance* | Evapotranspiration | mm/day | Model Tanks |
| | | Stream recharge | Mm/day | |
| | | Precipitation | Mm/day | |
| 3 | *artificial recharge* | Permeability aquifer | m/second | Infiltration Model |
| | | Deep layer aquifer | m | |
| | | Potentiometric surface | - | |
| | | Ring of artificial recharge | m | |

Source: by conducted

## RESULTS AND DISCUSSION

### Analyzed of quality Recharge Area

This study of analyzed quality of recharge area, it have purposes for get a land unit as data input in environmental management strategy of recharge area. Spatial model condition quality of recharge area is analyzed by scoring / weighting at each of component parameter and given weighting for each of component parameter as degree of influence regarding to infiltration's process. Based on the results calculated by weightings per each parameter and scoring per each parameters (Suharyadi 2001). Based on the results by conducted of scoring**,** then overlay process in ArcGIS can be done with all parameters (landuse factor, slope factor, precipitation factor and type soil factor).

This data are given in **Table 2.** Regarding to classification of quality recharge area Based on the results by conducted from total value of score with scale number between classes.

**Table 2.** Classification of quality recharge area

| No | Interval Score | Condition | Statement |
|---|---|---|---|
| 1 | >56 | Condition good | class I |
| 2 | 47-56 | Condition normal nature | class II |
| 3 | 46-39 | Condition starting damaged | class III |
| 4 | 38-31 | Condition less damaged | class IV |
| 5 | <31 | Condition strong damaged | class V |

Source: by conducted

Based on the results by conducted is total value scoring Classification of quality recharge area as shown in **Table 3.** Regarding to condition existing quality of recharge area and as show in **Figure 1.**

**Table 3.** The analyzed of condition of the quality recharge area

| No | Condition *of quality recharge area* | Wide area (ha) | Percent (%) |
|---|---|---|---|
| 1 | Condition good | 130 | 5,20 |
| 2 | Condition normal nature | 1398 | 55,5 |
| 3 | Condition starting damaged | 515 | 20,4 |
| 4 | Condition less damaged | 382 | 15,2 |
| 5 | Condition strong damaged | 96 | 3,80 |
| Total | | 2522 | 100 |

Source: by conducted

Based on the results by conducted that quality of recharge area in study area, classified in good nature category is 5,20% (Class I); 55,50% in normal nature (Class II), 20,40% in starting damaged (Class III); 15,20% in less damaged (Class IV); and 3,80% in strong damaged (Class V). The existing condition will be impact and influence for environmental component (abiotic, abiotic, and culture).

### 3.2. Analyzed the existing impact of artificial recharge potential

Analyzed the existing impact of artificial recharge potential in the research area is used by approach with infiltration's model (Suripin 2010) following below:

**Q= 2r. KBH/ ln (B/r) ..........................................................(1)**

This data are given in **Table 4.** regarding to impact *artificial recharge* potential .

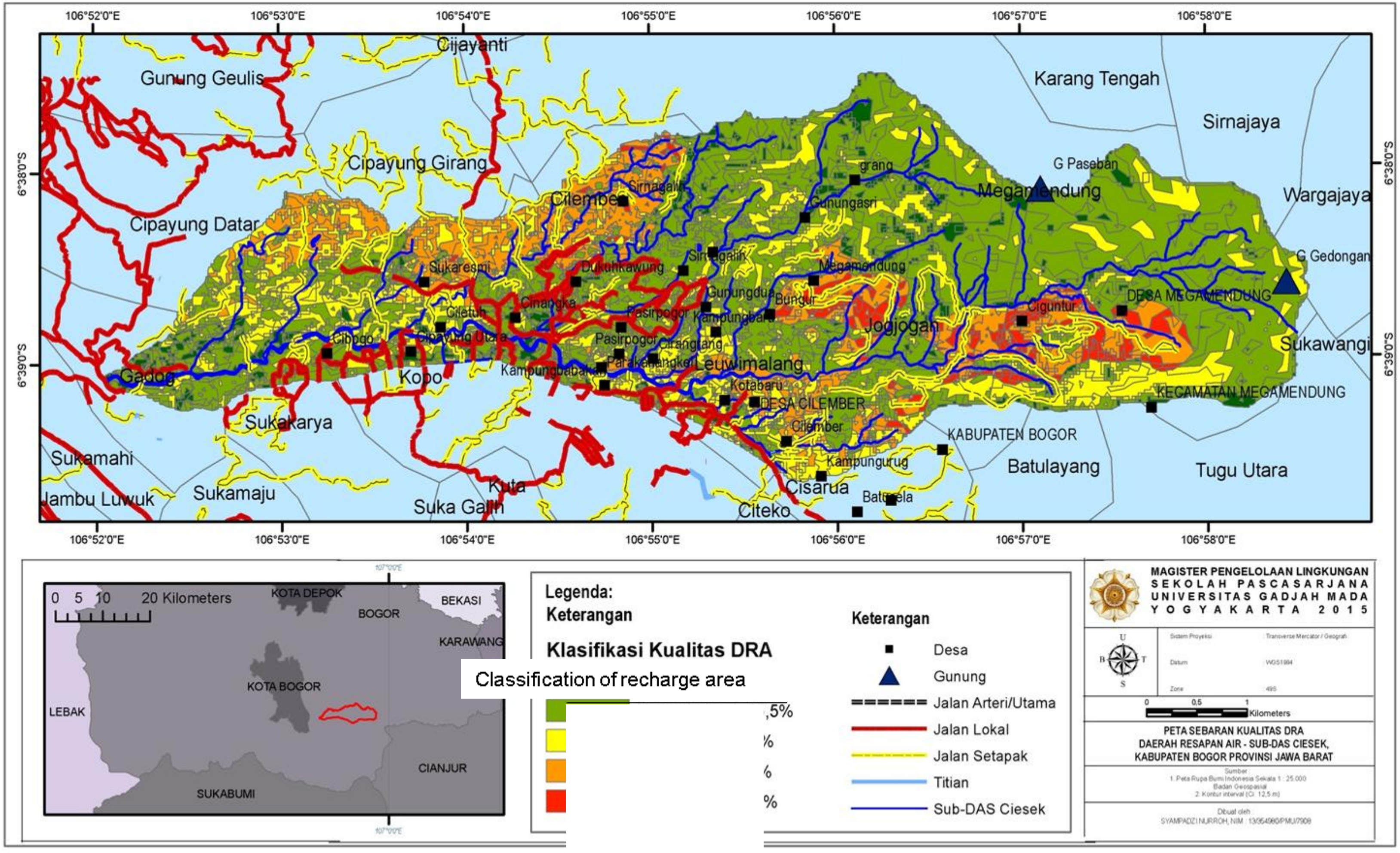
**Table 4**. The impact of artificial recharge potential

| No | Components | Units | Value |
|---|---|---|---|
| 1 | (Q) recharge= 2r. KBH/ ln (B/r) | $m^3/s$ | 0,00022 |
| 2 | (n) Total recharge artificial | units | 265 |
| 3 | (t) time | minute | 1500 |
| | Volume potential (V = n.Q.(T/86400).1000) | | 1,0227 mm/d |

| Month | The impact of artificial recharge (mm) | | | |
|---|---|---|---|---|
| | 2013 | Average | 2014 | Average |
| January | 14,32 | 0,651 | 14,32 | 0,651 |
| February | 6,14 | 0,279 | 4,09 | 0,227 |
| March | 8,18 | 0,372 | 11,25 | 0,511 |
| April | 11,25 | 0,511 | 8,18 | 0,390 |
| Mei | 10,23 | 0,465 | 8,18 | 0,372 |
| June | 6,14 | 0,279 | 8,18 | 0,390 |
| July | 7,16 | 0,325 | 5,11 | 0,232 |
| August | 1,02 | 0,046 | 6,14 | 0,279 |
| September | 3,07 | 0,139 | 1,02 | 0,049 |
| October | 9,20 | 0,418 | 5,11 | 0,232 |
| November | 6,14 | 0,279 | 11,25 | 0,536 |
| December | 16,36 | 0,651 | 8,18 | 0,372 |
| Total | 99,20 | | 91,02 | |

Source: by conducted

Based on the results of potential of the volume water recharge artificial by considering every one of rain and index infiltration (ϕ) where rain < 10 mm/hour there was no mainstream surface is to recharge artificial does not happen process infiltration into the ground.



Gunung Geulis
Cijayanti
Cipayung Girang
Cipayung Datar
Karang Tengah
Sirnajaya
Wargajaya
G Paseban
Megamendung
G Gedongan
DESA MEGAMENDUNG
Sukawangi
KECAMATAN MEGAMENDUNG
Tugu Utara
Batulayang
KABUPATEN BOGOR
Jogjogan
Ciguntur
Leuwimalang
DESA CILEMBER
Cilember
Cisarua
Citeko
Kampungurug
Sukakarya
Sukamahi
Jambu Luwuk
Sukamaju
Kuta
Suka Galih
Kopo
Gadog
Cibogo
Sukaresmi
Cinangka
Dukuhkawung
Kampungbabakan
Kotabaru
106°52'0"E
106°53'0"E
106°54'0"E
106°55'0"E
106°56'0"E
106°57'0"E
106°58'0"E
6°38'0"S
6°39'0"S
0 5 10 20 Kilometers
KOTA DEPOK
BOGOR
BEKASI
KARAWANG
KOTA BOGOR
LEBAK
CIANJUR
SUKABUMI
Legenda:
Keterangan
Klasifikasi Kualitas DRA
Classification of recharge area
Keterangan
Desa
Gunung
Jalan Arteri/Utama
Jalan Lokal
Jalan Setapak
Titian
Sub-DAS Ciesek
MAGISTER PENGELOLAAN LINGKUNGAN
SEKOLAH PASCASARJANA
UNIVERSITAS GADJAH MADA
YOGYAKARTA 2015
0 0,5 1 Kilometers
PETA SEBARAN KUALITAS DRA
DAERAH RESAPAN AIR - SUB-DAS CIESEK,
KABUPATEN BOGOR PROVINSI JAWA BARAT

## Analyzed the Influence Actual Performance Artificial Recharge

### a. Analyzed overland flow by SCS-Curve Number

The Analyzed of runoff at the end of 2013 and 2014 by using this method SCS-CN, where the Analyzed this method does not enter a performance factor recharge artificial in location or the following is performed 265 units in detail concerning the result **Table 5.** Component instantiation model SCS-CN in AMC II.

**Table 5.** Components SCS-Curve Number in each piece of landuse (AMC II)

| Landuse Covering | Type Soil | Group Soil | Wide Area (ha) | % | CN II | CNp - II |
|---|---|---|---|---|---|---|
| Forest | Dystropepts | B | 1017 | 40,32 | 55 | 22,17 |
| Agroforestry | Dystropepts | B | 537,09 | 21,29 | 66 | 14,05 |
| Agriculture land | Dystropepts | B | 470,07 | 18,64 | 71 | 13,23 |
| Settlement area | Dystropepts | B | 172,43 | 6,84 | 68 | 4,65 |
| Paddy field | Dystropepts | B | 219,99 | 8,72 | 70 | 6,10 |
| Abandons Land | Eutropepts | B | 93,43 | 3,70 | 69 | 2,56 |
| Water bodies | - | - | 12,46 | 0,49 | 100 | 0,49 |
| Total | | | 2522,47 | 100,00 | | 62,77 |

Source: by conducted

Determining index CN in potentially CN II or in a land humidity normal, so it is needed conversion value index CN. Following is presented in detail as shown in **Table 6.** conversion result the CN in every AMC potentially humidity land (AMC).

**Table 6.** Index Curve Number in each AMC I, II and III.

| No | Date | P (mm) | Sum AP-5 | AMC | S | Ia | condition | Qsurf |
|---|---|---|---|---|---|---|---|---|
| | | | Kategori AMC / Presipitasi (mm): I < 35; II 35-53; III > 53 | CN I = 4,2 x CN II / (10-0,058 x CN II); CN III = 23 x CN II / (10+0,13 x CN II) | CN; S= (25400/CN)-254 | P >= Ia ; S>= Ia + F ; dan F +P - Ia - Q | >= Ia | $Q_{surf}$ : $(P-0,2S)^2$ / (P+0,8) |
| 10 | 19/12/2014 | 0 | 197 | 3 | 79,50 ; 66 | 13,10 | 0 | 0,00 |
| 11 | 20/12/2014 | 75 | 176 | 3 | 79,50 ; 66 | 13,10 | 1 | 29,88 |
| 12 | 21/12/2014 | 16 | 164 | 3 | 79,50 ; 66 | 13,10 | 1 | 0,11 |
| 13 | 22/12/2014 | 91,5 | 160 | 3 | 79,50 ; 66 | 13,10 | 1 | 42,49 |
| 14 | 23/12/2014 | 52 | 190 | 3 | 79,50 ; 66 | 13,10 | 1 | 14,36 |
| 15 | 24/12/2014 | 27 | 81 | 3 | 79,50 ; 66 | 13,10 | 1 | 2,39 |
| 16 | 25/12/2014 | 34 | 100 | 3 | 79,50 ; 66 | 13,10 | 1 | 4,98 |
| 17 | 26/12/2014 | 7 | 98 | 3 | 79,50 ; 66 | 13,10 | 0 | 0,00 |
| 18 | 27/12/2014 | 110 | 97 | 3 | 79,50 ; 66 | 13,10 | 1 | 57,56 |

Source: by conducted

AMC (a land moisture) is influenced by the number of rainfall previously over 5 days with the number of < 35 mm (CN I) in a dry, 35-53 mm (CN II) in a normal condition, and > 53 mm (CN III) in wet conditions. Based on the results by conducted by runoff volume in 2013 and 2014 to 482.17 and 519.01 mm. This data is given in **Table 7.** Regarding for conducted volume stream of surface (overland flow with the SCS-CN method in location research.

**Table 7.** Total volume runoff in 2013 and 2014

| Month | Precipitation (mm) | | Volume *runoff* (mm) | | coefficient Runoff (c) | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| January | 788 | 513 | 195,51 | 54,60 | 0,048 | 0,013 |
| February | 788 | 305 | 14,78 | 38,40 | 0,004 | 0,009 |
| March | 338 | 531 | 82,18 | 57,44 | 0,020 | 0,013 |
| April | 405 | 450 | 27,35 | 75,55 | 0,007 | 0,017 |
| Mei | 344 | 614 | 60,24 | 195,41 | 0,015 | 0,045 |
| June | 494 | 200 | 1,03 | 3,88 | 0,000 | 0,001 |
| July | 123 | 348 | 35,60 | 21,23 | 0,009 | 0,005 |
| August | 275 | 250 | 0,02 | 2,35 | 0,000 | 0,001 |
| September | 131 | 33 | 0,00 | 0,00 | 0,000 | 0,000 |
| October | 70 | 95 | 9,79 | 0,00 | 0,002 | 0,000 |
| November | 268 | 548 | 16,33 | 80,21 | 0,004 | 0,018 |
| December | 262 | 456 | 105,85 | 122,04 | 0,026 | 0,028 |
| Total | 4041 | 4342 | 548,68 | 651,11 | 0,136 | 0,150 |

Source: by conducted

**b. Analyzed for direct runoff with Hydrographs Units**

Hydrograph units used to run sampling calculated rain with fluctuations hydrograph principal. Hydrograph units, used to prediction components hydrographs mainstream events rain. In defining the stream directly in the unit which is called the thick of runoff/stromflow (Qd) every one of rain gauge. According to Viessman (1977) and Griend (1979) in Suprayogi (1991) hydrograph units page (master of unit hydrograph) a DAS made Based on a few instances the results rain, with how to calculate value from some hydrograph units.

Suprayogi (1991) said that the variables that affect equation model Qd, Qp and (ϕ) that is depth rain (precipitate) and the index rain before (API) that consists of a API-7 (index rain 7 days); API-5 (index rain 5 days); and API-1 (index rain 1 days before). While equation model Tp and Tb is influenced by the characteristics rain itself that consists of rain intensity maximum (Im), long rain (T) and time reached rain maximum (Tm). Based on the results by conducted regression equation progress within to determine direct runoff in location or by similarities (2), as following:

$$\mathbf{Qd = - 1,28 + 0,176\ P - 0,00188\ API\text{-}5 \quad (2)}$$

By conducted statistics from similarities, (R2) the coefficient correlation of R-Sq = 97.0 percent, with the great value was can be declared that the equations can figured out characteristic of the rain and water catchment area in the location. Equation result (2) model Qd to calculate direct runoff for 2 years in the unit mm as shown in **Table 8.**

**Table 8.** Total direct runoff with equation hydrograph units (Qd)

| Month | Precipitation (mm) | | Volume (mm) | *runoff* | Coefficient runoff (c) | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| January | 788 | 513 | 110,79 | 63,80 | 0,027 | 0,015 |
| February | 788 | 305 | 40,39 | 38,33 | 0,010 | 0,009 |
| March | 338 | 531 | 51,15 | 71,03 | 0,013 | 0,016 |
| April | 405 | 450 | 39,18 | 58,34 | 0,010 | 0,013 |
| Mei | 344 | 614 | 66,13 | 92,22 | 0,016 | 0,021 |
| June | 494 | 200 | 11,08 | 22,51 | 0,003 | 0,005 |
| July | 123 | 348 | 33,01 | 48,48 | 0,008 | 0,011 |
| August | 275 | 250 | 13,64 | 28,42 | 0,003 | 0,007 |
| September | 131 | 33 | 3,10 | 4,35 | 0,001 | 0,001 |
| October | 70 | 95 | 28,25 | 7,06 | 0,007 | 0,002 |
| November | 268 | 548 | 32,05 | 72,99 | 0,008 | 0,017 |
| December | 262 | 456 | 70,05 | 65,65 | 0,017 | 0,015 |
| Total | 4041 | 4342 | 498,82 | 573,18 | 0,123 | 0,132 |

Source: by conducted

**c. Verification of the impact of artificial recharge**

The Role of artificial recharge in location or is to lack down by surface (runoff), this means protection program is to the water absorption area with the making artificial recharge able to reduce the number of direct runoff. Thus, approaches performance through artificial recharge runoff potential is analyzed by SCS-CN assumed the input from artificial recharge reckoned while Analyzed direct runoff using hydrograph mainstream is the actual runoff as information and data existing in the location or.

In this research done by the count Analyzed performance potential artificial recharge with infiltration approach the concept that has been discussed in the previous chapter. Thus, to find out the influence performance actual and potential of artificial recharge. This data is given in **Table 9.** ratio to assess the actual and potential.

**Table 9.** The ratio similarities to assess the actual and potential

| Note | Component |
|---|---|
| ΔDRO | SCS-CN (*Overland flow*) – flow of hydrograph (*Direct runoff*) |
| ΔRAP | ΔDRO - *Artificial Recharge Potential* |
| ΔKRP | $\Delta KRP = \frac{\Delta DRO}{\Delta RAP} \times 100\,\%$ ..................................................................**(3)** |
| ΔIRP | $\Delta IRP = \frac{\Delta DRO}{OvFlow\ SCS\text{-}CN} \times 100\,\%$ .................................................................. **(4)** |

Source: By conducted

On the common related to equal (3) ratio between ΔDRO and ΔRAP are noted by ΔKRP (performance potential Artificial Recharge) which is a ratio of ΔDRO (mm/year) that is the difference in the number of Explore-overland trips flow (SCS-CN) and direct runoff from hydrograph mainstream while ΔRAP (mm/year) that is the difference ΔDRO (mm/year) with the artificial recharge Potential (mm/year). Thus, while for knowing actual performance indicators of success of artificial recharge. On the common while related to equal (4) ratio between ΔDRO and Explore-overland trips flow (SCS-CN) (actual performance Artificial Recharge), this equation can explain what influence performance artificial recharge significantly to increasing mainstream the surface. This data is given in **Table 10.** regarding to verification performance artificial recharge in location or.

**Table 10.** Verification result performance artificial recharge in location.

| Symbol | Components | Year | |
|---|---|---|---|
| | | 2013 | 2014 |
| P | Precipitation (mm) | 4040 | 4342 |
| Verification | Statement | | |
| SCS-CN | Overland flow (mm) | 549 | 651 |
| hydrograph Units | Direct runoff (mm) | 499 | 573 |
| | Artificial Recharge Potential (mm) | 99 | 91 |
| | ΔDRO | 50 | 78 |
| | ΔRAP | 49 | 13 |
| Impact AR Potential | ΔKRP | 50% | 86% |
| Impact AR actual | ΔIRP | 9,1% | 12,0% |

Source: By conducted

Based on the results by conducted by using SCS-Curve Number related to the bloodstream directly (runoff/overland-flow) by considering potential performance from artificial recharge can be concluded that in the previous year function from the performance potential artificial recharge can be said that both seen from the ΔKRP of 50 percent in 2013 and, additional performance of potential to 86 percent at the end of 2014. Based on the results by conducted actual performance indicators of success artificial recharge can reduce the surface flow seen from the ΔIRP of 9.1 percent in 2013 and 12 percent at the end of 2014. This value can be explained that with artificial recharge can reduce the surface runoff at the area research.

**Analyzed of Water Balance**

In this research, analyzed of equilibrium in water balance is associated with the quality water absorption area that location or have 49.21 % high quality water absorption area who enters the category, this will direct proportion to water quality equilibrium in water balance. Information and data related to the balance existing water balance component as input water absorption area for environmental management.

Suprayogi *et al* (2009) said that the explanations on the relationship between the flow into the (inflow) and the flow out (outflow) in a certain period called balance sheet, or the balance of water, precipitating as input page (inflow) while debit mainstream, evapotranspiration and changes water reserves as (outflow). In this research by the limitation tool to get through data height water in the location observations to debit estimated mainstream, it is done modeling by using methods linear regression in layers in determining than water daily to calculate and recharge for estimation river during the same 2 years.

Soewarno (1991) said that the method regression analysis can be used in a good manner for debit estimated peak annual flood price (mean annual floods). Analyzed evapotranspiration uses a model for Penman analyzing of evapotranspiration actual while changes reserves groundwater, from Tanks Model.

Equilibrium of water balance in the location or will the verification process using Tanks model. This data is given in **Figure 3.** and **Figure 4.** about hydrograph mainstream avoid fines from authorities by ensuring equilibrium in balance sheet water Tanks optimization Models and observation at the end of 2013 and 2014.

Based on the results by conducted using Tanks Model, the difference between outflow estimate and observations by a margin of 29 mm (2014) and 166 mm (2013), this is influenced by his great value of

0.94 R2 (2013) and 0.91 (2014). But great value in each R2 in could be categorized as very good (> 0.80) and models can figured out conditions in and the coastal decent enough to be used. Following is presented in detail regarding result **Table 11.** Tanks optimization models in estimated water balances in the location.

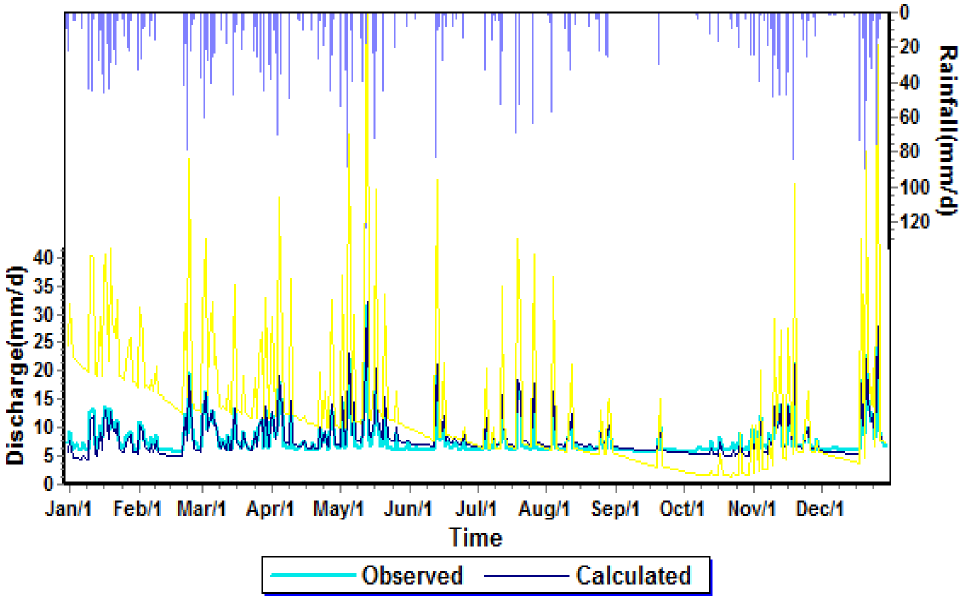



**Figure 3.** Fluctuations of rainfall data in recharge flow (2013).

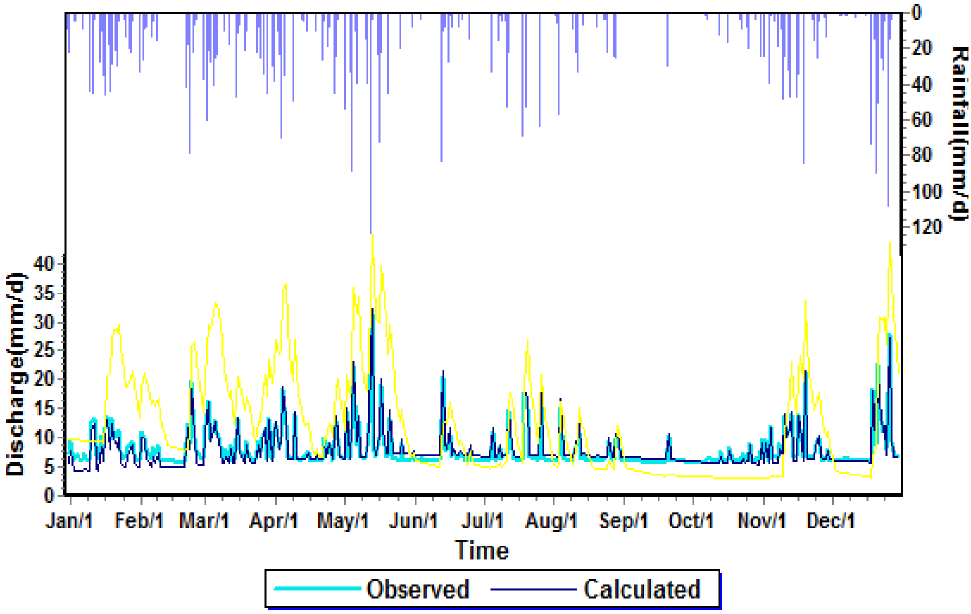



**Figure 3.** Fluctuations of rainfall data in recharge flow (2014).

**Table 11.** Optimization result component water Tanks Model

| Notation | Part of Component | Year (mm) | |
|---|---|---|---|
| | | 2013 | 2014 |
| Water balance | Inflow R (Precipitation) | 4041 | 4342 |
| | Outflow Observation | 2832 | 2911 |
| | Outflow Calculation | 2904 | 2890 |
| | ET Observation | 1119 | 1121 |
| | ET calculation | 894 | 894 |
| | Stored Observation | 90 | 310 |
| | Stored calculation | 243 | 558 |
| Stream Total (*Water Flow*) | Surface flow | 541 | 645 |
| | Intermediate Flow | 210 | 205 |
| | Sub-Base Flow | 1997 | 1667 |
| | Base Flow | 154 | 372 |
| | Total | 2902 | 2889 |

Source: by conducted; Tank Models performance

Water availability information can be seen from components optimization result is made up the balance of water, the total streams of water and the balance than water in each concept tanks. The tank optimization Models factors correction for precipitation component of 1.1 and evapotranspiration actual of 0.8. While other factors correction in using the methods Penman was 0.99.

Optimization result tank Models at the end of 2013 data total rainfall and evapotranspiration each of 4041 mm; total recharge flow of 2904 mm; that is divided into surface flow 541; intermediate flow 210 mm; sub-base flow 1997 mm; and base flow 153 mm. Optimization result tank Models at the end of 2014, Based on the results analyzed optimization, total rainfall data of 4342 mm and total recharge flow of 2890 mm that is divided into surface flow; 645 mm; intermediate flow 205 mm; sub-base flow 1667 mm; and base flow 372 mm.

Setiawan (2003) said that tanks Model assumes that the amount runoff and infiltration is a function of the amount of water which is stored in the land, thus stream (total water flow) is going to be used to verify performance artificial recharge in location or. Land use existing affect water balances in water absorption area. This data is shown in **Figure 5**. about the influence of land become aware of the balance water by results examine of literature

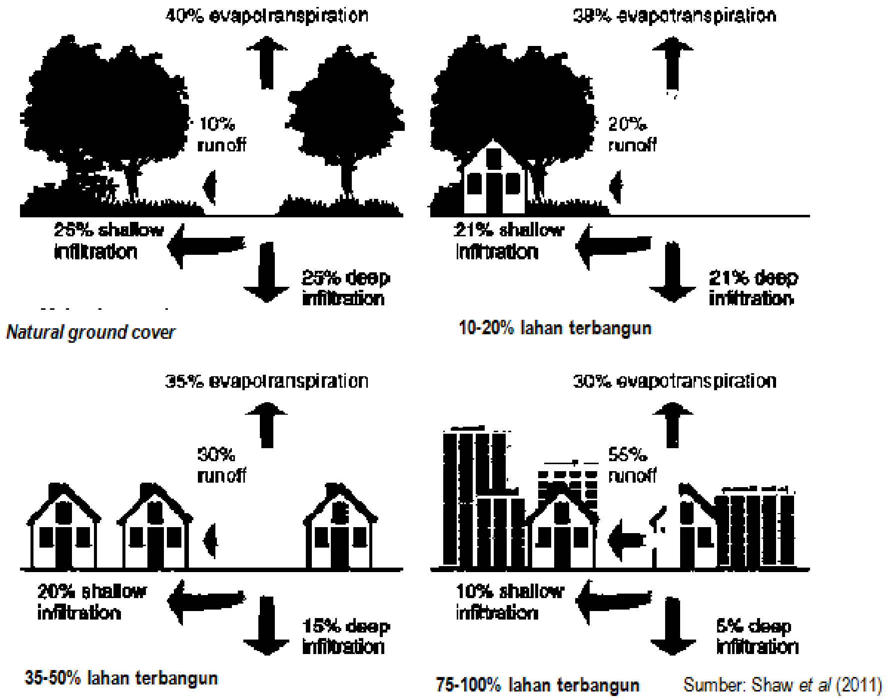



**Figure 5.** The influence of land (impervious surface) to water balance

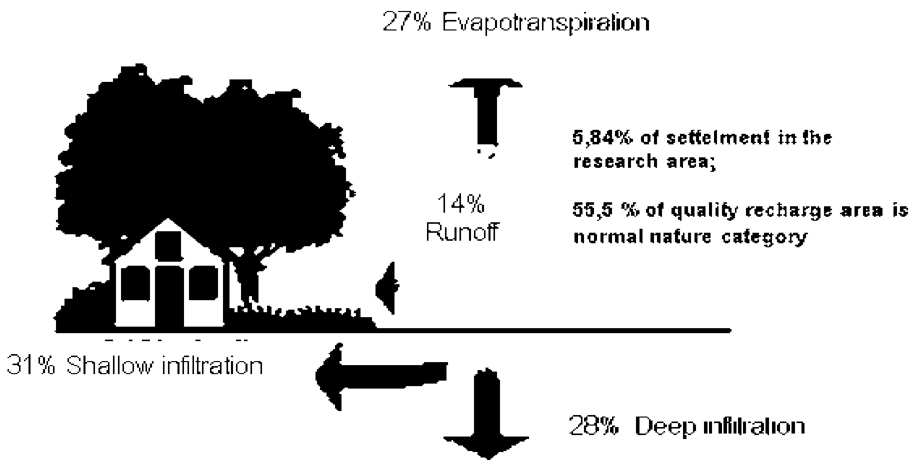



**Figure 6.** Illustrations of water balances in the location with 5,84% is settlement area

Shaw *et al* (2011) said that process runoff because impervious area that mean settlement area can increase regard to runoff significantly. It concept is supported by Tanks model optimization which that result can be represented for total recharge in water balance. All of the process water balance in the research area to significantly reach for peak runoff if settlement area wider than before. For ensure the protection and sustainable a quality recharge area that is good and implementing conservation and soil and water the quality began to critical and critical. All by mean that need to be limited for issues of permit building.

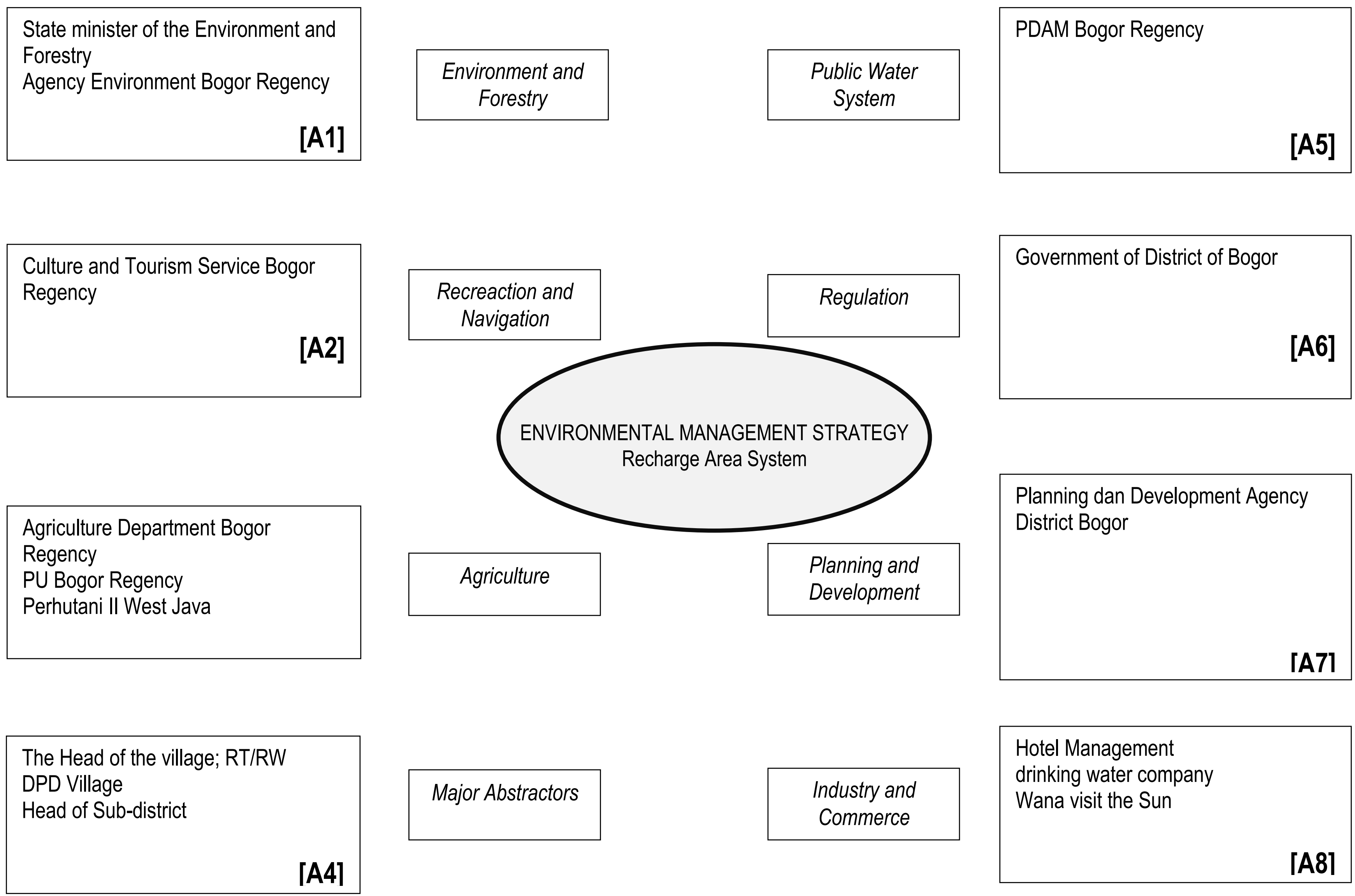
**Environmental Management strategy**

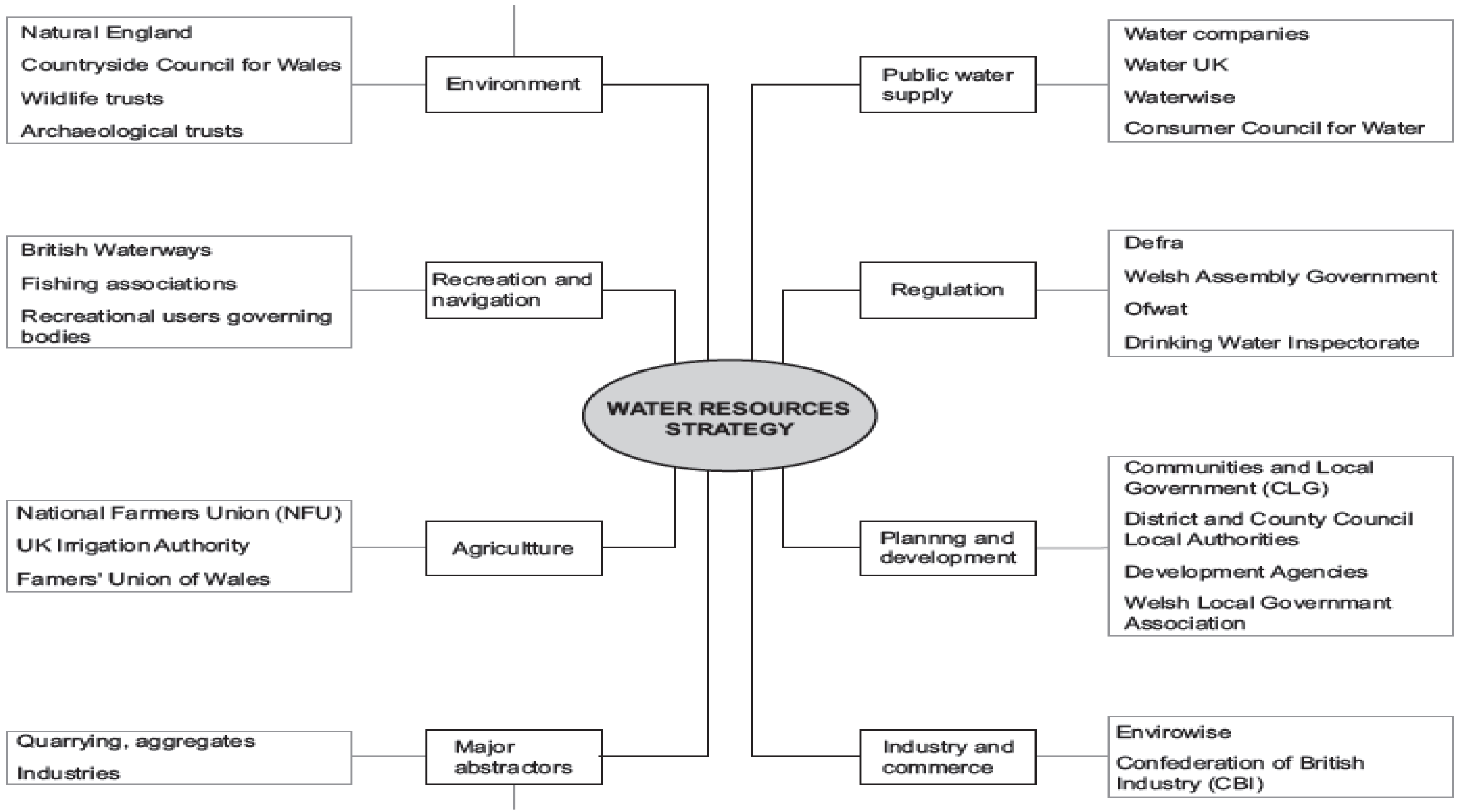
Management efforts with the approach technical support to ensure that input rainfall, flowing and can be accommodated stored maximally in water absorption area through strategy formulation environmental management of water absorption area with the approach technical approach and institutions, as follows:

1. Management strategy technical approach based on the results potential and environmental problems in the location or that is served at Table 13. The characteristics eco-region affect quality water absorption area and hence to keep and preserve in eco-region hilly steep mountain (Natural Environment) (57.76 percent) as a process that infiltration natural (interception ; stream flow) and protection aggregate land; mountains hilly (Sub-natural Environment) as buffer zone between the cultivation and the protected areas; to ensure sustainable water conservation and land in the area descending Hill (28.13 percent ) (semi-natural Environment) as the agriculture land and source a community; and to continue the program artificial recharge in the area (10.41 percent) plain /wave (cultural environment management strategy)
2. Institutional approach based on the results stakeholders that relate to one another in the location or that is presented in Table 13. Including ensuring policy RTRW Bogor Regency 2015-2030 synergy with national policies related to preserve and maintain quality water absorption area; make sure supervision, monitoring and evaluation control procedures RTRW and rehabilitation efforts and conservation in an integrated manner that involved the community with links work; make sure the revision RTRW Bogor Regency in 2015-water absorption area especially 2030. In accordance with technical to maintain and preserve forest cover (natural environment and sub-natural environment) and making artificial recharge (cultural environment) and various programs and compensation, the incentive; ensure the protection and sustainable a quality recharge area that is good and implementing conservation and soil and water On the quality began to critical and critical.

Table 12. Environmental management strategy with the approach technical and institutions

| **Characteristic of Environment** | ***Point Of View*** |
|---|---|
| Natural Environment<br>Steep Mountain hilly<br>Precipitating naturally trapped by the tree/vegetation (interception and stream flow). Based on the results quality recharge area with a good condition of 47,70 percent, able to accommodate and drain input rainfall of 55% (2890 mm) and store up to groundwater 9% (400 mm. Based on the results observation result biota water t consists of the type of freshwater shrimp hurang (*Macrobrachium pilimanus*), paray (*Rasbora elegans*), beunteur (*Puntius binothaus*), tail sword (*Xiphoporus helleri*), and kehkel (*Glypthotorax paltpogon*). Institutional approach : [A1]; (A6) ; (A7) ; (A5) ; (A2) ; (A3) ; [A8];(A4) |  |
| Sub-natural Environment<br>Mount Hilly<br>Precipitation will naturally go into the promised land (through the process infiltration and percolation and were accommodated in aquifer). Based on the results quality recharge area with a normal experience of 43,36 percent, able to keep the balance sheet water via the stream flow the surface of 14 percent. Thus protection against eco-region in sub-natural environment must be maintained.<br>Institutional approach : [A1]; (A6) ; (A7) ; (A2) ; (A3) |  |
| Semi-natural Environment<br>The high wave<br>Precipitation will naturally go into the promised land (through the process shallow infiltration and deep infiltration and were accommodated in aquifer). Based on the results quality recharge area with a critical started, it is rather critical and very critical of 52,30 percent to overcome mainstream the surface of 14 percent. Processing method land with water conservation and land can reduce the flow the surface.<br>This approach institutions : (A6) ; (A7) ; (A4) ; (A3) |  |
| Cultural Environment<br>The broad plain slope/wave<br>Precipitation was cached up by the water (controls the amount of mainstream surface/runoff). Based on the actual results performance artificial recharge (265 unit) can reduce the flow of surface 9.1-12 percent. With the addition unit artificial recharge able to keep the water balance in the area research. This approach institutions : (A6) ; (A7) ; (A3) ; |  |


State minister of the Environment and Forestry
Agency Environment Bogor Regency
[A1]
Environment and Forestry
Public Water System
PDAM Bogor Regency
[A5]
Culture and Tourism Service Bogor Regency
[A2]
Recreaction and Navigation
Regulation
Government of District of Bogor
[A6]
ENVIRONMENTAL MANAGEMENT STRATEGY
Recharge Area System
Agriculture Department Bogor Regency
PU Bogor Regency
Perhutani II West Java
Agriculture
Planning and Development
Planning dan Development Agency District Bogor
[A7]
The Head of the village; RT/RW
DPD Village
Head of Sub-district
[A4]
Major Abstractors
Industry and Commerce
Hotel Management
drinking water company
Wana visit the Sun
[A8]


WATER RESOURCES STRATEGY
Environment
Natural England
Countryside Council for Wales
Wildlife trusts
Archaeological trusts
Recreation and navigation
British Waterways
Fishing associations
Recreational users governing bodies
Agricultture
National Farmers Union (NFU)
UK Irrigation Authority
Famers' Union of Wales
Major abstractors
Quarrying, aggregates
Industries
Public water supply
Water companies
Water UK
Waterwise
Consumer Council for Water
Regulation
Defra
Welsh Assembly Government
Ofwat
Drinking Water Inspectorate
Planning and development
Communities and Local Government (CLG)
District and County Council Local Authorities
Development Agencies
Welsh Local Governmant Association
Industry and commerce
Envirowise
Confederation of British Industry (CBI)

## 4. CONCLUCIONS

Based on the results and constraints problematical formulation object and scope of study or who is supported by the concept that there is a theory and by conducted that, to answer the question purpose in this research it can be concluded that:

1) Based on the results performance recharge speed of artificial in reducing the surface can be determined by the performance approach potential recharge artificial (ΔKRP) and the performance actual recharge artificial (ΔIRP). Based on the results by conducted (ΔKRP) to 50 percent in 2013 and 86 percent at the end of 2014, while (ΔIRP) by 9 percent and 12 percent. The value (ΔIRP) is indicators of success in reducing speed of the surface in the location or, so that the recharge artificial as many as 265 units to be able to infiltration of 50 mm and 78 mm;
2) Based on the results by conducted equilibrium in balance sheet water Tanks to use Model, with total land area wakes up 5.84 percent, evapotranspiration (27%); runoff (14%); shallow infiltration (31%); and deep infiltration (28 percent). The percentage was able to explain that the land was awake (impervious surface) significantly improve runoff in the location.
3) strategy formulation of management environmental for recharge area with the approach technical approach and institutions, as follows:
    a) management strategy technical approach based on the results potential and environmental problems in the location. The characteristics ecoregion affect quality water absorption area and hence to keep and preserve in ecoregion hilly steep mountain (Natural Environment) (57.76 percent) as a process that infiltration natural (interception; stream flow) and protection aggregate land; mountains
    b) hilly (Sub-natural Environment) as buffer zone between the cultivation and the protected areas; to ensure sustainable water conservation and land in the area descending Hill (28.13%) (Semi-natural Environment) as the agriculture land and source a community; and to continue the program artificial recharge in the area (10.41%) plain slope/wave (Cultural Environment.
    c) management strategy institutions approach Based on the results stakeholders that had an interest, including ensuring policy RTRW Bogor Regency 2015-2030 synergy with national policies related to preserve and maintain quality water absorption area in the location or by prioritizing 5 Sub-Watershed in DAS Ciliwung upstream, DAS Ciliwung. To ensure supervision, monitoring and evaluation control

procedures RTRW and rehabilitation efforts and soil conservation and water in an integrated manner that involved the community with links work efficiently as the rural economy in the location; make sure the revision RTRW Bogor Regency in 2015-water absorption area especially 2030 (Puncak, catchment area, Ciesek watershed) according to environment particularly in building permits to be limited.

**BIBLIOGRAPHY**

Adibah, N., Kahar, S. dan Sasmito, B. (2013) “Aplikasi Penginderaan Jauh Dan Sistem Informasi Geografis Untuk Analisis Daerah Resapan Air (Studi Kasus : Kota Pekalongan)”. *Jurnal Geodesi Universitas Diponegoro. 2*(2), pp.141-153.

Asdak, C. (2002) *Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Yogyakarta: Gadjah Mada University Press.

Arsyad, S. (2007) *Konservasi Tanah dan Air*. Bogor: Institut Pertanian Bogor Press

Chow, V.T., Maidment, D.R., and Mays, L.W. (1988) *Handbooks of applied Hydrology*. New York: McGraw Hill International Editions- Civil Engineering.

Gordon, N.D., McMahon, T.A, Finlayson, B.L., Gippel, C.J., Nathan, R.J. (2004) *Steram hydrology: an introduction for ecologist* (*second edition*). London: John Wiley and Sons, LTD.

Lee, R. (1998) *Hidrologi Hutan*. Yogyakarta: Gadjah Mada University Press.

Muta’ali, L. (2012) *Daya dukung lingkungan untuk perencanaan pengembangan wilayah*. Yogyakarta: Gadjah Mada University Press.

O’Riordion, T. (1995) The Global Environment Debate, dalam *Environmental science for environmental management*. Diedit oleh O’Riordion, T., Singapore: Longman Singapore Publishers (Pte) Ltd.

Setiawan, B.I. (2003) Optimasi Parameter Tank Model. *Buletin Keteknikan Pertanian*. Institut Pertanian Bogor. 17(1),pp. 8-20.

Seyhan, E. (1977) *Dasar-dasar Hidrologi*. Yogyakarta: Gadjah Mada University Press.

Shaw, E.M., Beven, K.J., Chappel, N.A., and Lamb, R. (2011) *Hydrology in Practice (4th edition)*. London/New York: Spon Press.

Suharyadi, R. (2001) *Penginderaan Jauh Untuk Studi Kota*. Yogyakarta: Fakultas Geografi, Univeristas Gadjah Mada.

Suprayogi, S. (1991) *Kajian Model Hujan-Aliran Permukaan Sub DAS Cibarengkok Citanduy Jawa barat*. Theses. Institut Pertanian Bogor

Suprayogi, S., Budi, I.S., dan Lilik, B.P. (2003) Penerapan Beberapa Model Evapotranspirasi Di Daerah Tropika, *Buletin Keteknikan Pertanian*. *17*(2),pp. 7-13.

Suprayogi, S,. Purnama, I.L.S. dan Darmanto, D. (2013) *Pengelolaan Daerah Aliran Sungai*. Yogyakarta: Gadjah Mada University Press.

Soewarno. (1991) *Hidrologi: Pengukuran dan Penglohan Data Aliran Sungai (hidrometri)*. Bandung: Penerbit. Nova.

Tandjung, S.H dan Gunawan, T. (2006) Ekologi dan Ilmu Lingkungan. Yogyakarta: Universitas Gadjah Mada.

Viessman, W. dan Lewis, G.L. (2008) *Introduction to Hydrology*. 4th Ed. London: Spon Press, LTD.