The Phosphorous Distribution by SWAT Model for Inshore Alluvial Plain River System in North Jiangsu, China

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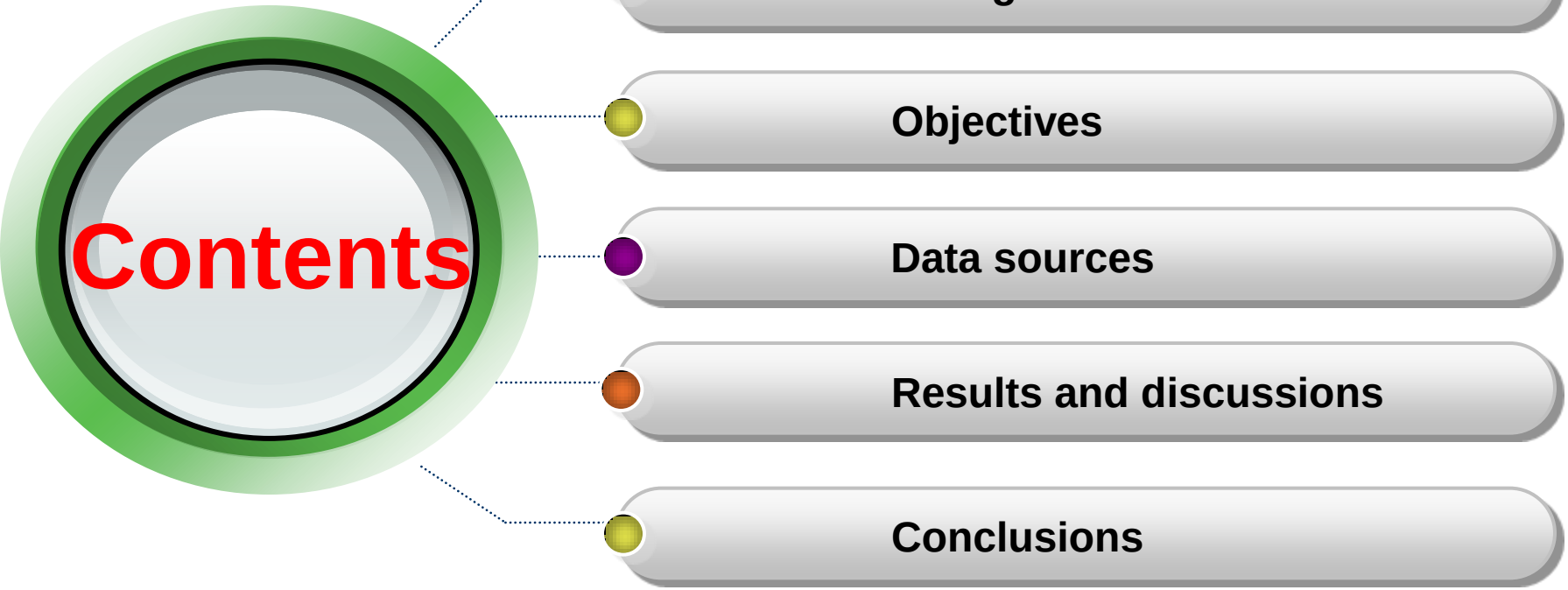
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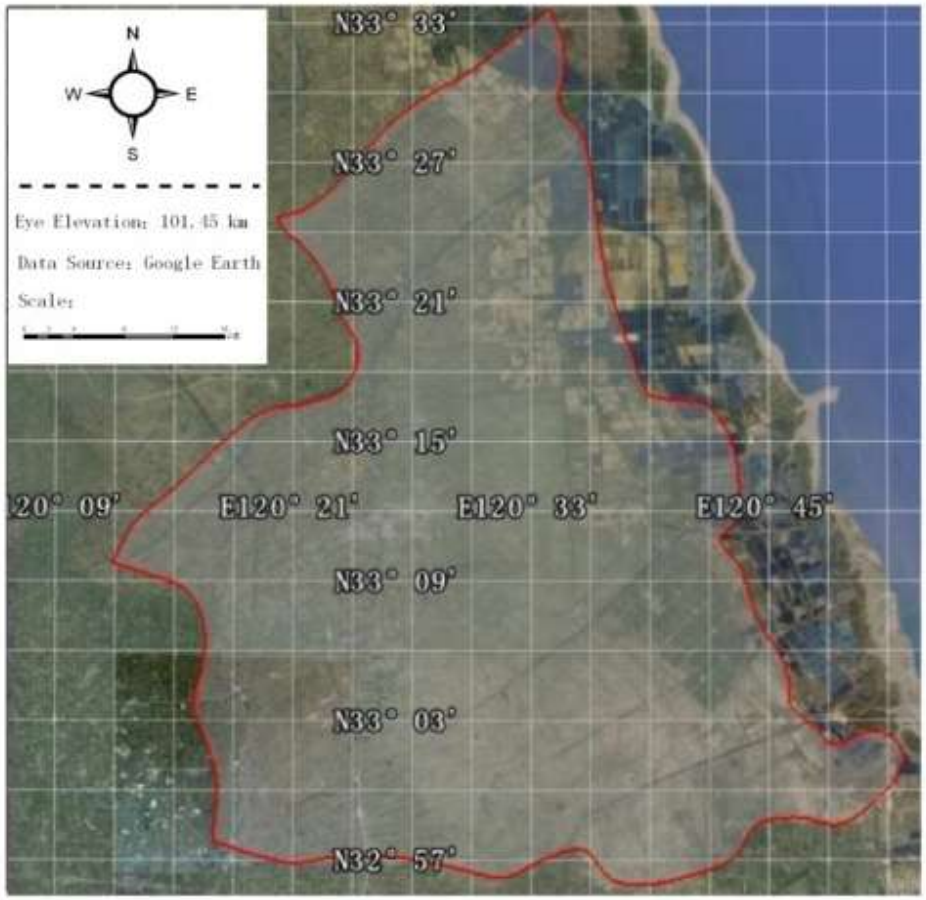
Background

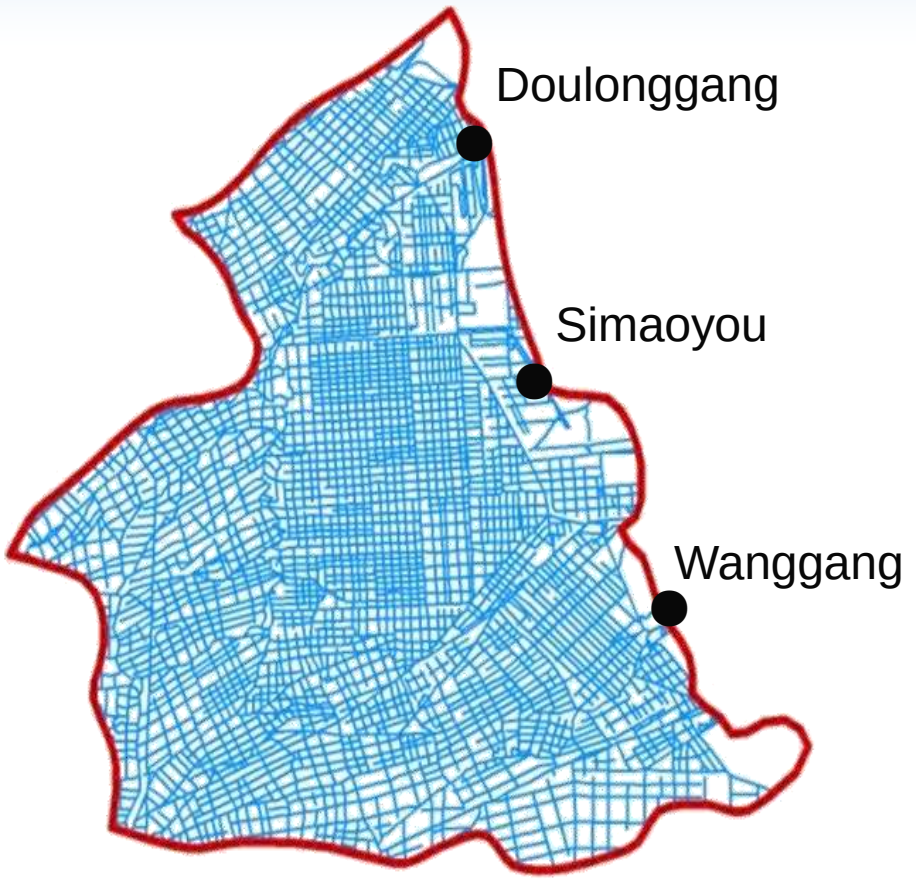
- Recently, some studies about non-point source (NPS) pollution in plain river networks were taken in China. But, most of them were focused on field scale and regional simulations of NPS by model were insufficient.
- The study area is characterized by dense river system and less difference in elevation. Agricultural activities in this region are extremely heavy for its farm land accounts for 87.47% of the whole area.

Study Area



Research area: Dafeng City, Jiangsu Province, China

- In this area, the river system is complex and there are three outlets of the watershed. Rivers of the area are discharged into Yellow Sea directly.
- The major landuse types are paddy (25.19 %), arid (32.14 %) and orchard(30.14%)



1:250000 river system of study area

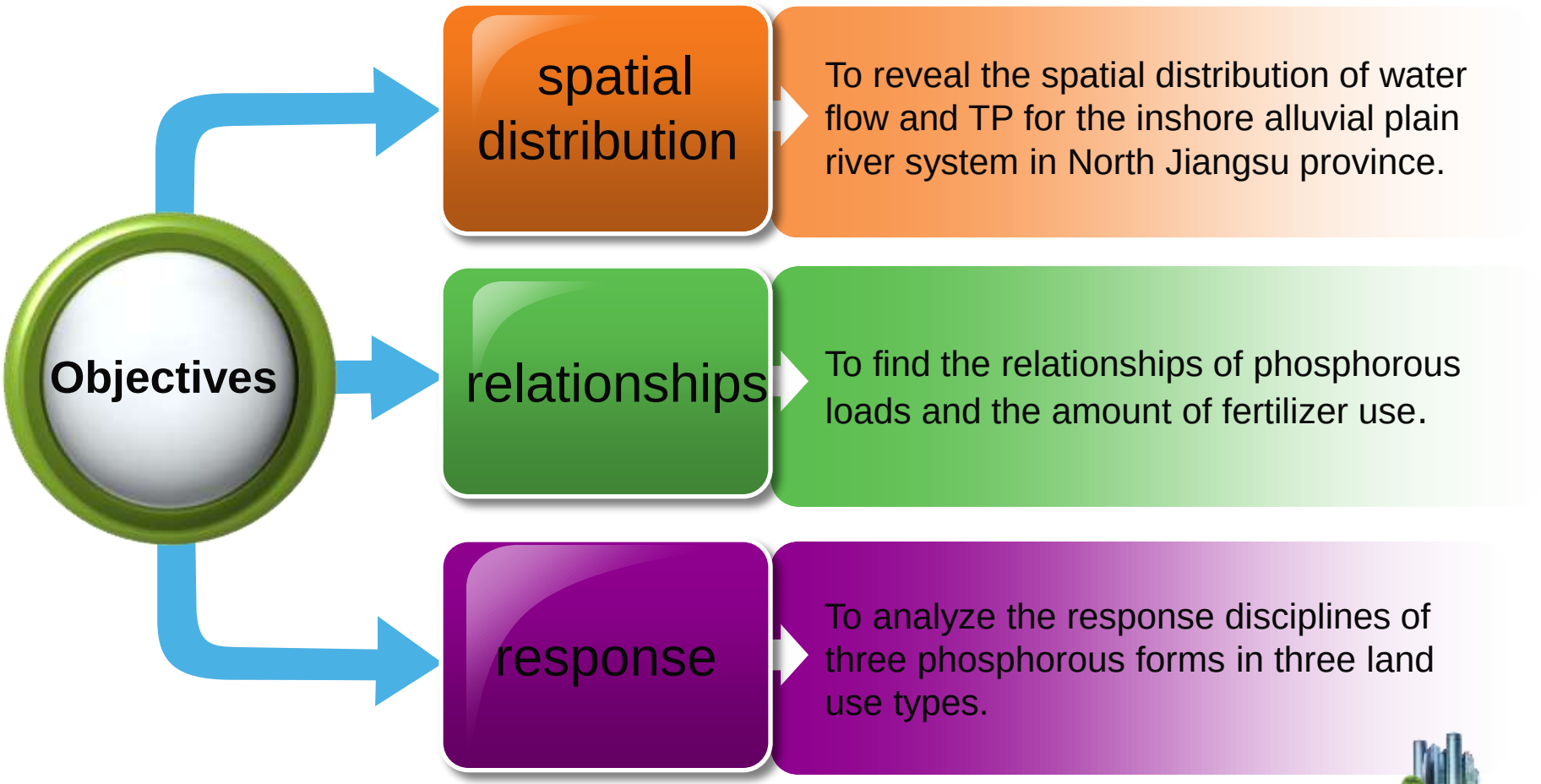
- The local ecological system is very sensitive for there are two national natural reserves.
- Mechanical models are rarely used in this region for the complexity of hydrological process. Thus, NPS researches were usually concentrated in statistics analysis of monitoring data or fertilizer usage.

❖ Condition of Dafeng river channel

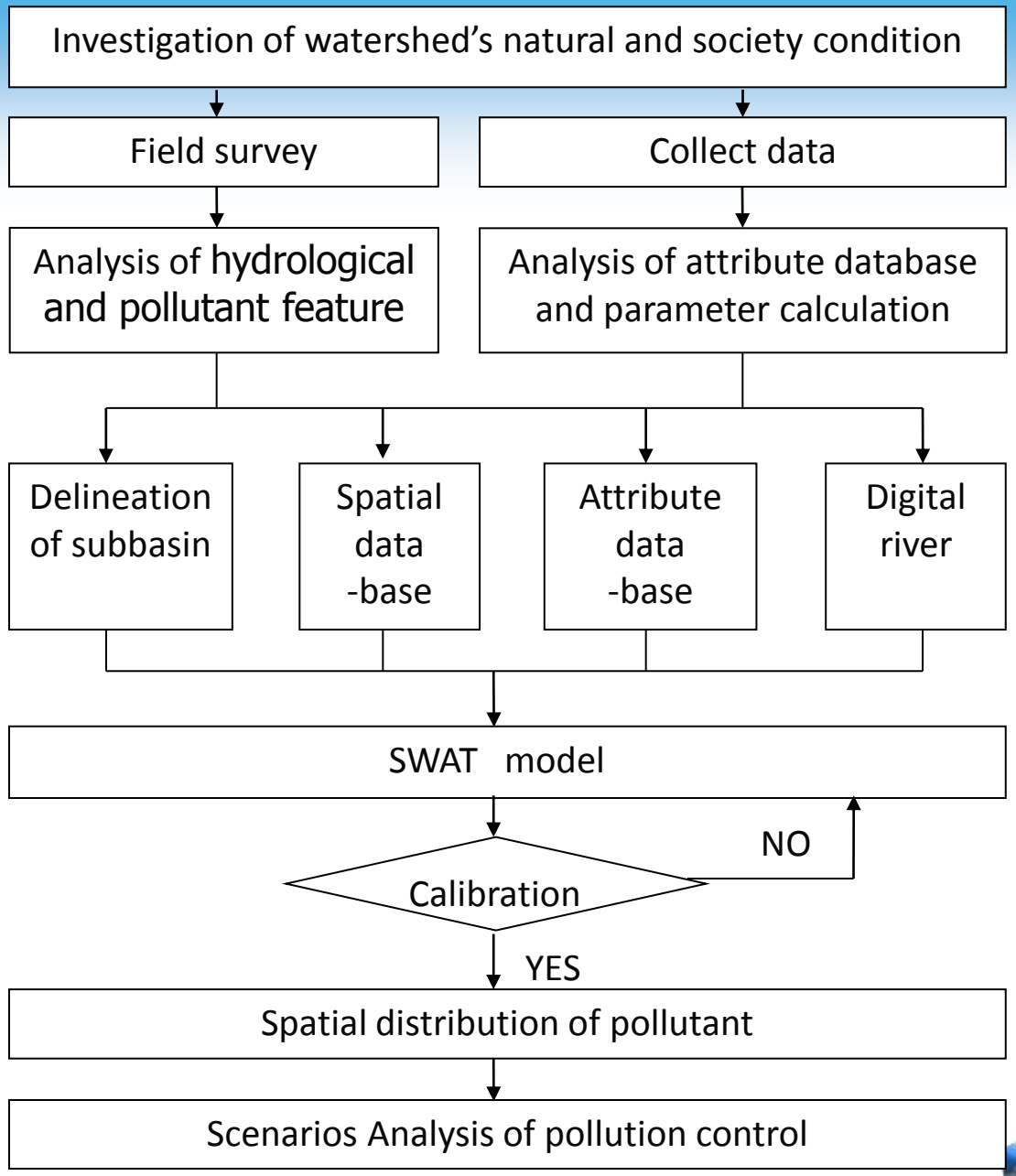
Farmland condition of Dafeng

- Fertilizer rate in study area was extremely high and water quality of the area are degraded continuously.
- To study fertilizer reduction will be a reasonable and useful practice in order to control the degraded water environment.

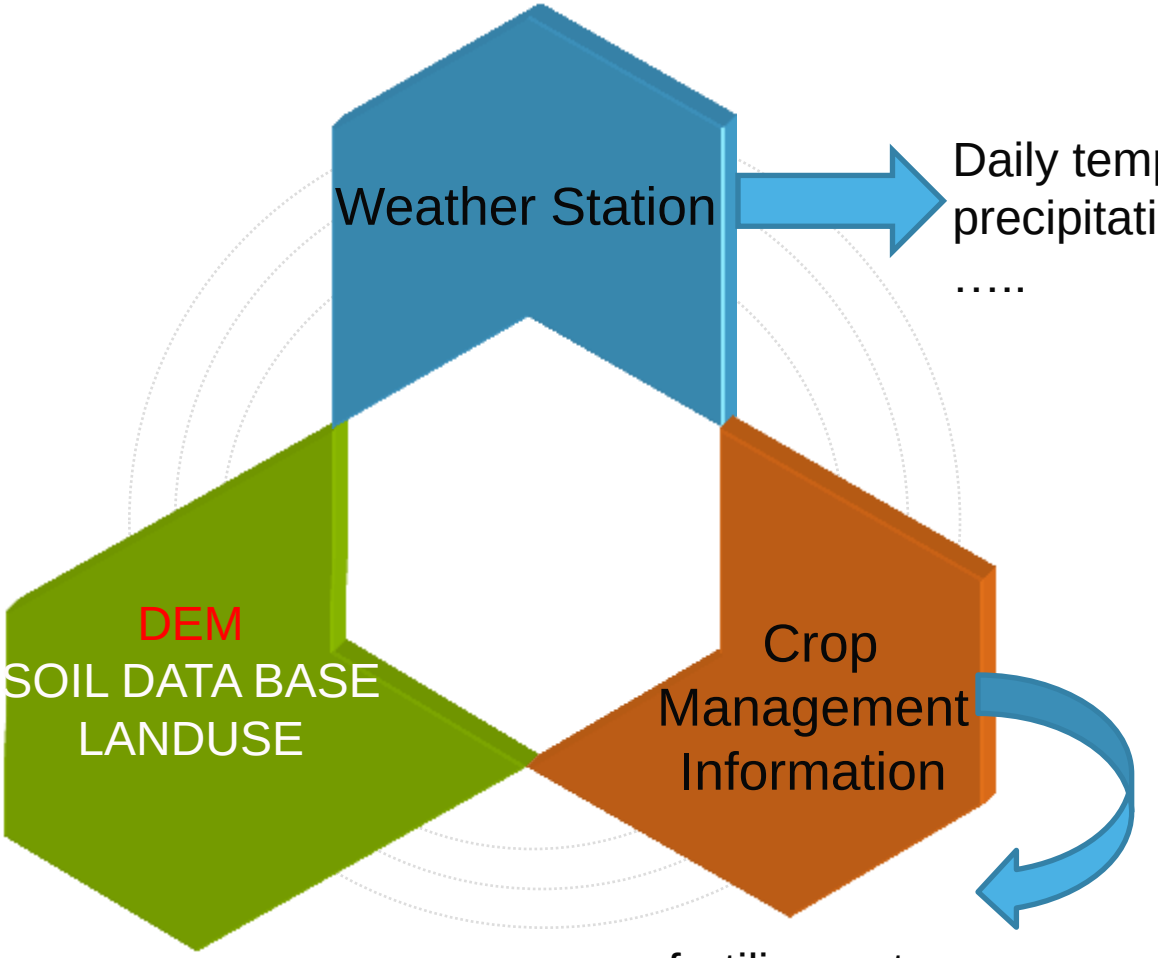
Objectives


Objectives
spatial distribution
To reveal the spatial distribution of water flow and TP for the inshore alluvial plain river system in North Jiangsu province.
relationships
To find the relationships of phosphorous loads and the amount of fertilizer use.
response
To analyze the response disciplines of three phosphorous forms in three land use types.

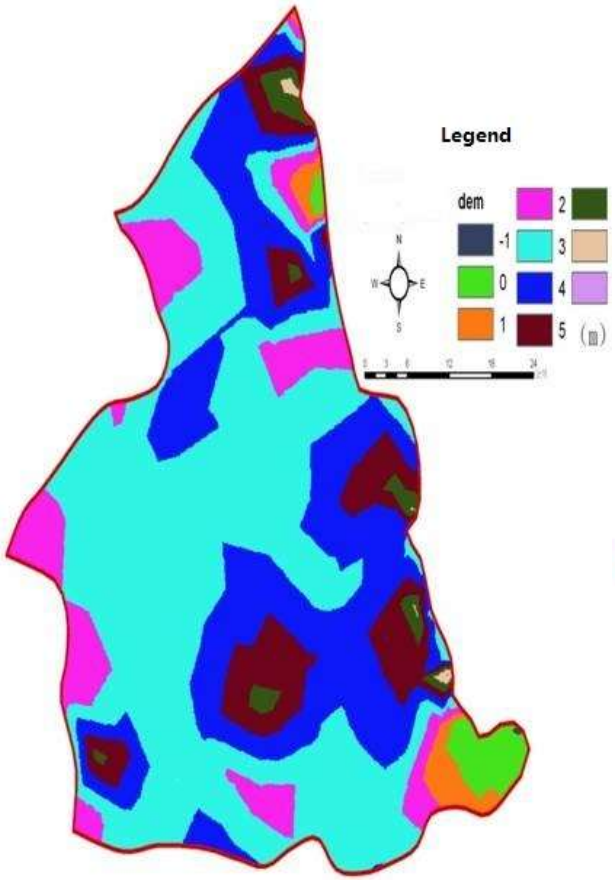
Flowchart


Investigation of watershed's natural and society condition
Field survey
Collect data
Analysis of hydrological and pollutant feature
Analysis of attribute database and parameter calculation
Delineation of subbasin
Spatial data -base
Attribute data -base
Digital river
SWAT model
Calibration
NO
YES
Spatial distribution of pollutant
Scenarios Analysis of pollution control

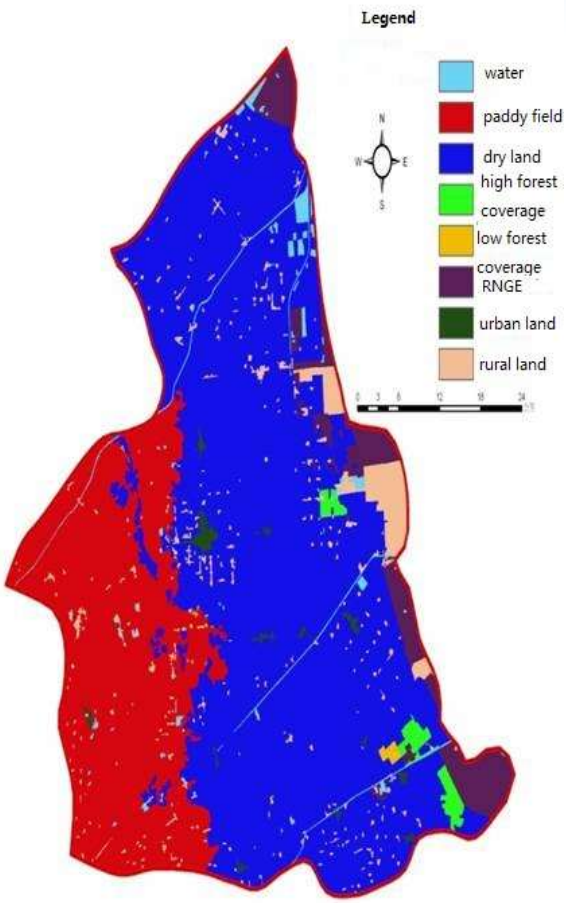
Data sources



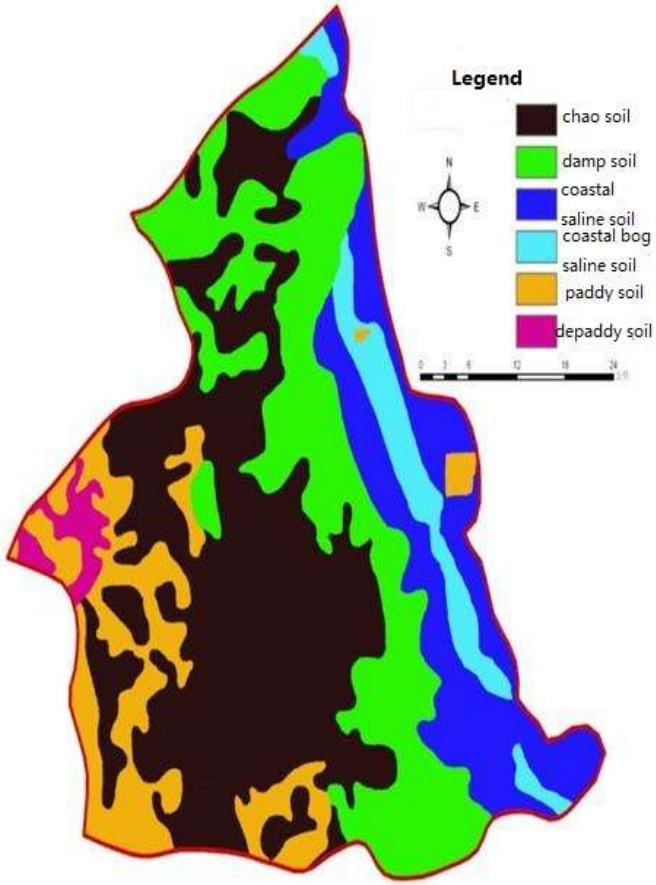
Input data



DEM

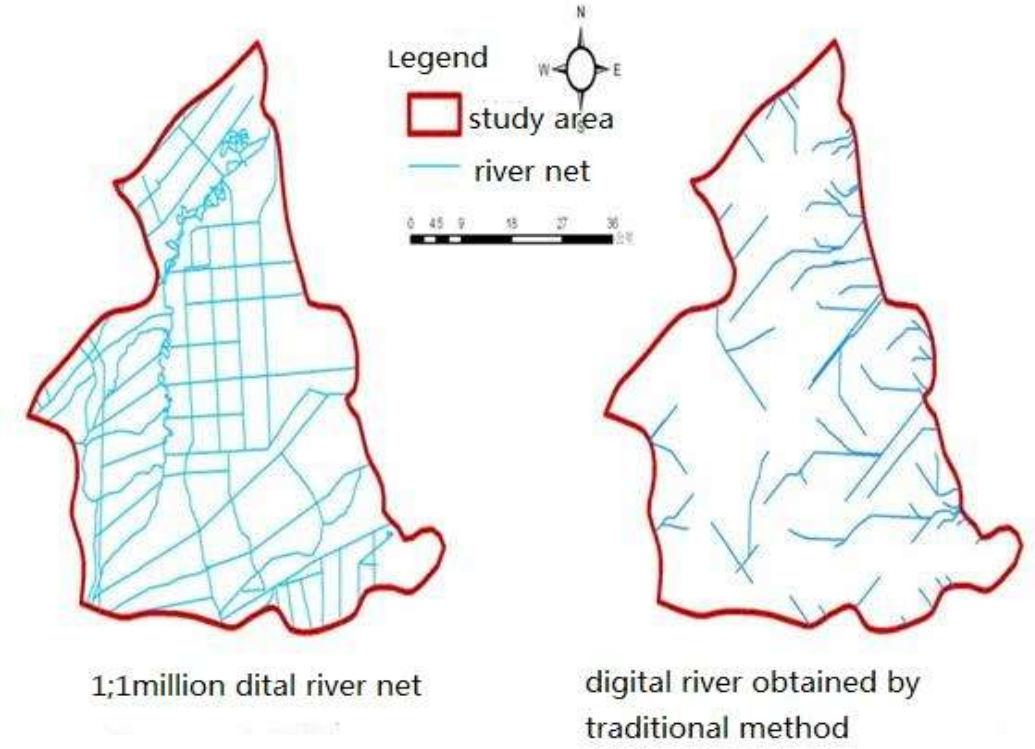


LANDUSE



SOIL

- To draw the digital river is very hard because of flat terrain



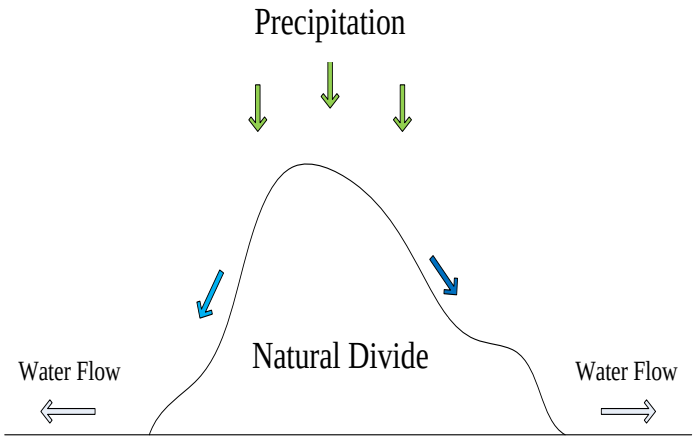
1;1million dital river net

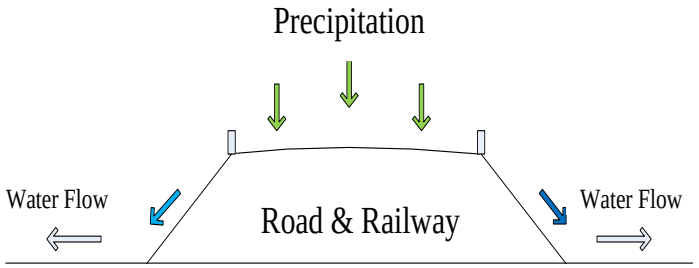
digital river obtained by traditional method

- Digital River

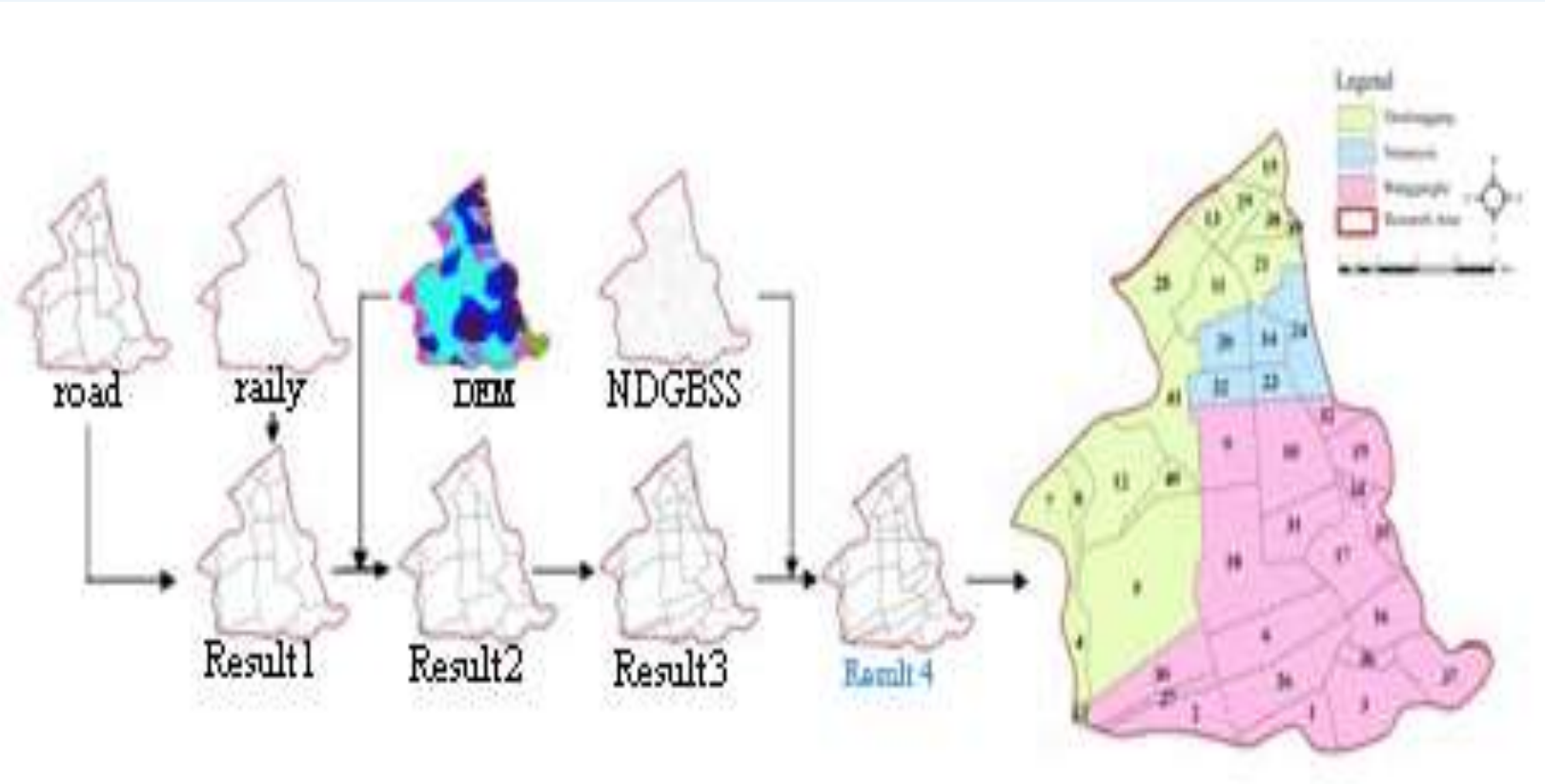
Manually designed watersheds and streams

- Because of less than 8 meters' difference in elevation, extremely intensive river network and the complicated hydraulic connection among the rivers. Considering the distribution of bridges(culverts) and sluice gates, the sub-basins were delineated based on roads and rails network.





Result and discussion

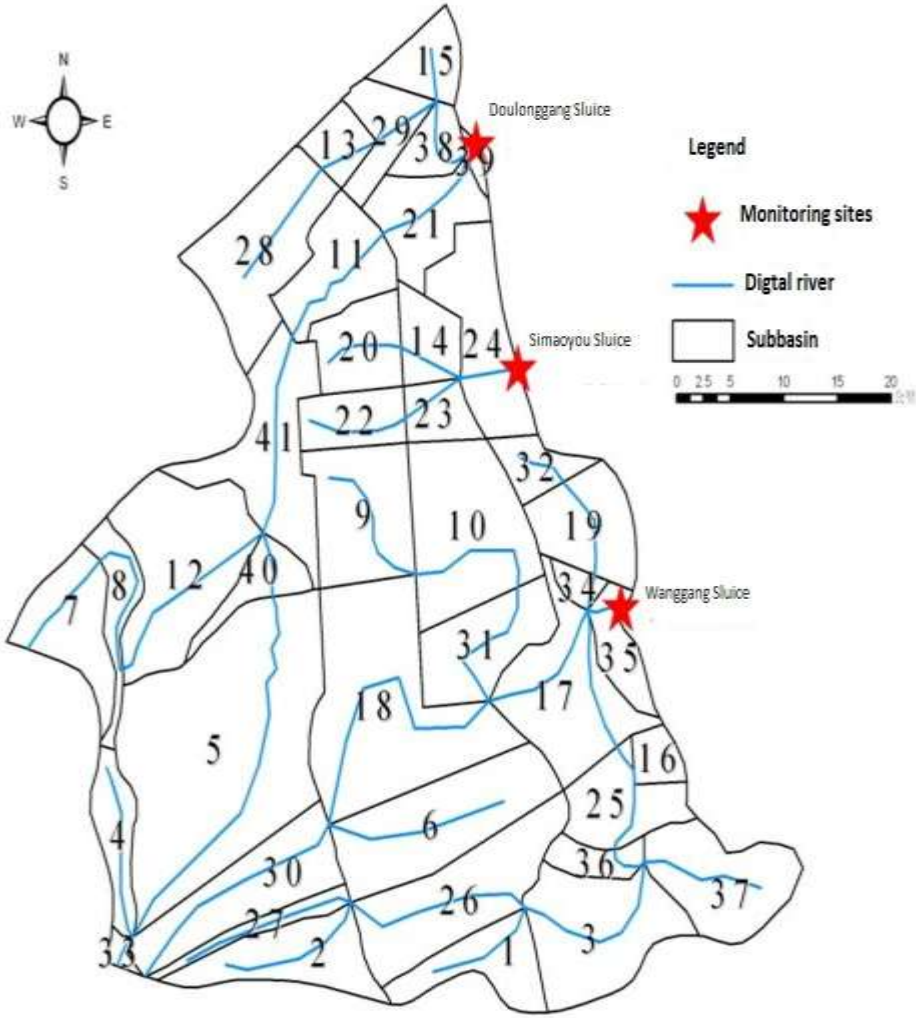


Flowchart of sub-basins delineation and the final result of the manually designed sub-basins

Calibration Results

- We selected monitoring data of three watershed outlets as to carry out calibration and validation.

- SWAT-CUP software was used to calibrate the model, with the Sequential Uncertainty Fitting (SUFI-2) method to model Uncertainty analysis and calibration.



Calibration ***Results***

The monitored data of hydrology, organic phosphorus and mineral phosphorus from 2003 to 2008 is used. Four groups of 700 times SWAT simulation could lead to a reasonable results. The following is the parameters we chose to calibrate.

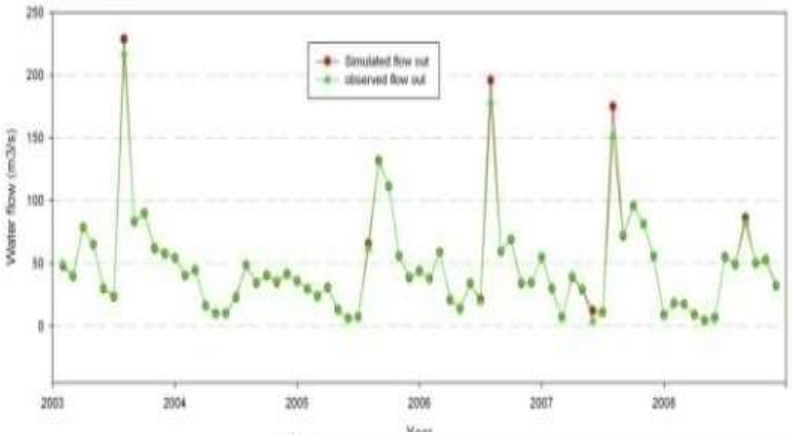
parameters	parameters	parameters	parameters
r__CN2.mgt	v__BC2.swq	v__GWQMN.gw	v__Rchrg_Dp.gw
v__ALPHA_BF.gw	v__BC3.swq	v__REVAPMN.gw	v__SOL_SOLP(1-2).chm
v__GW_DELAY.gw	v__AI1.wwq	v__Usle_P.mgt	v__PSP.bsn
v__CH_N2.rte	v__AI5.wwq	v__Ch_Cov.rte	v__ERORGP.hru
v__CH_K2.rte	v__AI6.wwq	v__Ch_Erod.rte	v__RS2.swq
v__ALPHA_BNK.rte	v__K_N.wwq	v__Spcon.bsn	v__RS5.swq
v__SOL_AWC(1-2).sol	v__NPERCO.bsn	v__Spexp.bsn	v__K_P.wwq
r__SOL_K(1-2).sol	v__SOL_NO3(1-2).chm	v__RSDCO.bsn	v__AI2.wwq
a__SOL_BD(1-2).sol	v__SOL_ORGN(1-2).chm	r__SLSUBBSN.hru	v__ERORGN.hru
v__SFTMP.bsn	v__Phoskd.bsn	v__RS3.swq	v__ERORGN.hru
v__CANMX.hru	v__Pperco.bsn	v__RS4.swq	v__ERORGN.hru
v__ESCO.hru	v__Sol_Orgp(1-2).chm	v__BC1.swq	v__ERORGN.hru

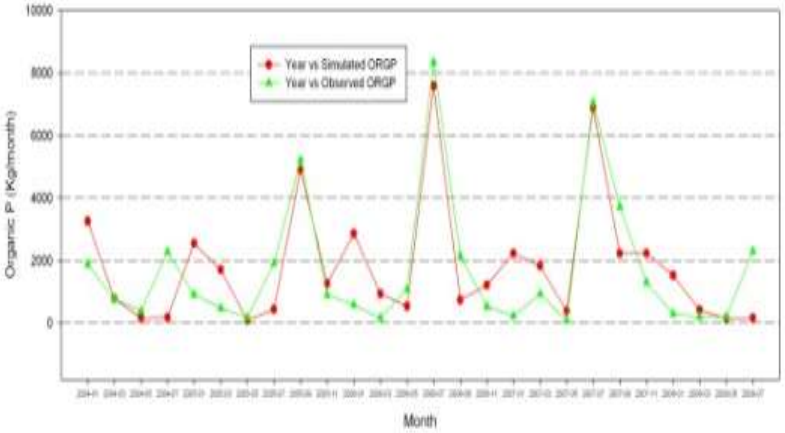
Calibrating Results of SWAT model

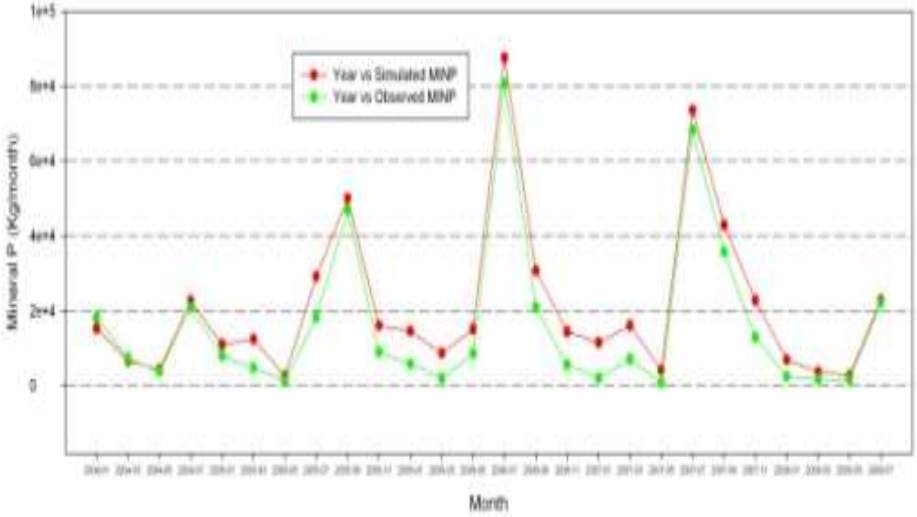
Watershed	Items	Pearson Correlation(R^2)	Nash-Sutcliffe
Doulonggang	Water Flow	0.96	0.80
	Organic Phosphorus	0.77	0.56
	Mineral Phosphorus	0.93	0.43
Simaoyou	Water Flow	0.99	0.96
	Organic Phosphorus	0.62	0.34
	Mineral Phosphorus	0.97	0.57
Wanggang	Water Flow	0.79	0.69
	Organic Phosphorus	0.73	0.71
	Mineral Phosphorus	0.81	0.77

- In the table, we could find that simulation results of Doulonggang watershed was better than others.

Comparing the simulation results with monitoring data of water flow, organic P and mineral P simulation in Doulonggang watershed

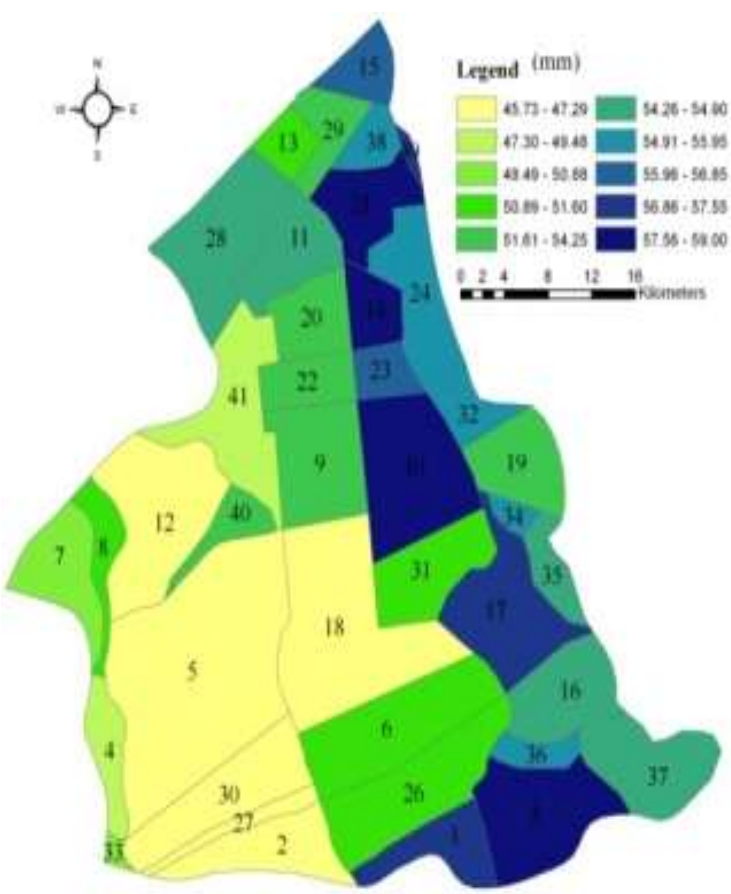


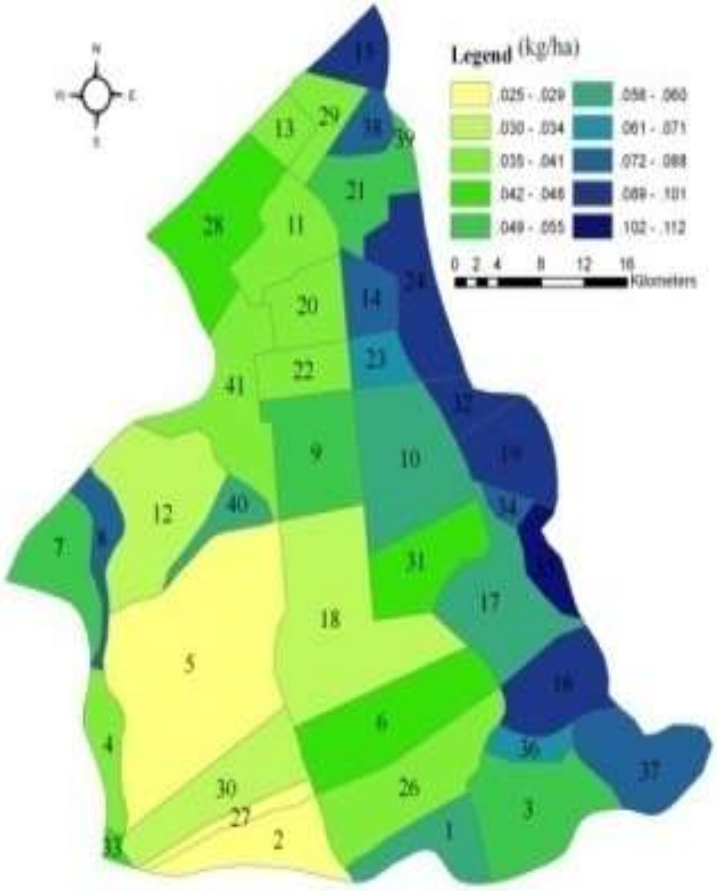




- From the figure, the water flow displayed an excellent simulation.
- The simulation of organic P and mineral P were not as good as water flow. But the results were acceptable.
- In water flow simulation, the most significant feature was the flood peaks of simulation obviously higher than those of monitor data.
- This phenomenon was caused by the flood storage of dense river system. In Dafeng city, river system was extended to every single field. Even the farmer’s house was surrounded by streams. While a rainfall reaches the streams, overflow will not appear until the river way is filled.

Spatial distribution of rainfall and TP in Dafeng area from 2003 to 2008





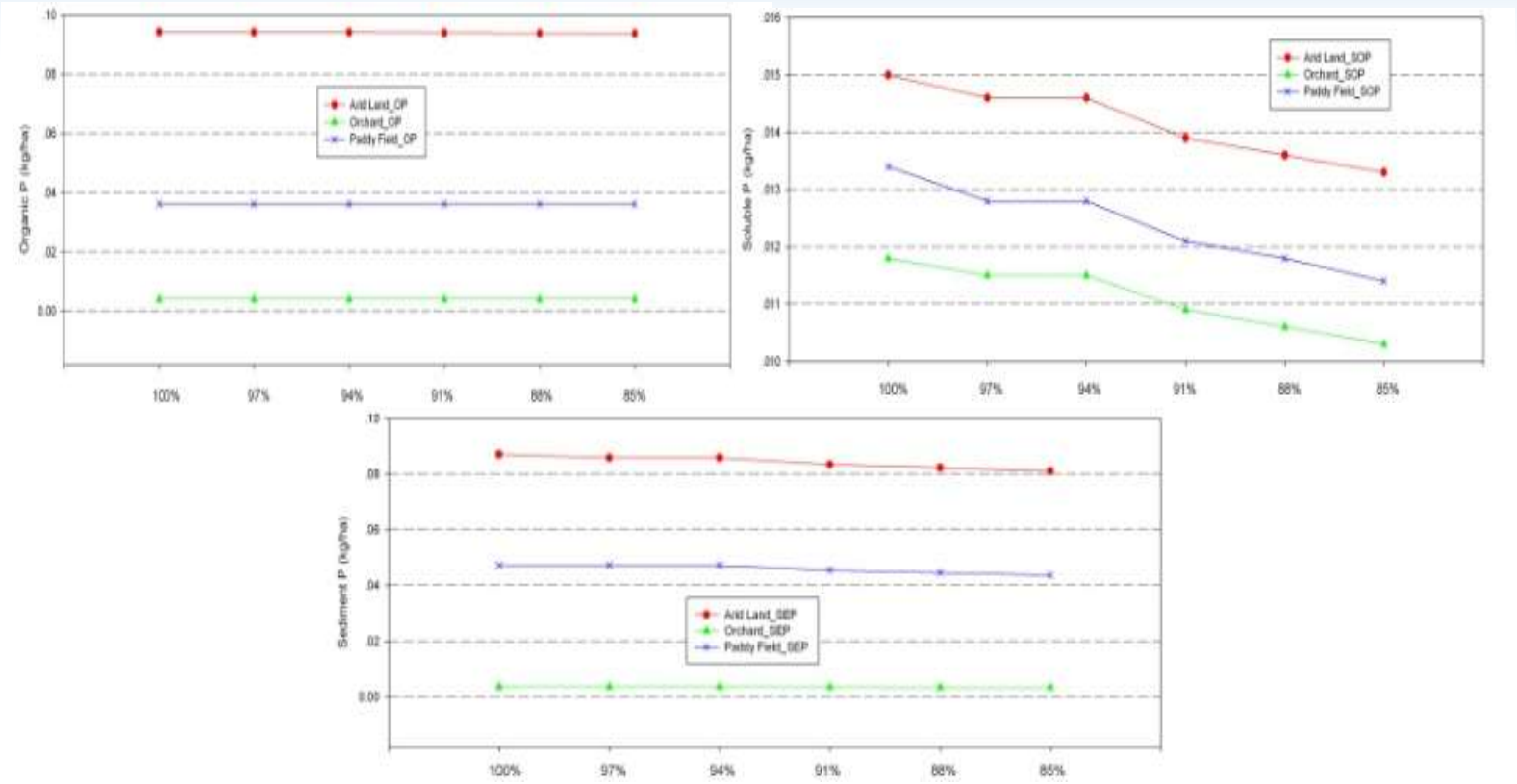
- Spatial distribution of rainfall and TP showed relatively coincident result.
- Water flow and TP in east were higher than the west. There was no obvious difference in north and south.
- Downstream of Simaoyou and Wanggang watersheds has the highest rainfall (59.0mm/month) and TP.

BMPs Design

- The scenarios were designed based on the actual fertilizer rate of 2005.
- A step 3% was chosen for its short enough to reveal the possible details of response and long enough to represent the potential downward capability of total fertilizer rate.
- The range was limited between 85% and 100% of the fertilizer rate in 2005. The fertilizer database consists of phosphate fertilizer and compound fertilizer.

The scenarios of fertilizer rate

Items	Fertilizer usage kg/ha	Nitrogenous fertilizer kg/ha	Phosphate fertilizer kg/ha	Compound fertilizer kg/ha
Increasing 3% based on actually used in 2005	1094.797	557.1991	371.6549	144.7047
Actually used in 2005	**1062.91**	**540.97**	**360.83**	**140.49**
Reducing 3% based on actually used in 2005	1031.023	524.7409	350.0051	136.2753
Reducing 6% based on actually used in 2005	999.1354	508.5118	339.1802	132.0606
Reducing 9% based on actually used in 2005	967.2481	492.2827	328.3553	127.8459
Reducing 12% based on actually used in 2005	935.3608	476.0536	317.5304	123.6312
Reducing 15% based on actually used in 2005	903.4735	459.8245	306.7055	119.4165



Organic P, soluble P and sediment P in three land use types

From the chart，arid land contributed the most phosphorus and the phosphorus coming from the orchard was significant less than other two landuse types.

Conclusions

Spatial distribution

The spatial distribution of rainfall and TP showed the water flow and TP in east were both higher than that in west.

Relationship

The scenarios concluded that phosphorus loads were linear correlation to the fertilizer rates in three different landuse types.

Response

Sensitivity with fertilizer reduction： Soluble P> Sediment P >Organic P; Paddy field presented great P reduction response. Arid land and orchard were moderate response.

Thank you for your attention!