Study on Setting Appropriate Size of Riparian Buffer Zone in Urban Basin by Using SWAT Model

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INTRODUCTION

- Recently, as the importance of managing nonpoint source pollution has increased, studies on riparian buffer zone, one of effective managing plans are conducted deeply in and outside the country.
- The size of riparian buffer zone are very Influential to the efficiency of pollutant emission mitigation.
- Factors considered when deciding the width of riparian buffer zone are land-use, status of vegetation and ground covering, slope, soil, regional characteristics and function.
- In this study, optimal width of riparian buffer zone was decided depending on the results of SWAT model which could be applied with considering above – mentioned factors in urban area.

Materials and Method

- **Targeting watershed**

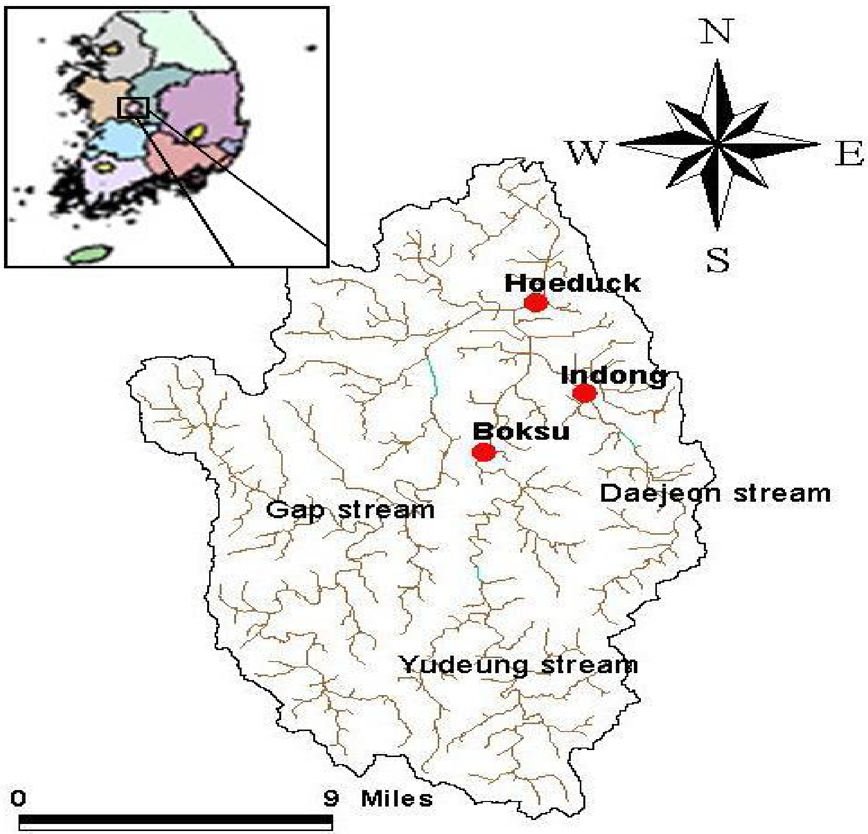


Fig. 1 Gapcheon(Stream) Watershed Map

- **Area**

  Boksu : 16,046ha

  Indong : 6,144ha

  Hoeduck : 64,903ha.

Survey of point source pollution

- **Survey of current situation of point sources pollution**

Table 1 Target Level of Total Influent and Effluent Loads for Administrative Districts

Administrative Districts		2002 Year					
		BOD_5(kg/day)		T-N(kg/day)		T-P(kg/day)	
		Source LOAD	Effluent LOAD	Source LOAD	Effluent LOAD	Source LOAD	Effluent LOAD
Total		172,624	30,119	32,629	14,431	4,245	1,227
Daejeon City Sum		168,618	29,092	31,324	13,679	4,032	1,163
Daejeon City	Donggu	23,157	3,440	5,017	881	572	95
	Junggu	18,780	2,460	4,476	555	501	65
	Seogu	36,838	5,716	8,538	1,387	1,054	153
	Yuseonggu	27,191	11,253	6,508	9,354	722	653
	Daeduckgu	62,652	6,222	6,785	1,501	1,183	197
Chungcheongnamdo Sum		4,006	1,027	1,305	752	213	64
Chungcheong-g Namdo	Kyeryong City	2,560	538	768	407	89	31
	Keumsangun	137	54	53	38	8	3
	Nonsan City	1,308	435	484	308	117	31

Survey of water quality and streamflow discharge

- **Monthly data of water quality (2002~2005) :**
  Provided by information system of water environment of the Ministry of Environment installed near Indong, Boksu and Hoeduck station.
- **Daily data of streamflow (2002~2005) : Waterlevel data gau-ged at each station were changed to Daily streamflow dicha-rge with rating curve equation in table 2**

Table 2 Yearly Stage-Discharge Equations for Stations

Station	Year	Stage - Discharge Equation	Range
Indong	2002 ~ 2003	$Q = 7.627h^{0.892}$	$0.01 \le h \le 0.26$
		$Q = 44.17h^{2.191}$	$0.26 < h \le 1.89$
	2004 ~ 2005	$Q = 0.231H^{7.376}$	$0.96 < H \le 2.75$ ($H = h + 1$)
Boksu	2002	$Q=0.041(h+0.782)^{7.027}$	$0.16 \le h \le 1.14$
		$Q=-45.840h^2+472.963h-476.06$	$1.14 < h \le 2.88$
	2003 ~ 2004	$Q=35.166(h-0.430)^{3.672}$	$0.78 \le h \le 1.80$
		$Q=248.070(h-1.290)^{1.182}$	$1.80 \le h \le 2.95$
	2005	$Q = 1.725(h + 0.172)^{8.01}$	$1.00 < h < 1.57$
		$Q = 318.469(h - 1.247)^{0.693}$	$1.57 < h < 2.67$
Hoeduck	2002~2003	$Q = 227.841(h-0.614)^{1.549}$	$0.67 \le h \le 3.95$
	2004~2005	$Q = 234.477 \times (h-0.68)^{1.667}$	$0.73 \le h \le 2.65$
		$Q = 436.918 \times (h-1.1)^{1.1589}$	$2.65 < h \le 4.07$

Status of land-use

Status of land-use for each subbasin

In Boksu subbasin, forest and farmland account for 93% and urban area accounts for 4.4% and in Indong subbsin, forest and farmland 78% and urban area 14%. In Hoeduck subbasin which shows total status of subbasins in Gapcheon watershed, forest and farmland account for 75% and urban area 19%.

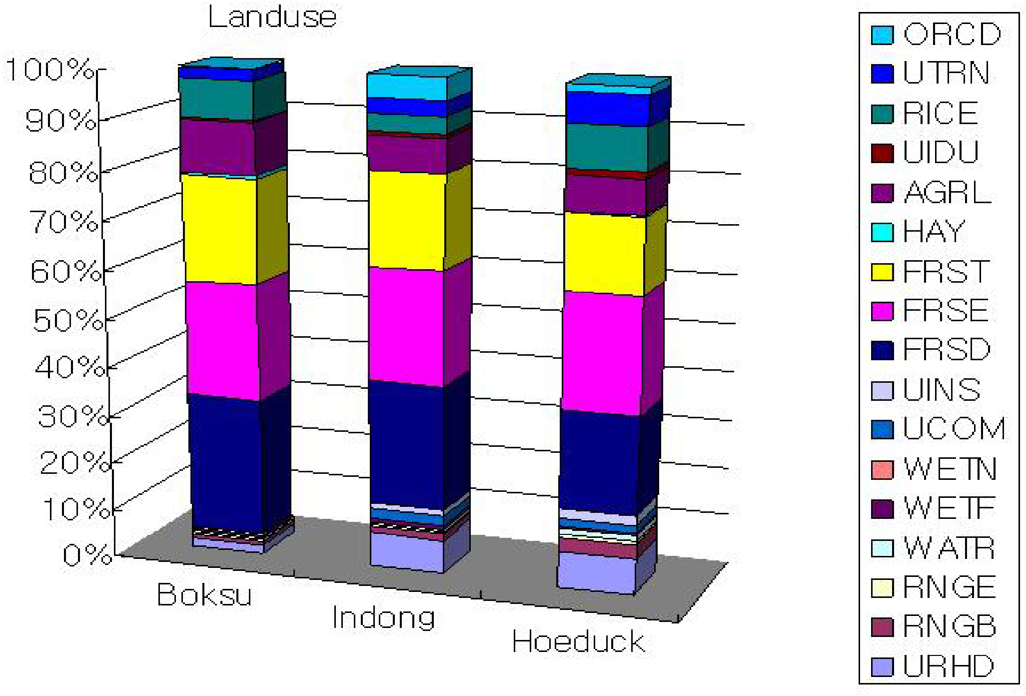
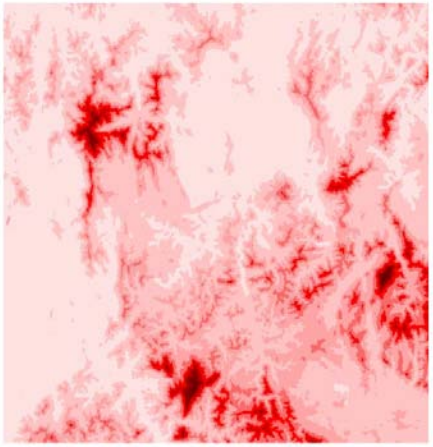


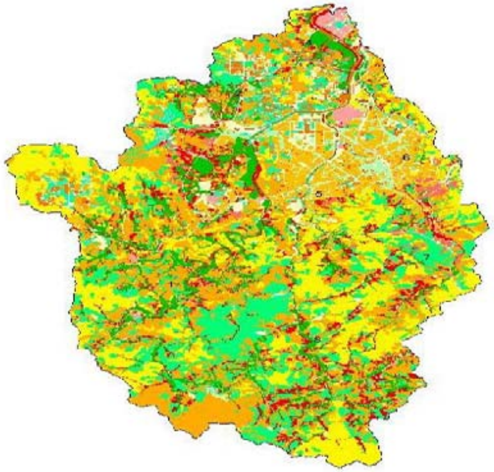
Figure.2 Status of land-use in Boksu, Indong and Hoeduck subbasin in Gapcheon watershed

SWAT model application

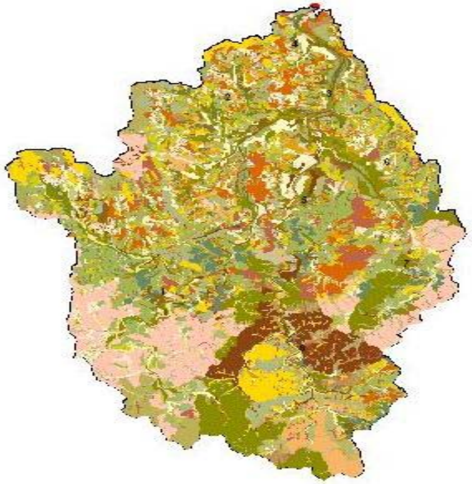
GIS input data



Dem(30m×30m)



Landcover(1: 25,000)



Soil (1: 25,000)

Hydrometeological **data**

Daily precipitation data and climatic data of Daejeon Observatory from Jan. 2002 to Dec. 2005 were input and as meteorological, temperature (maximum, minimum) and solar radiation data were used. Also, data of wind speed and relative humidity in Daejeon and Geumsan area were used

Construction of GIS data of riparian buffer zone

- **Size(width) : 15, 30, 50, 100, 200, 300, 500, 1000m (from river bank)**
- **Plant species : Deciduous tree, Evergreen tree**

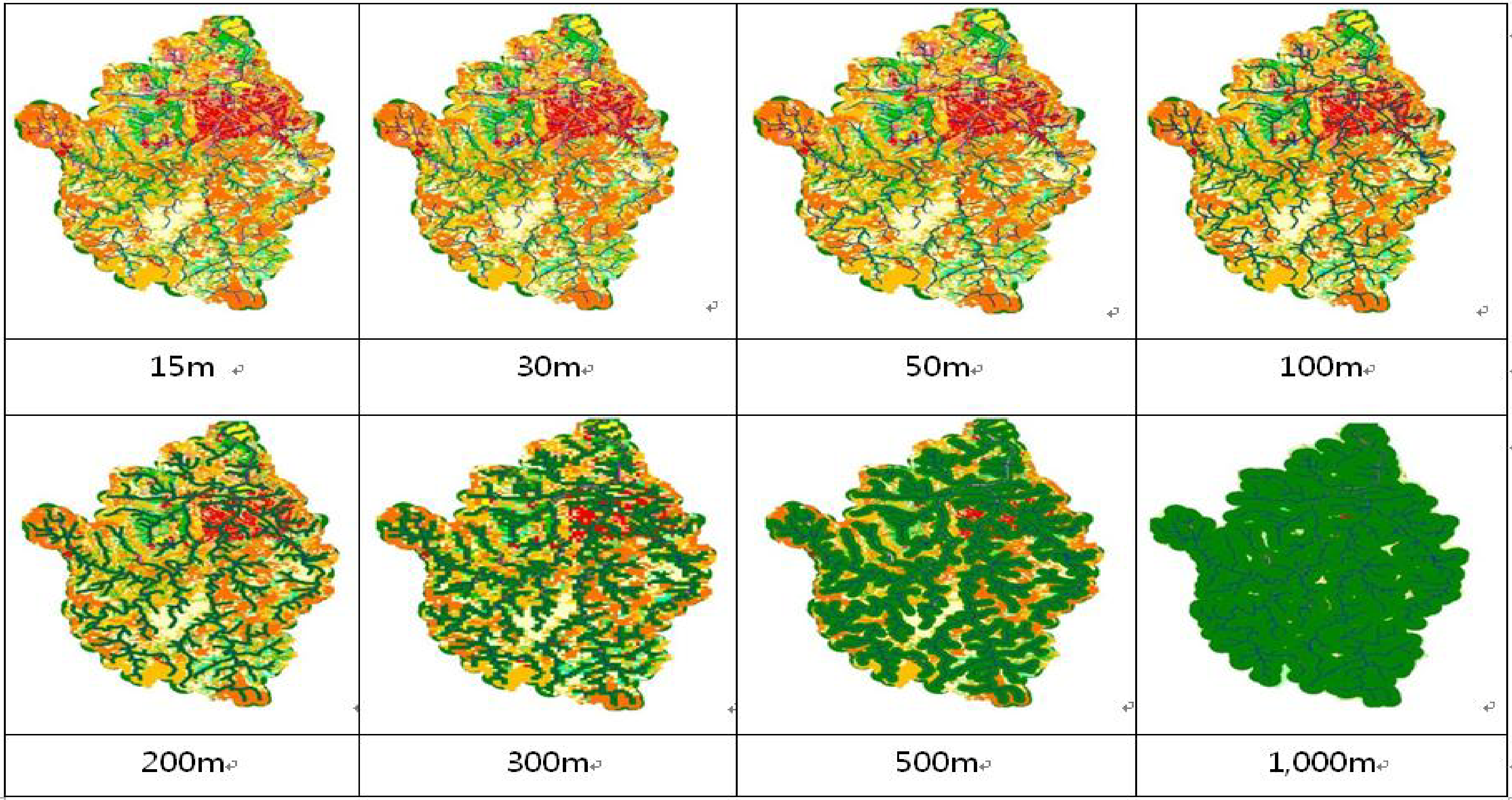


Figure.3 GIS input data by the size of riparian buffer zone.

Calculation of discharging loads of point source pollution and delivery coefficient

Table 3 Administrative Occupied Ratio for Subbasins

SWAT2000 Subbasin(ID)	Administrative Occupied Ratio (Subbasin area / Daejeon city area)
Gapcheon(Stream) Upstream(2)	Seogu(0.76)+Yuseonggu(0.40) +Nonsan City, Kyeryoungcity, Keumsankgun(Gapcheon A)
Gapcheon(Stream) Downstream(6)	Seogu(0.16)+Yooseonggu(0.41) +Daeduckgu(0.14)
Yudeungcheon (Stream) upstream(1)	Junggu(0.58)+Keumsangun (yudeung A)
Yudeungcheon (Stream) Downstream(3)	Seogu(0.080)+Junggu(0.24)
Daejeoncheon (Stream) Upstream(4)	Donggu(0.70)+Junggu(0.16)
Daejeoncheon (Stream) Downstream(5)	Donggu(0.29)+Junggu(0.02)+ Daeduck(0.04)

Table 4 Nutrients Delivery Ratio for Subbasins

Subbasin(ID)	Nutrients Delivery ratio	
	T-N	T-P
Gapcheon Upstream(2)	0.84	0.41
Gapcheon Downstream(6)	0.67	0.20
Yudeungcheon Upstream(1)	0.48	0.11
Yudeungcheon Downstream(3)	0.57	0.15
Daejeoncheon Upstream(4)	0.52	0.13
Daejeoncheon Downstream(5)	0.52	0.13

- **Amount of applied fertilizer and amount of agricultural chemical usage**

major crops and amount of applied fertilizer and agricultural chemical usage by each vegetative period were input.

- **Method for assessing model performing result**

Evaluation index(nash&sutcliffe value)method is mainly used for hydrologic model's evaluation and COE defined like the following.

$$COE = 1 - \frac{\sum_{i=1}^{n} (\beta_{mi} - \beta_{ci})^2}{\sum_{i=1}^{n} (\beta_{mi} - \overline{\beta_m})^2}$$

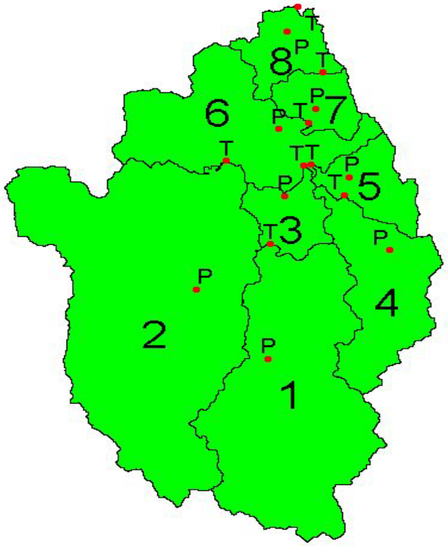
COE means evaluation index of discharge amount,
n means comparison days,

β_{mi} means observed discharge amount, β_{ci} means presumed discharge amount, and

$\overline{\beta_m}$ means average discharge amount through the whole period.

Application of SWAT model by the size of riparian buffer zone

- **Division of subbasins**



Dividing the target watershed into 8 small subbasins, delivery loads were calculated by using the streamflow Discharge and data on water quality in Boksu, Indong and Hoeduck areas and 6 small basins which are upper basins in Hoedeok, the final verifying outlet Hoeduck were analyzed.

Fig. 4 Water Quality Investigation Sites and Point Source Locations
(P : A Point Source Location, T : A Water Quality Investigation Site)

Determination of optimum parameter

Optimal parameters for streamflow discharge

Table 5 Optimized outflow Parameters for 3 sites

Parameter	Subbasin		
	ID 4 (Indong)	ID 1 (Boksu)	ID 6 (Hoeduck)
CN	Initial CN + 4	Initial CN +8	Initial CN + 2
SLOPE	0.328	0.264	0.096
SLSUBBSN	0.038	0.050	60.976
SOL_AWC	Initial SOL_AWC + 0.05	Initial SOL_AWC	Initial SOL_AWC
ALPHA FACTOR	0	0.0087	0.0075
GW_DELAY	0	115	132

Optimal parameters for T-N and T-P load

Table 6 Optimized Parameters for T-N and T-P Loading of SWAT simulation

Parameter	Gapcheon watershed
	All subbasins (6 Subbasins)
Phosphprus Percolation Coefficient (PPERCO)	14
Phosphorus Soil Partitioning Coefficient (PHOSKD)	150
Nitrate Percolation Coefficient (NPERCO)	0.4

Results of calibration and validation

Calibration(2002~2003)

Table 7 Calibration Result for Streamflow)

Station	Estimated Calibration Results for Streamflow				
	Daily		Monthly		Total volume
	COE	R^2	COE	R^2	R.E.
Indong	0.48	0.51	0.62	0.77	11%
Boksu	0.50	0.52	0.74	0.80	22.5%
Hoeduck	0.67	0.69	0.86	0.87	11%

Table 8 SWAT Calibration Results for T-N and T-P loading

Site	Monthly loading				Total load	
	COE		R^2		R.E.	
	T-N	T-P	T-N	T-P	T-N	T-P
Indong	0.72	0.78	0.73	0.79	15%	7%
Boksu	0.67	0.70	0.68	0.74	20%	18%
Hoeduck	0.69	0.73	0.73	0.82	11%	16%

Validation(2004~2005)

Table.9 Verification Result for streamflow

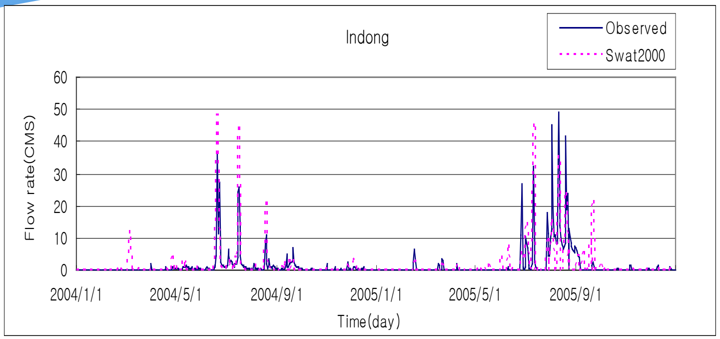
Station	Estimated Verification Results for streamtflow				
	Daily		Monthly		Total Volume
	COE	R^2	COE	R^2	R.E.
Indong	0.45	0.55	0.71	0.74	3%
Boksu	0.55	0.57	0.90	0.93	18%
Hoeduck	0.80	0.79	0.96	0.97	16%

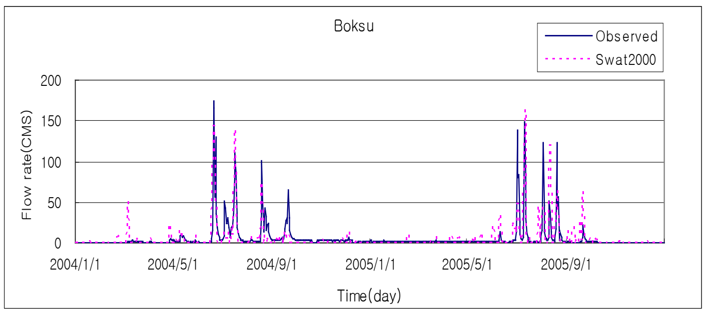
Table 10 SWAT Verification Results for T-N and T-P load

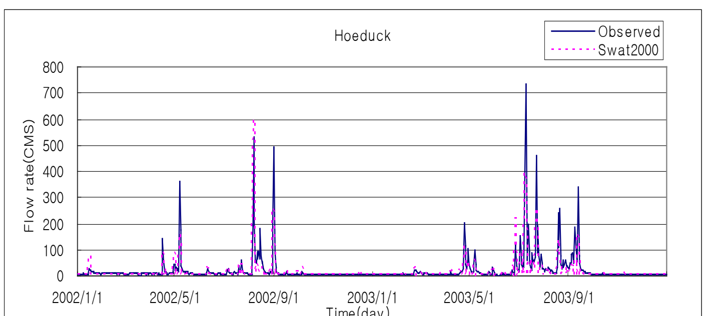
Site	Monthly load				Total load	
	COE		R^2		R.E	
	T-N	T-P	T-N	T-P	T-N	T-P
Indong	0.79	0.68	0.84	0.67	4%	3%
Boksu	0.69	0.59	0.65	0.80	11%	25%
Hoeduck	0.63	0.73	0.75	0.73	9%	9%

Validation(2004~2005)

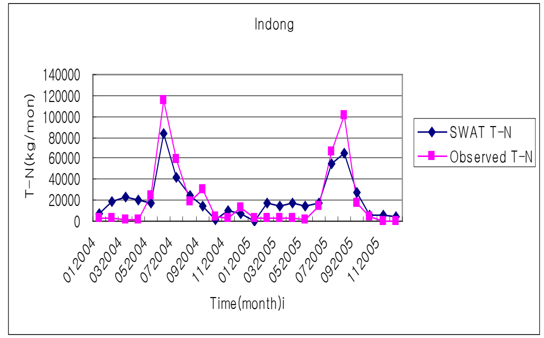
Streamflow

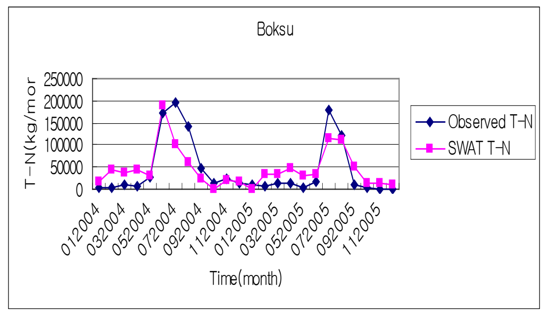


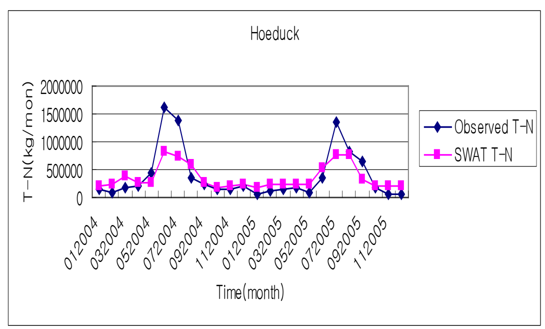




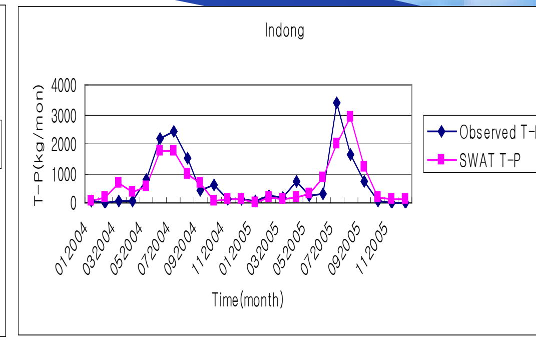
T-N

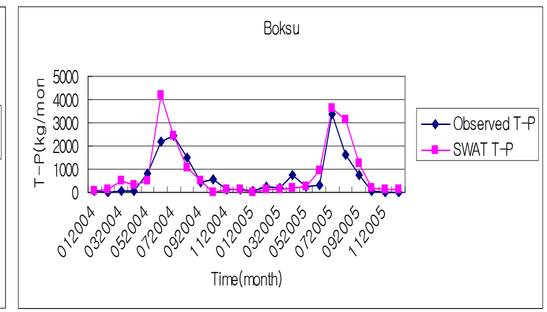


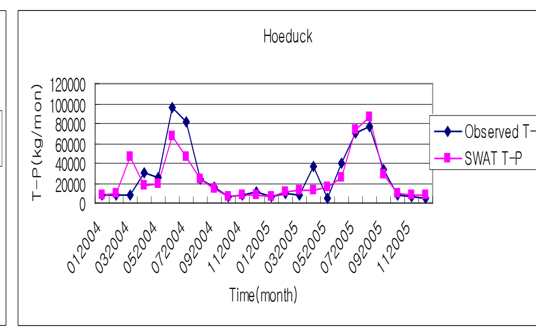




T-P



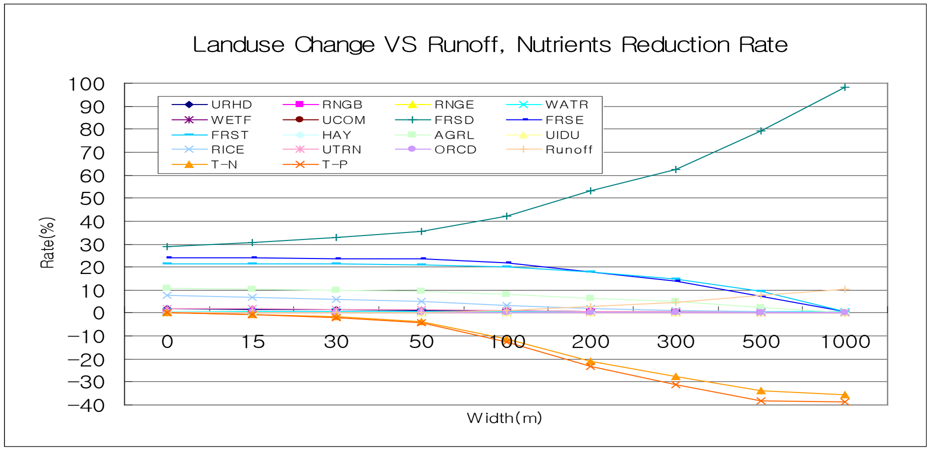




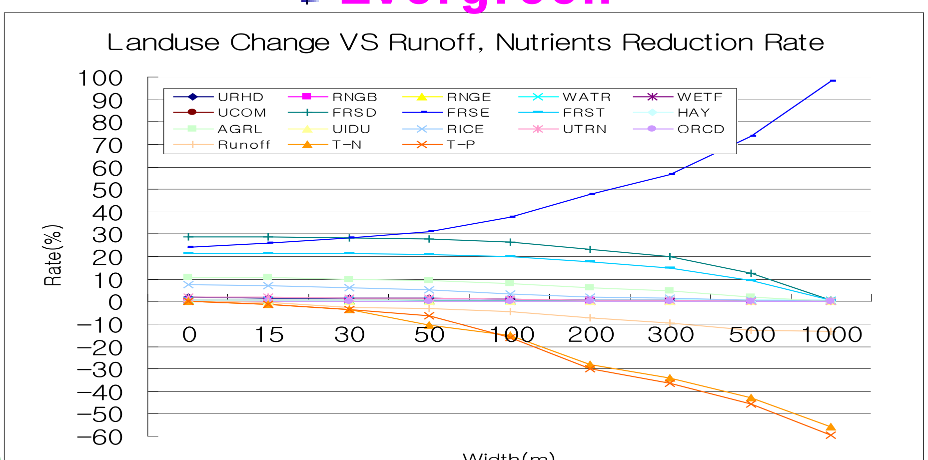
Results and discussion

Boksu

Deciduous



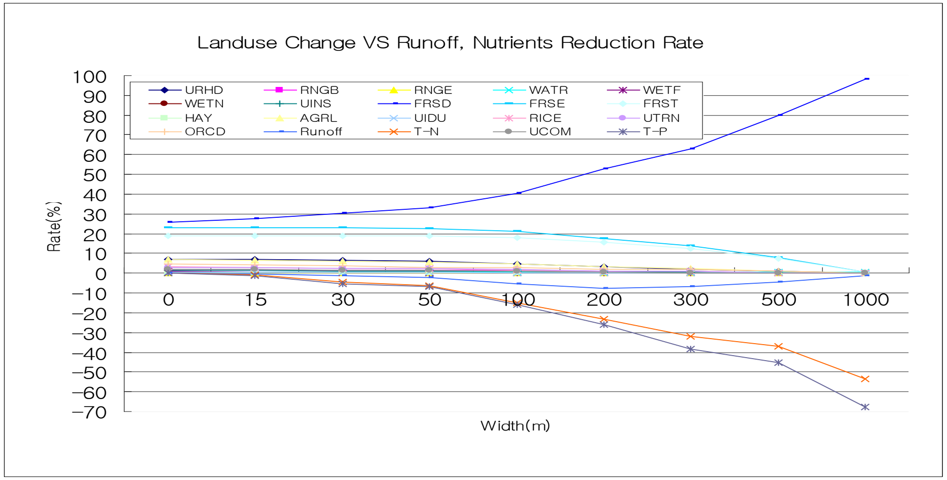
Evergreen



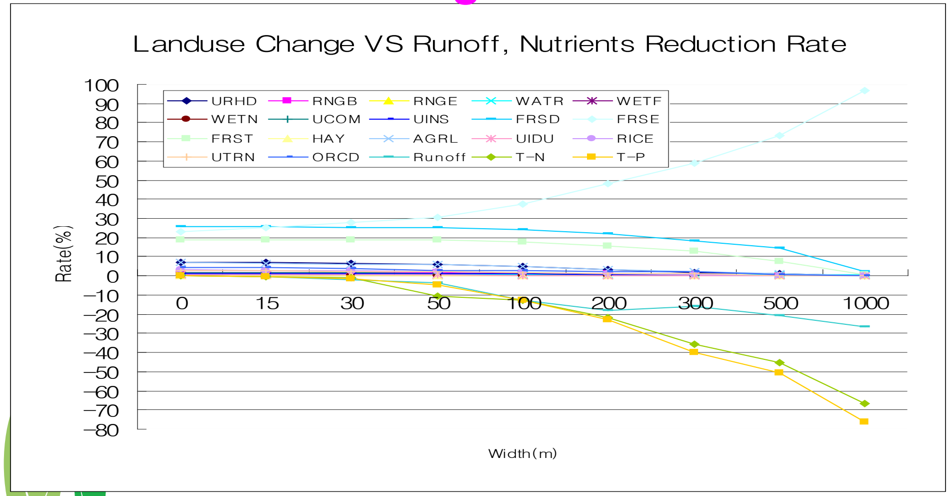
Land-use for Boksu subbasin is composed of 10% of farmland and stretches over the whole subbasin, so in case that 500m width of riparian buffer zone is set, farmland accounts for 2.6% of the zone, showing the gradual effect. It was found that for reducing 10% of discharging loads of T-N and T-P, 80m of deciduous trees or 70m of evergreen trees are needed. Amount of streamflow is constant in case of deciduous trees regardless of the size of riparian buffer zone and in case of evergreen trees, the amount has reduced.

Indong

Deciduous



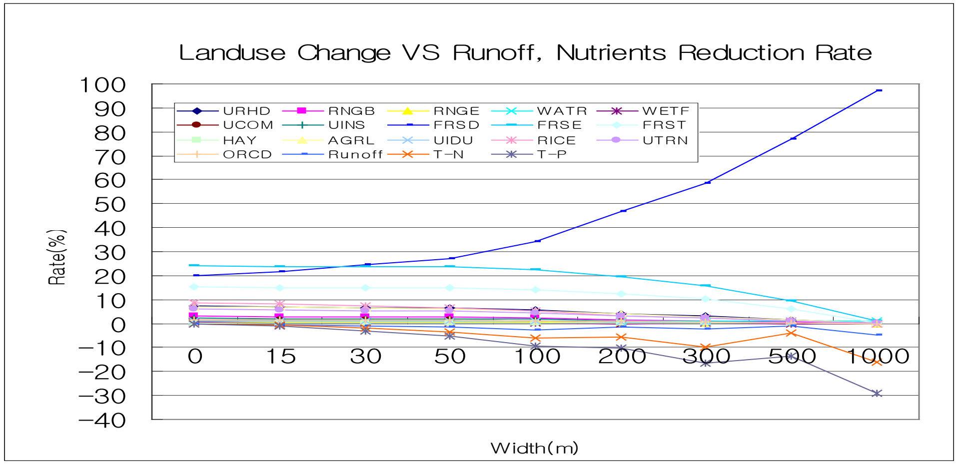
Evergreen



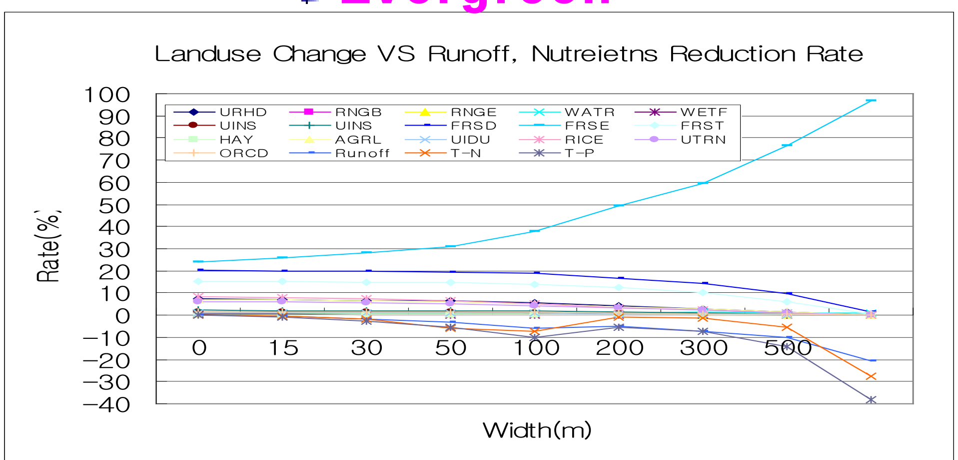
Land-use in Indong subbasin is composed of 14% of urban area and is located near a river. So, when making 500m width of riparian buffer zone, urban area accounts for 1.7%, showing very high reducing effect. Also, in order to reduce 10% of discharging loads of T-N and T-P, 70m of deciduous trees or 60m of evergreen trees are needed. When making riparian buffer zone with evergreen trees, amount of streamflow can be reduced.

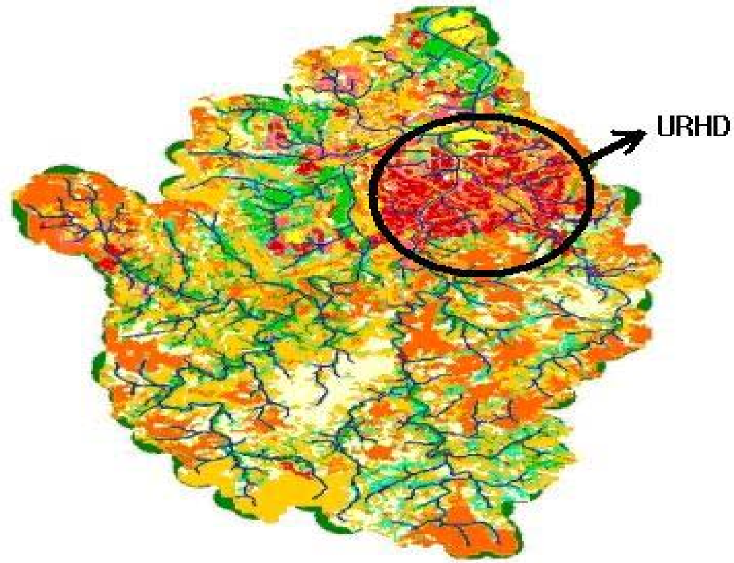
Hoeduck

Deciduous



Evergreen





In Hoeduck subbasin, urban area accounts for 19%, but this area is concentrated in the lower area of Gapcheon, having not so high effect. Also, in order to reduce 10% of discharging loads of T-N and T-P, 100~300m of deciduous trees can be effect but evergreen trees had effective at 100m but other case have no effect in reducing the loadings. Amount of streamflow was constant with deciduous trees regardless of the size of riparian buffer zone and it reduced with evergreen trees.

Conclusion

- COE index of monthly loads of T-N showed the value between 0.63 and 0.79 and that of T-N was 0.59~0.78, confirming that SWAT model has great applicability and reproducibility.
- The width of deciduous trees in Boksu subbasin was 80m and that of evergreen trees was 70m. That of deciduous trees in Indong subbasin was70m and that of evergreen trees was 60m. In case of Hoeduck subbasin, when the width of deciduous trees was 100~300m, reduced amount of discharging of total nitrogen and total phosphorus was -9.8% and -16.3% respectively and evergreen trees had effect at 100m but other case have no effect.
- Residential area with high density in Urban basin like Hoeduck Needs more precision analysis for sewage treatment system like a sewer pipe system which can make another NPS pollution in rainy season.

Thank you .