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Application of SWAT for nutrient load discharge estimation

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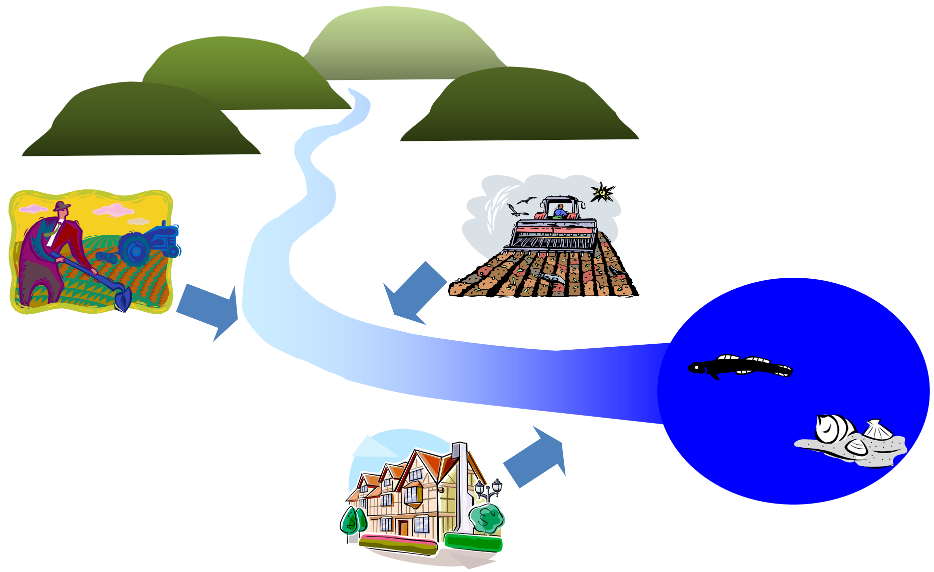
Background

Eutrophication in a lake proceeds, if a lot of SS and nutrition emptied into the lake from a river basin

It is very important to consider what is a well river basin management for improving downstream lake water environment



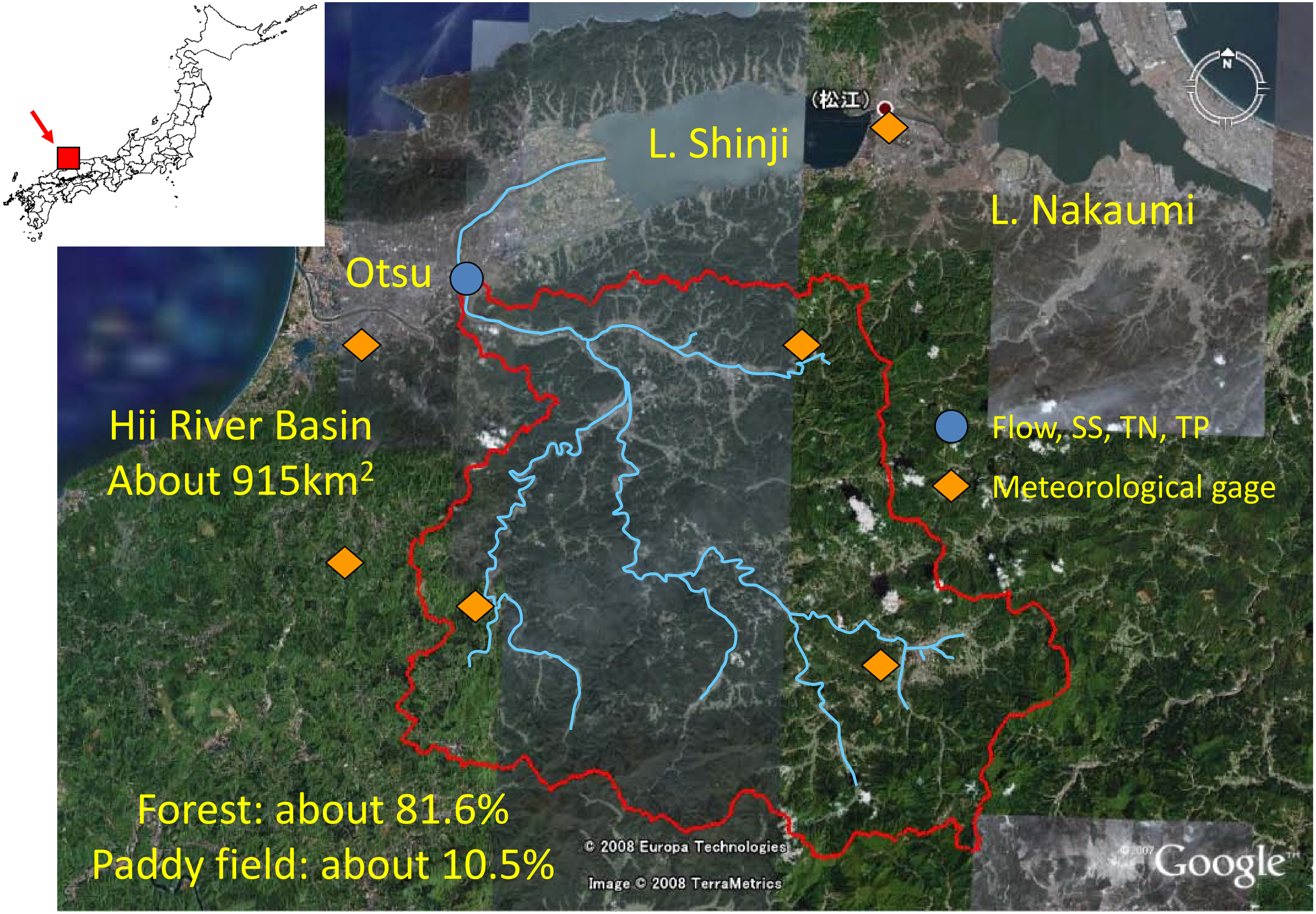
Objectives

The most important thing is to reduce nutrient loads discharge from the basin

The aims of this study

1. Simulate how much SS and nutrient load discharge from the river basin to the downstream lake

2. Figure out how much loads discharge to the river from each land use



Location of the Study Area

About Lake Shinji: Motivation for protect

1. Brackish lake: Delicate balance of saline and fresh water
2. Salinity level: 1/10 of sea water
3. Average water depth: 4.5m
4. The third largest brackish lake in Japan (79.1km^2)
5. 80 species of brackish water fish and shellfish
6. Annual catch of the clam is about 7,000t (40% of National total)
7. Sales amount of the clam is about 40 million dollars in the lake

Size: 2cm

http://www2.odn.ne.jp/shokuzai/Shijimi.htm

Corbicula japonica Prime,1864

Size: 5cm

http://fishing-forum.org/zukan/mashtml/M000712_1.htm

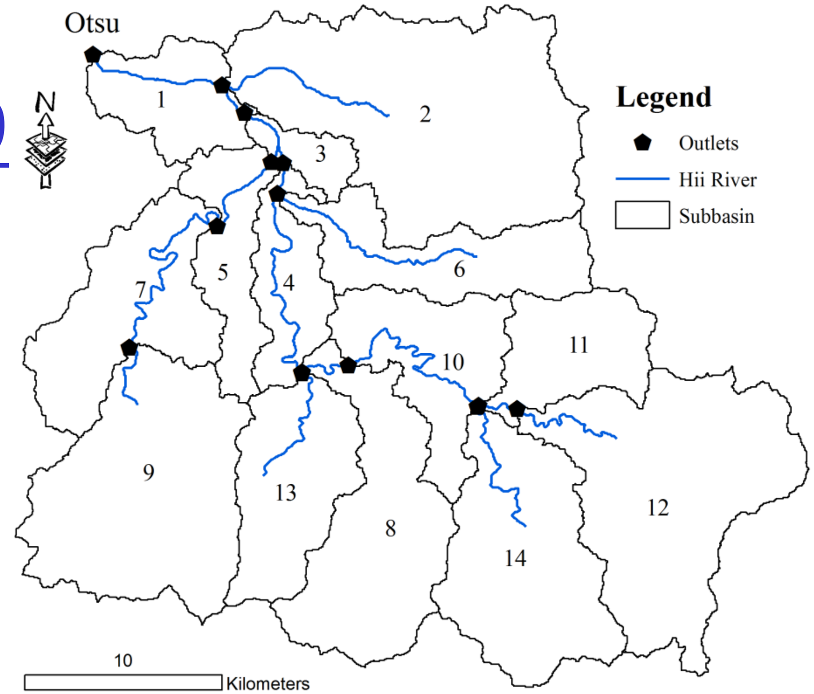
Gymnogobius taranetzi,1878

Snapshot at Otsu Point (outlet of whole basin) toward upstream

Methodology

Watershed

Divided by 14 subbasins (based on tributaries)



Simulation periods: 1985-2009

Calibration: 1988-1997 (10 years)

Validation: 1998-2009 (12 years)

Warm-up: 1985-1987 (3 years)

Target of simulation

Flow: Daily observed data

SS, TN, TP: Weekly – Monthly observed data

Parameter values calibration

Parameter values were calibrated "Manually" basically

Alpha-baseflow: Baseflow Filter Program (J.G. Arnold and P.M Allen, 1999)

Mainly calibrated parameter values

Hydrology

CN2: 35 - 80.6
SurLag: 1.75
ESCO: 0.6 - 0.8
EPCO: 0.89
GW_Delay: 25 - 29 days
Sol_Z1: 50 - 200 mm
Sol_AWC1: 0.18 - 0.33 mm H_2O/mm soil
Sol_K1: 0.03 - 2.5 mm/hr
CH_K: 0.81 mm/hr

Parameter values calibration

Parameter values were calibrated “Manually” basically

Mainly calibrated parameter values

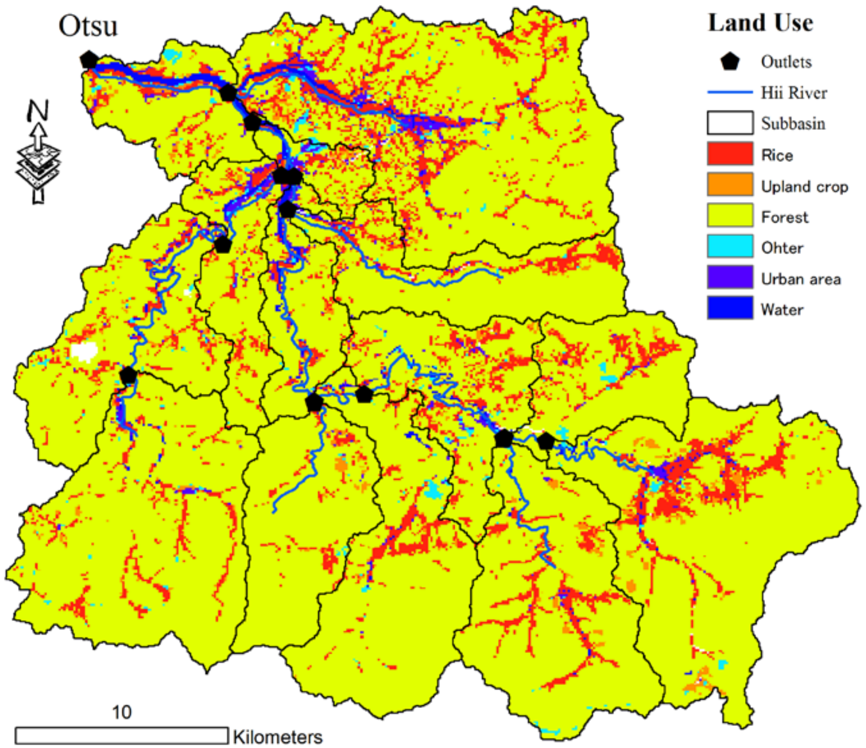
Sediment

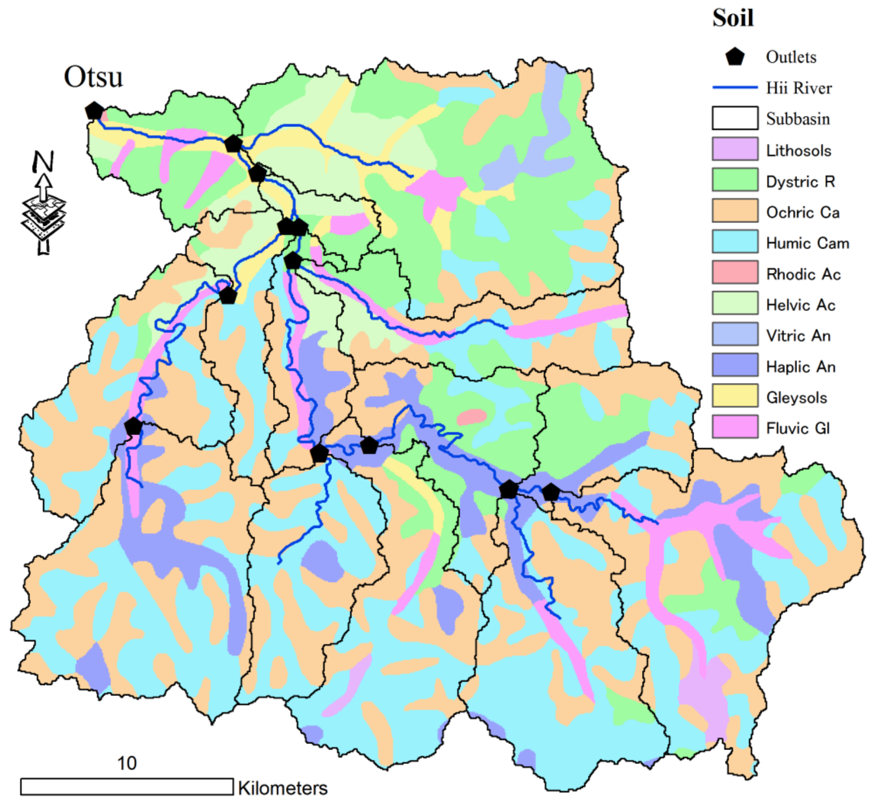
HRU_slp: 0.003 - 0.47 m/m
Slsubbsn: 0.9 - 17 m
USLE_P: 0.57 - 0.72
SPCON: 0.00036
SPEXP: 1.1
CH_EROD: 0.4
CH_COV: 0.5

Nutrient

N_UPDIS: 25
P_UPDIS: 15
Nperco: 0.7
Phoskd: 100 m^3/Mg
PSP: 0.685
RSDCO: 0.02

Land-use and Soil GIS data





Forest: about 81.6%
Paddy field: about 10.5%
Upland crop: 2.6%
Urban Area: 2.0%

Management Schedule (Rice)

	Beginning of May	Jun	Jul	Aug	Middle of Sep
Rice	Puddling Transplant				Harvest
	Base fertilizer		Additional fertilizer (End of July)		
	Irrigation (every week except during middle of June)				

This schedule was applied to Rice HRU in all subbasin

Management Schedule (Upland crop)

	Mar	Apr	May	Jun	Jul	-	Sep	Oct	Nov
Soybean				Tillage seeding					Harvest
				Fertiliz					
Japanese tea	Fertiliz	Fertiliz	Fertiliz		Fertiliz		Fertiliz		
Japanese persimmon	Fertiliz			Fertiliz				Fertiliz	

Main crop: Soybean

Additional crop: Japanese tea and persimmon (add fertilizer managements to soybean. Fertilizer amount was reduced based on cultivated area of tea and persimmon)

Model Performance Evaluation

1. Nash-Sutcliffe efficiency (*NSE*)
2. Coefficient of determination (R^2)
3. RMSE -observations standard deviation ratio (*RAR*)
4. Percent bias (*PBIAS*)

Model performance criteria

Satisfactory

Flow: NSE > 0.5; RSR ≤ 0.7; PBIAS ±25%

SS: NSE > 0.5; RSR ≤ 0.7; PBIAS ±55%

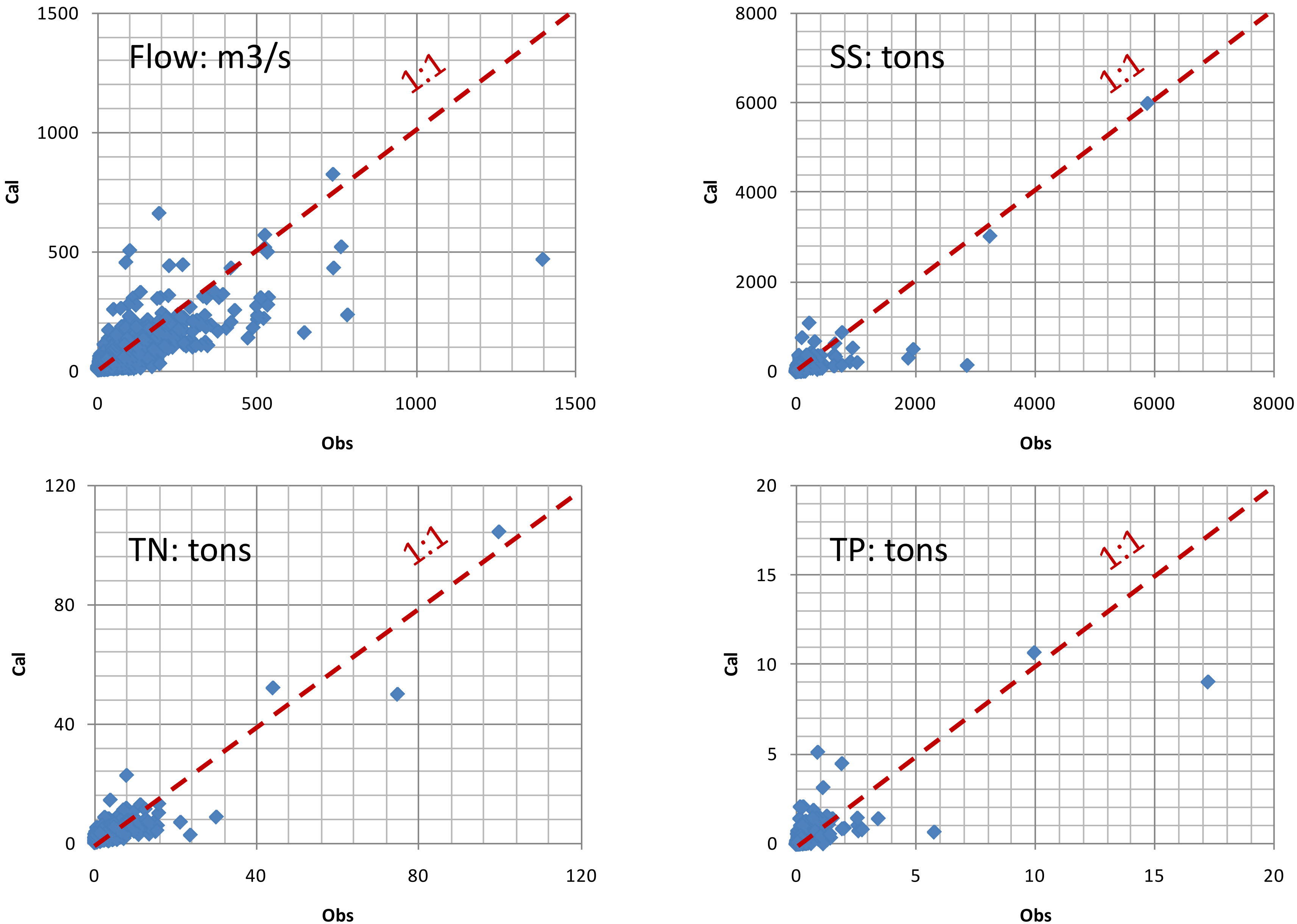
N&P: NSE > 0.5; RSR ≤ 0.7; PBIAS ±70%

(Moriasi et al., 2007)

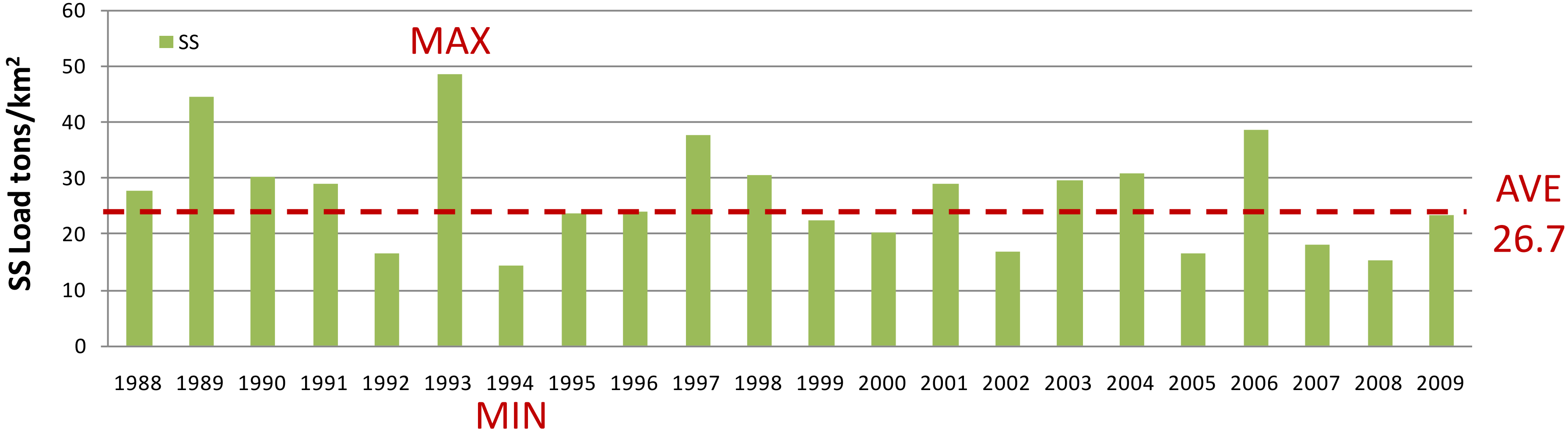
Summary of model performance

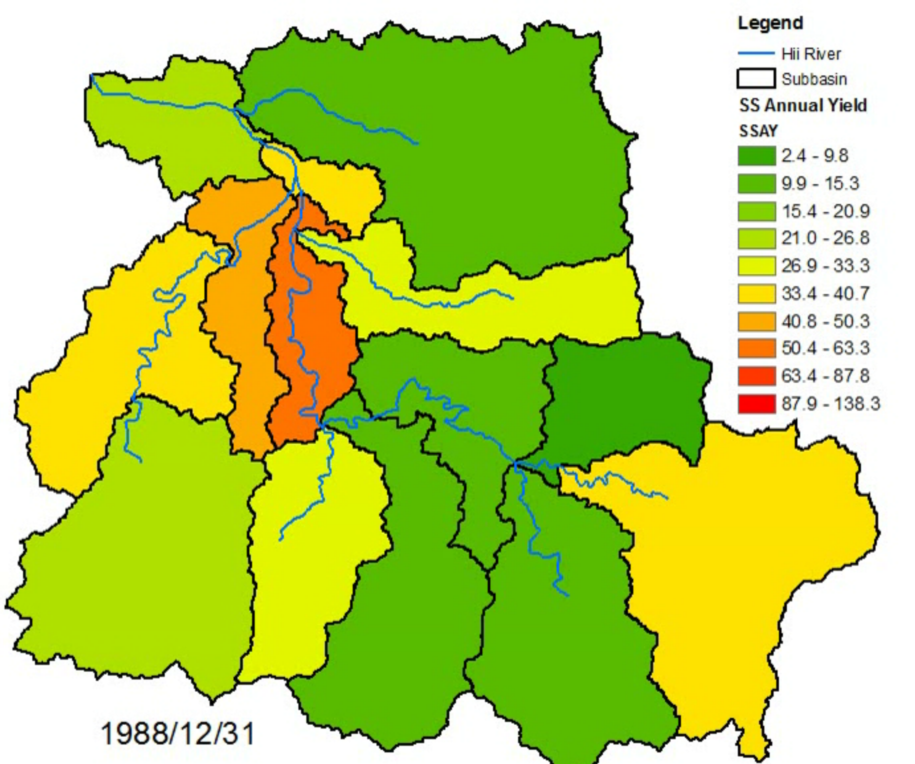
		NSE	R^2	RSR	PBIAS%
Flow	Cali.	0.62	0.62	0.62	1.07
	Vali.	0.54	0.56	0.68	1.13
SS	Cali.	0.83	0.83	0.42	11.09
	Vali.	0.53	0.54	0.68	12.25
TN	Cali.	0.84	0.86	0.40	4.79
	Vali.	0.63	0.67	0.61	3.92
TP	Cali.	0.68	0.72	0.56	13.31
	Vali.	0.63	0.66	0.61	7.46

Simulated results of Flow, SS, TN, TP



Annual load discharge and yield (SS)



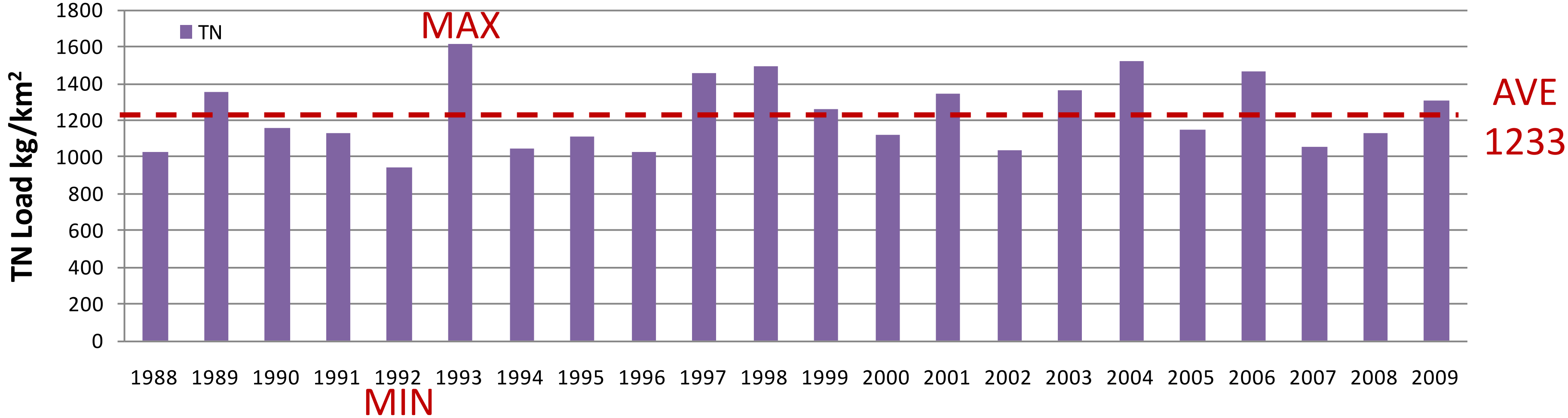


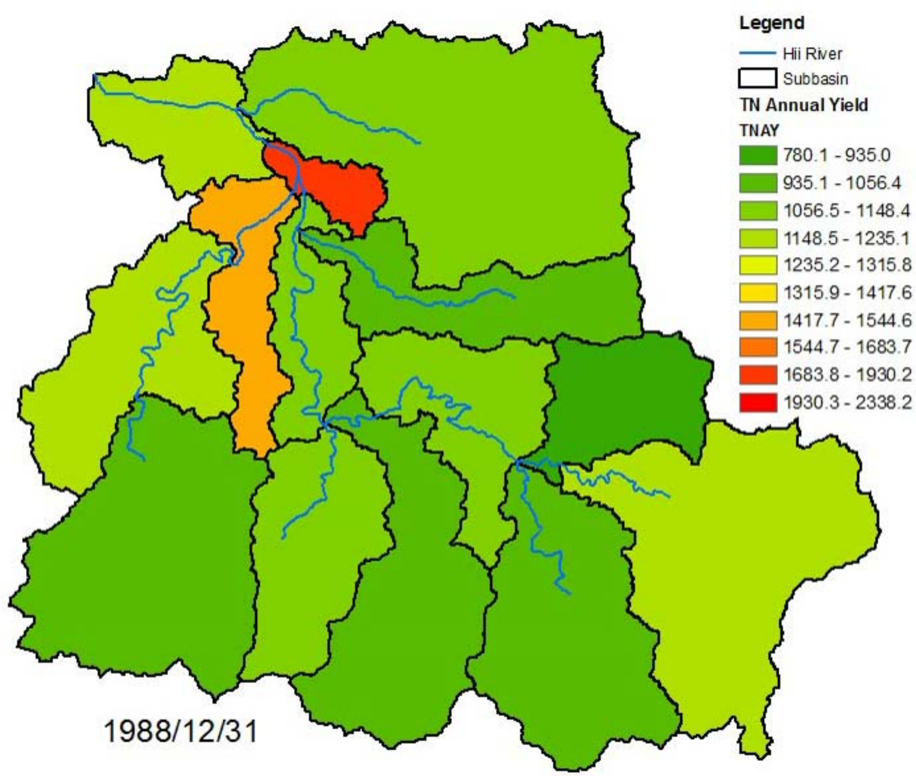
Annual yields from each subbasin varied every year

Highest: Sub No.4 (58.9 tons/km^2)

Lowest: Sub No.11 (12.9 tons/km^2)

Annual load discharge and yield (TN)



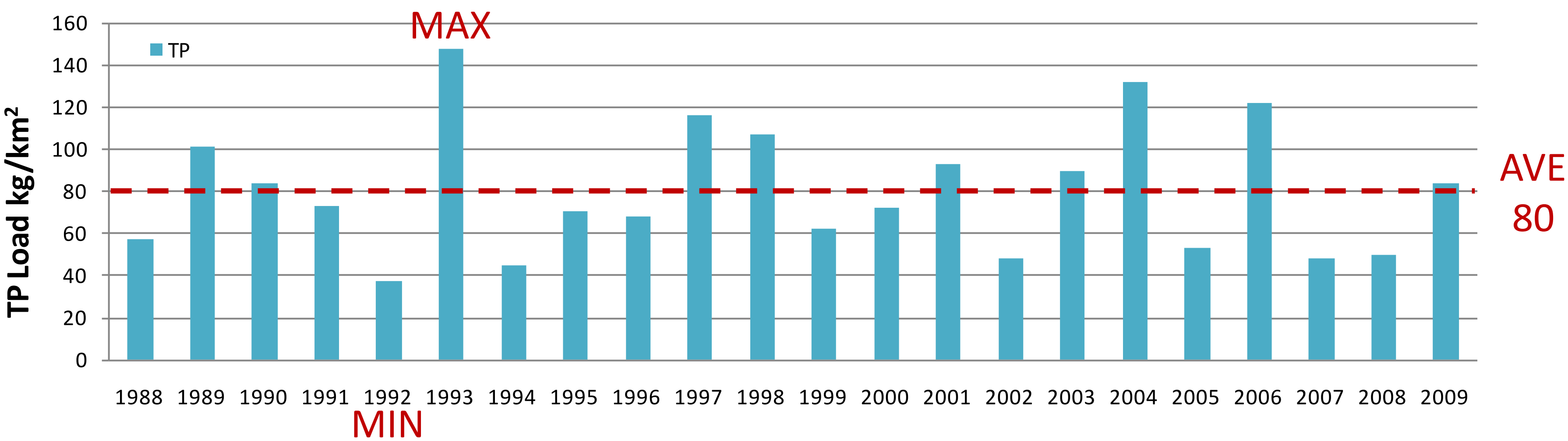


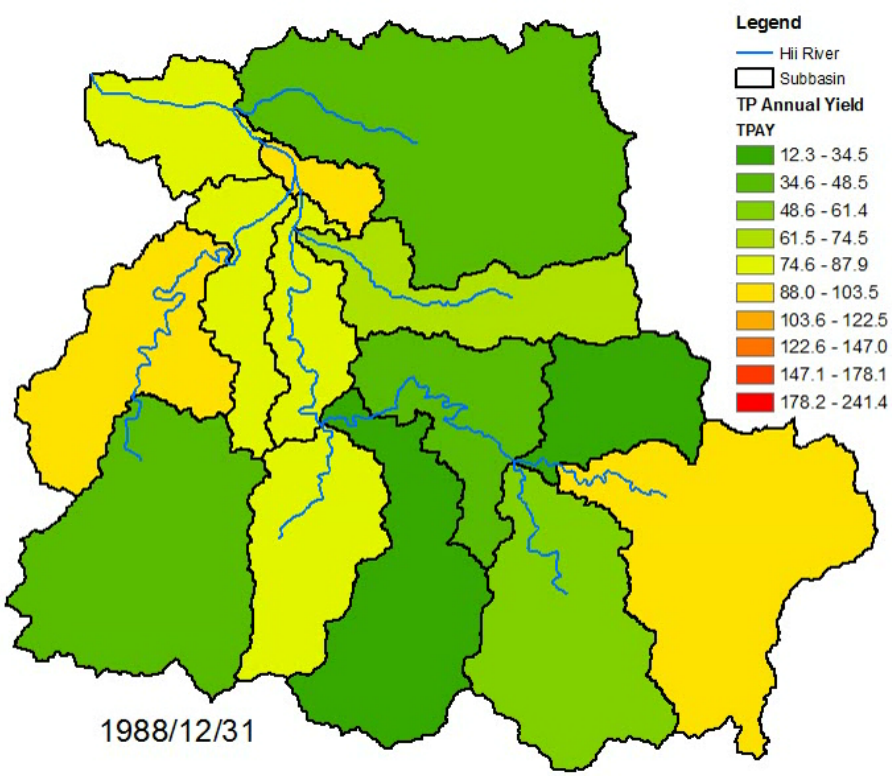
Annual yields from each subbasin varied every year

Highest: Sub No.3 (1777 kg/km^2)

Lowest: Sub No.8 (1118 kg/km^2)

Annual load discharge and yield (TP)



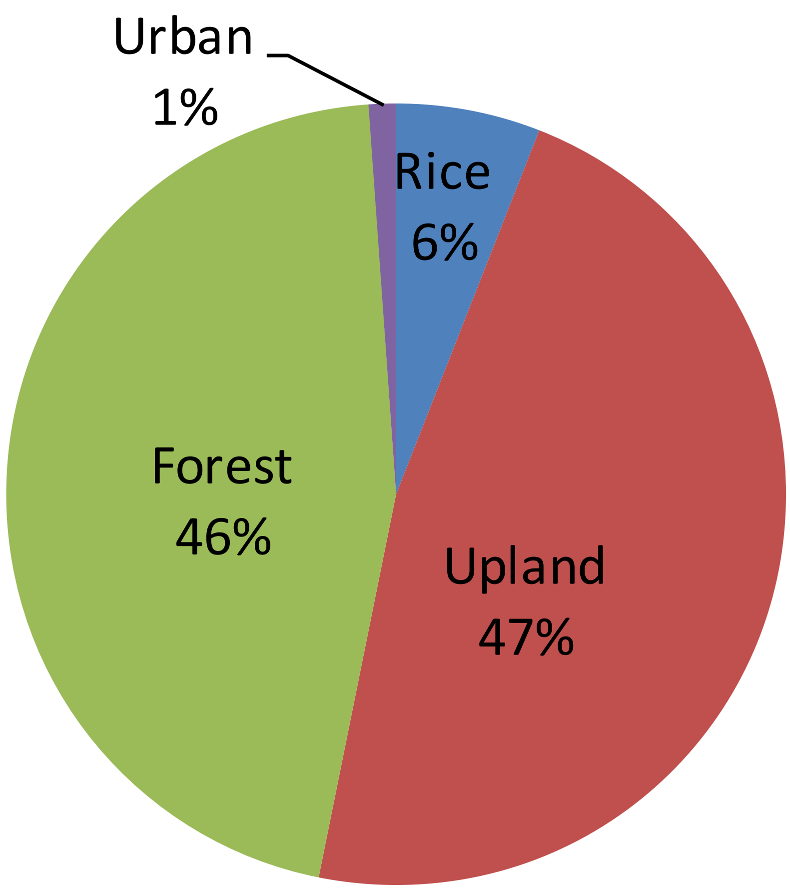


Annual yields from each subbasin varied every year

Highest: Sub No.12 (140 kg/km^2)

Lowest: Sub No.11 (44 kg/km^2)

Ratio of SS load from each land use (HRUs) against total load



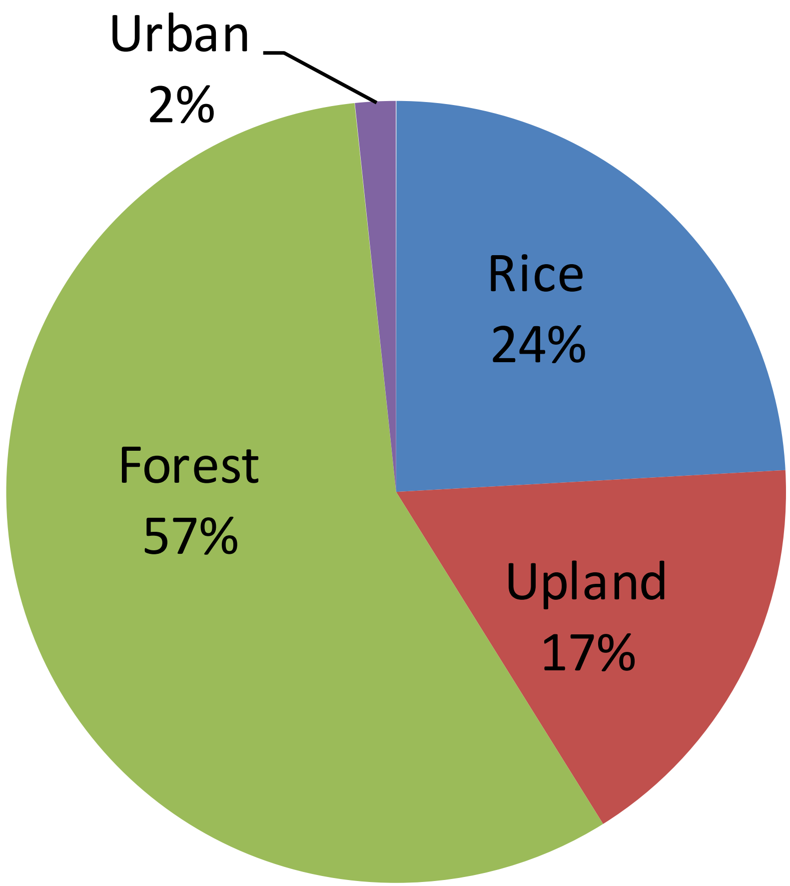
Ratio against total load

	SS unit load tons/ha
Rice	0.20
Upland	6.83
Forest	0.19
Urban	0.29

Upland > Urban > Rice > Forest

- Most SS load came from Forest and Upland
- Upland had the big impact for SS load production

Ratio of TN load from each land use (HRUs) against total load



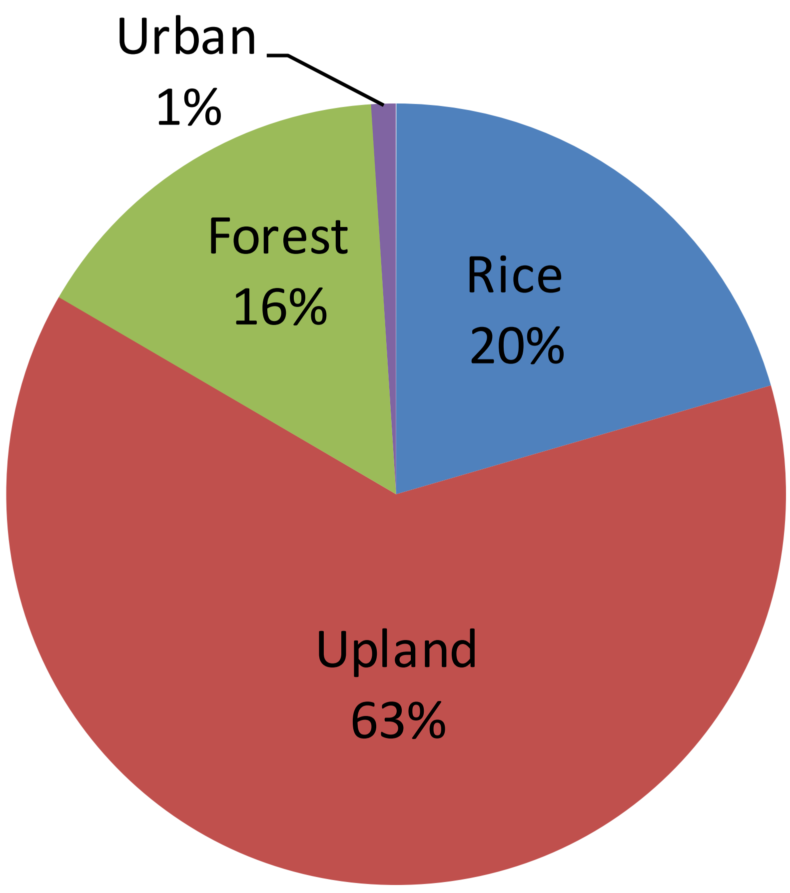
Ratio against total load

	TN unit load kg/ha
Rice	34.9
Upland	109.5
Forest	10.0
Urban	17.1

Upland > Rice > Urban > Forest

- Most TN load came from Forest, but Rice and Upland also had a large impact
- Rice and Upland showed similar ratio

Ratio of TP load from each land use (HRUs) against total load



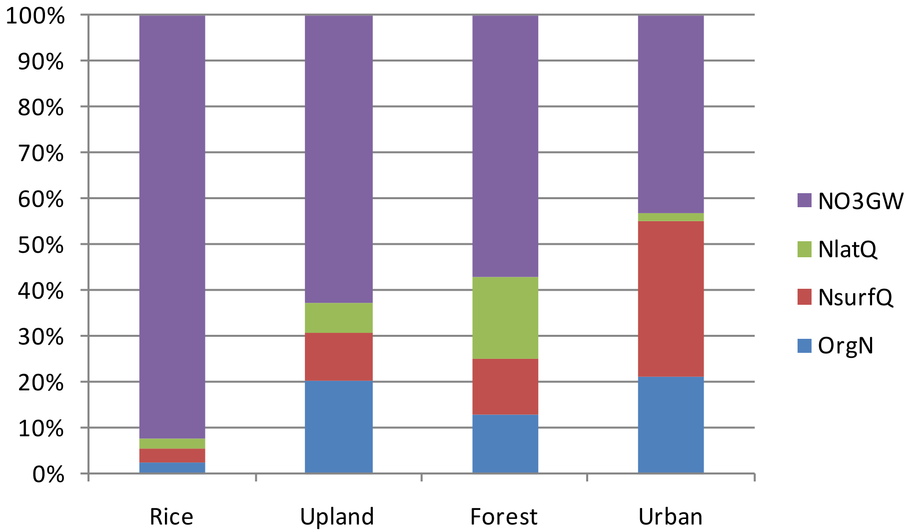
Ratio against total load

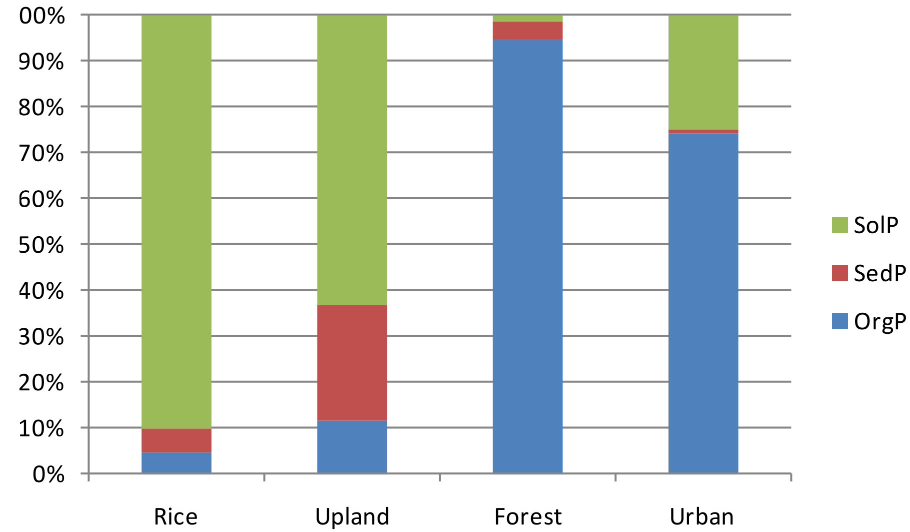
	TP unit load kg/ha
Rice	1.84
Upland	25.11
Forest	0.17
Urban	0.64

Upland > Rice > Urban > Forest

- Most TP load came from Upland
- Rice and Forest showed similar ratio

Internal ratio of TN and TP load from each HRU (land use) to reach





- In TN, ratio of NO_3 contributed in groundwater flow to the river was dominant in every land use
- In urban, nitrogen from surface run off also occupied larger portion in nitrogen discharge to the river

- In TP, ratio of organic phosphorus was dominant in Forest and Urban land uses.
- In agriculture, ratio of soluble phosphorus was dominant, especially in rice land use
- From upland field, mineral phosphorus attached to sediment also occupied larger portion in phosphorus discharge to the river

Conclusions

1. SWAT model could represent flow, SS, TN, and TP load discharges "Satisfactory" from 1988 to 2009
2. Average annual load discharges from the basin to down stream (Lake Shinji) were about 27 tons/km^2 in SS, 1233 kg/km^2 in TN, and 80 kg/km^2 in TP, respectively
3. In despite of low land use ratio (about 3%), upland crop had a large impact for SS, TN, and TP load discharges
4. A unit load from Forest was smallest value in SS, TN, and TP among the 4 categories, but had a larger impact to load discharges because forest has a largest area in the basin
5. Though a detail land use map is not available at this moment, it should be used for detail analysis in the future


Thank you very much for your attention!

Image: Japanese tea field located in hilly place

http://www.yunphoto.net/jp/photobase/hr/hr3520.html

Relationship between Annual Precipitation and Flow, SS, TN, TP discharge