UiO : Department of Chemistry
University of Oslo

Assessment of phosphorus loss risk from soil

- a case study from Yuqiao reservoir local watershed in north China

By
B.P. Joshi

Main supervisor: Rolf David Vogt
Co-supervisors: Grethe Wibetoe
Bin Zhou

Outline of the presentation

- Introduction
- Theory
- Materials and methods
- Results and Discussion
- Conclusions

The main issue

- *60 - 70% of the surface water resources in China have too poor quality*
- *Eutrophication is the main cause for poor ecological quality*

Working across borders

- Sino Tropia- Bilateral project between China and Norway (2011 – 2014)

- Funding supported by the Chinese Academy of Sciences (CAS) and the Research Council of Norway (RCN)

- Participating research institutes from China:
  - Tianjin Academy of Environmental Sciences (TAES)
  - Research Center for Eco-Environmental Sciences (RCEES)
  - Institute for Urban and Environmental Studies Chinese Academy of Social Science （CASS）
- Participating research institutes from Norway:
  - University of Oslo (UiO)
  - Norwegian Institutt for Water Research (NIVA)
  - Norwegian Institute for Urban and Regional Research (NIBR)

Study site description:

Local watershed of Yuqiao Reservoir

Why?

Yuqiao Reservoir

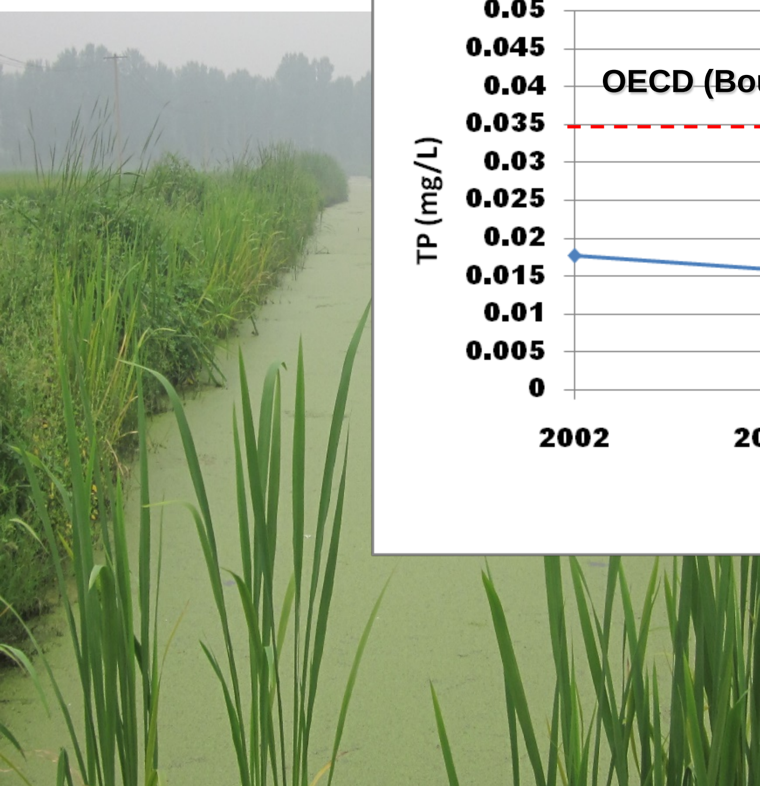
Local watershed

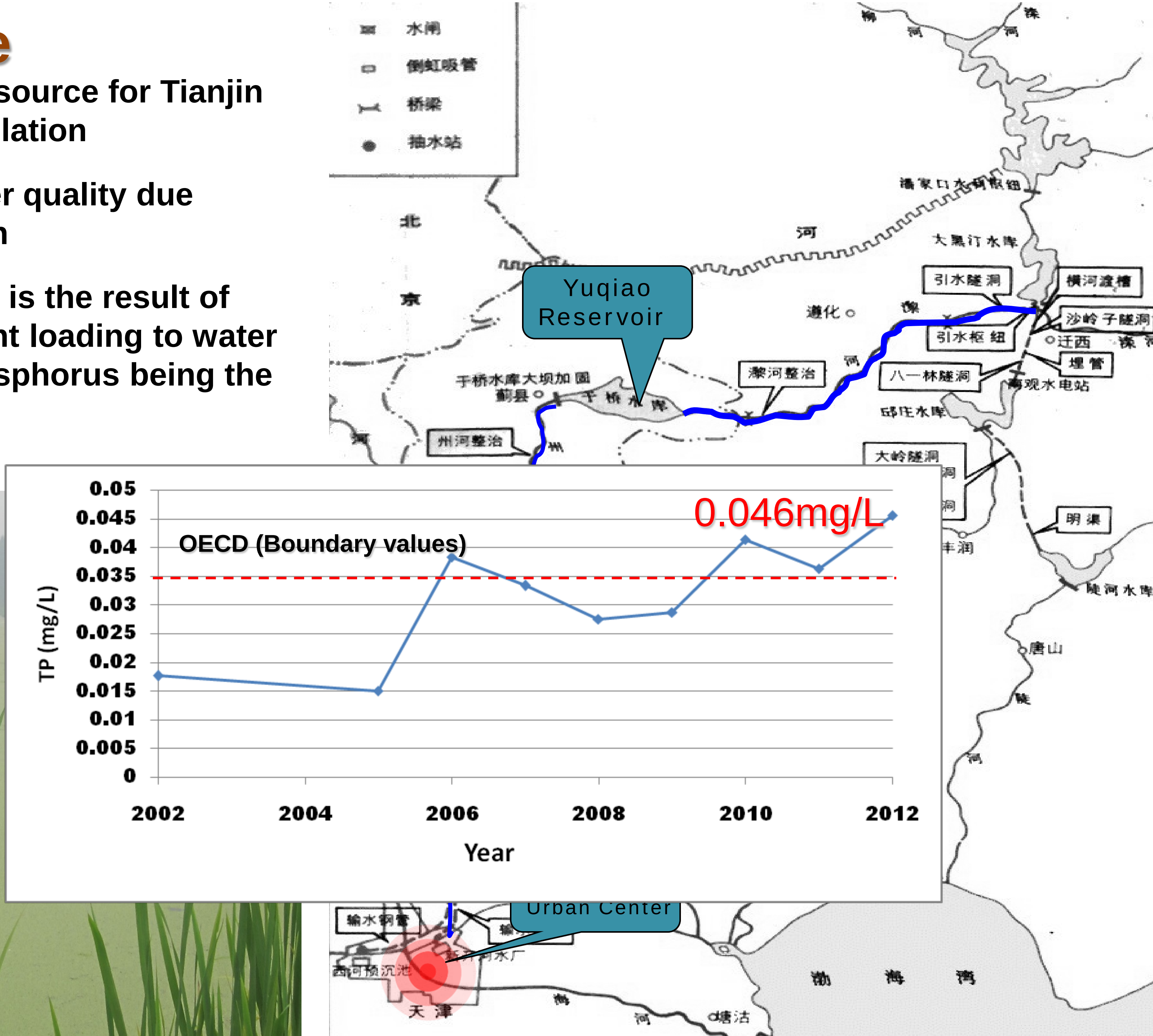
The case

●Drinking water source for Tianjin
6.36 million Population

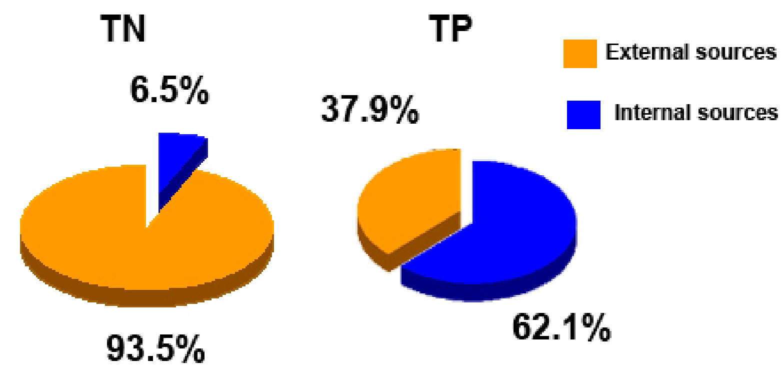
● Declining water quality due to Eutrophication

● Eutrophication is the result of excessive nutrient loading to water bodies, with phosphorus being the main problem.

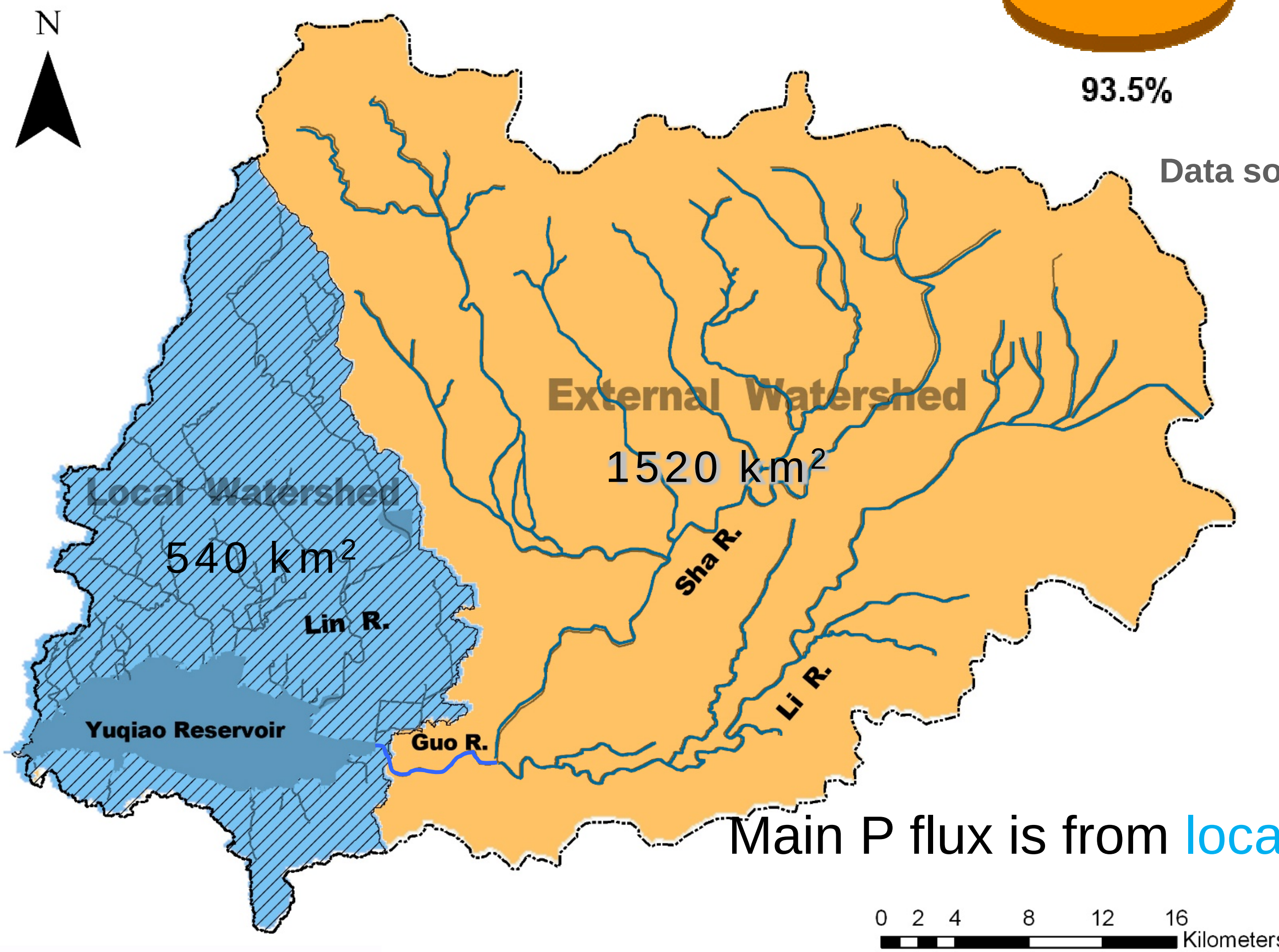




Source of nutrients



Data source: Ji County EPB(2009)



Main P flux is from local watershed

Main Non-point source pollution types

Livestock breeding

- Livestock population
- 370.0 tons manure/ year

People

- 137,000

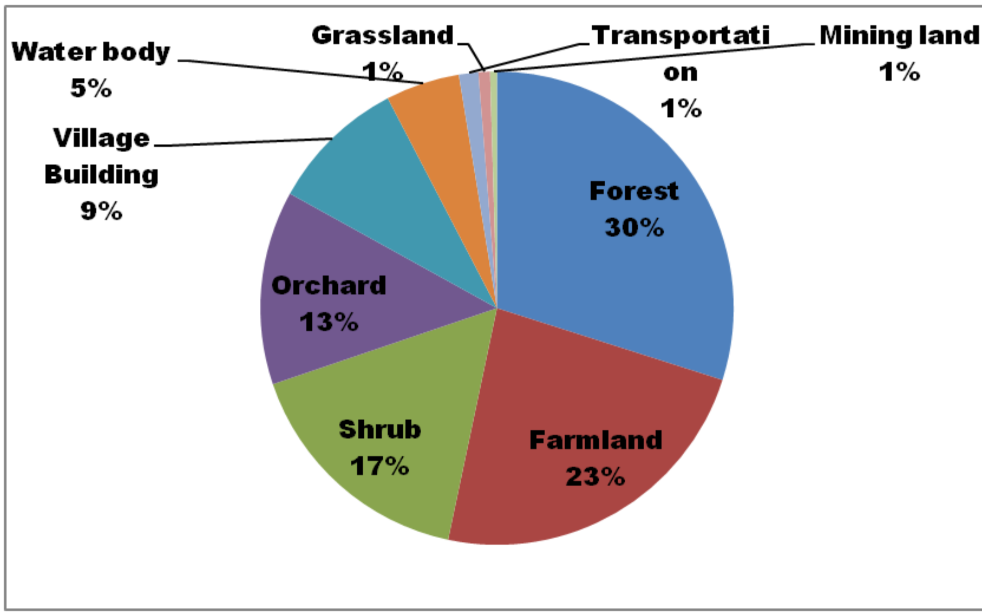
Farmland planting

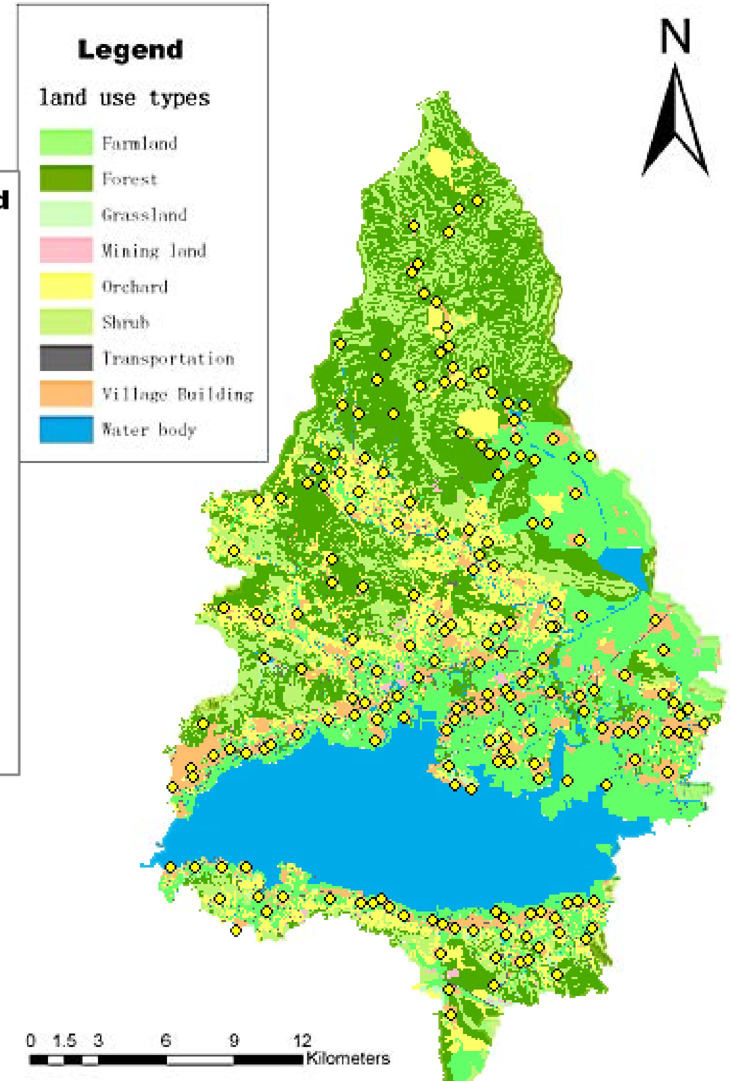
- 110,000 (Mu)

1Mu = 660m2

Land-use and population

Population
Land-use



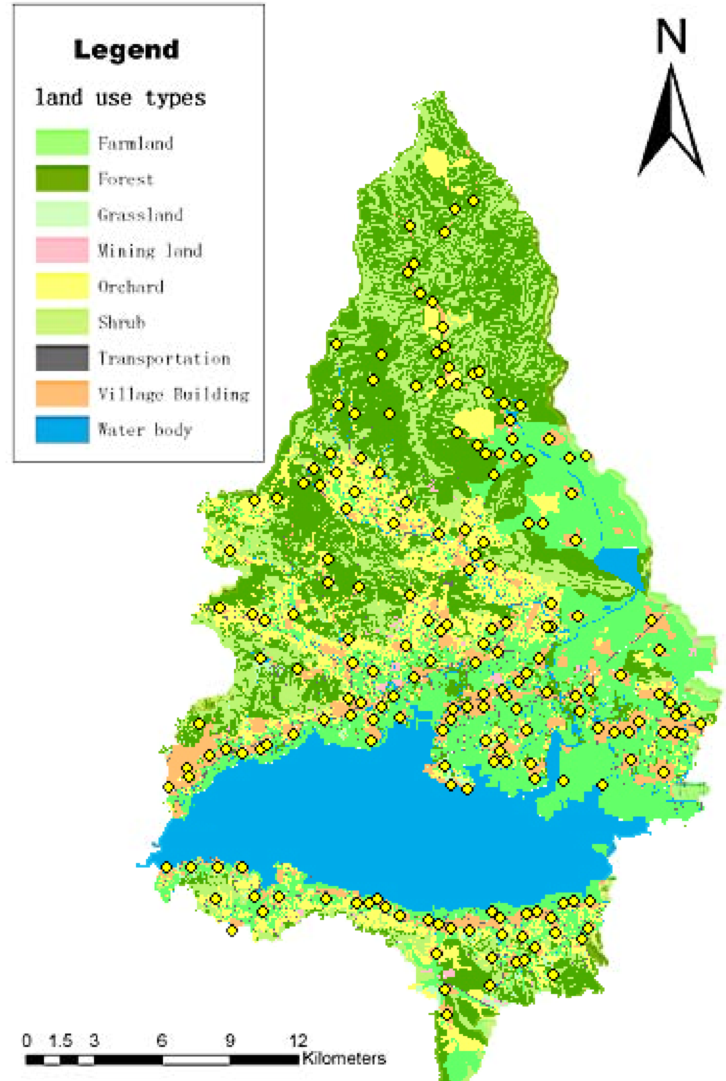


Farmland + orchard: 36%

Land-use and population

- 152 villages
- 137 000 residents in the local catchment
- Intensive agriculture with abundence use of fertilizers
- Clay soils with poor water infiltration in the flats
- Sandier soils in the mountain region

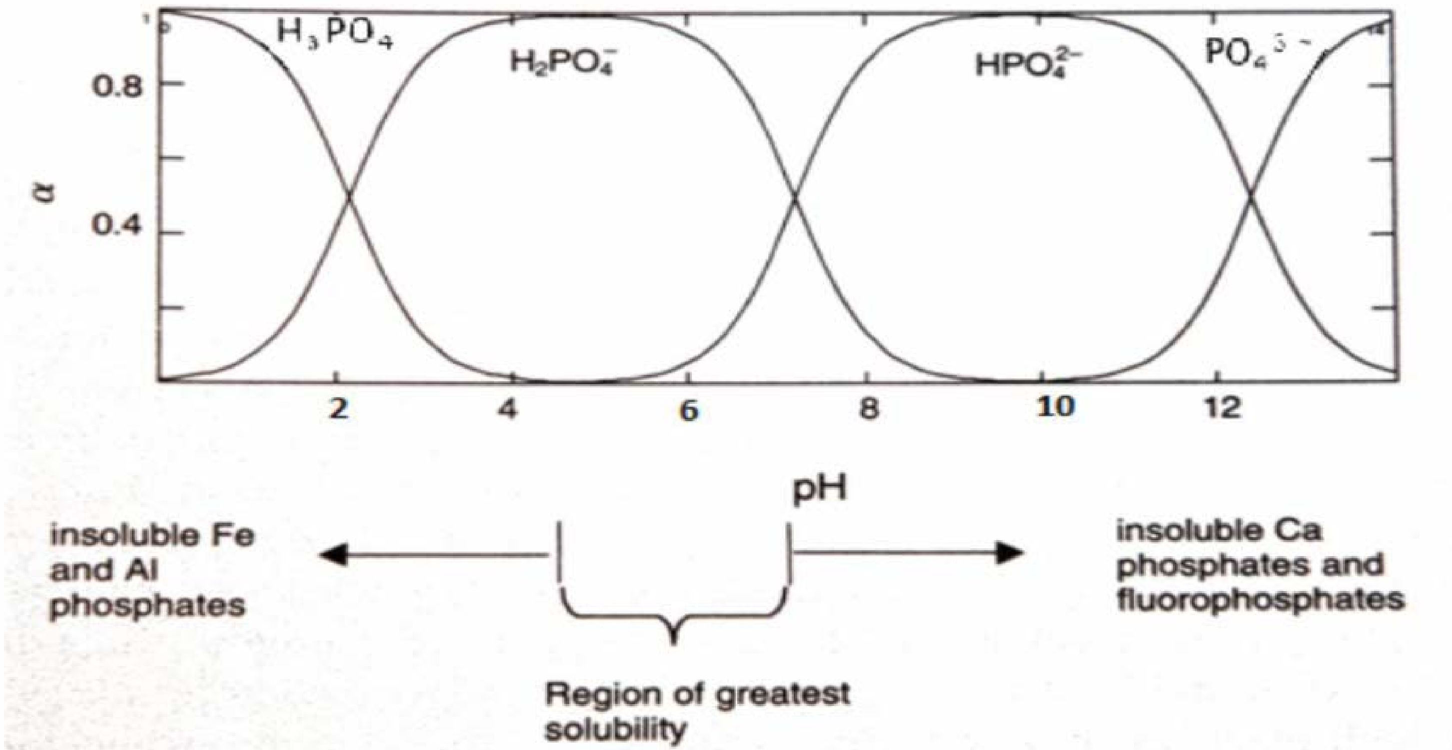
Population
Land-use



Objectives of the master thesis

- Achieving a better understanding of the hydro-geochemical processes that govern the transport of phosphorus from diffuse sources (soil) with respect to different land use types
- Evaluating risk of potential soil P losses
- Identifying the Critical source Area's (CSA's) with respect to phosphorus load into Yuqiao Reservoir

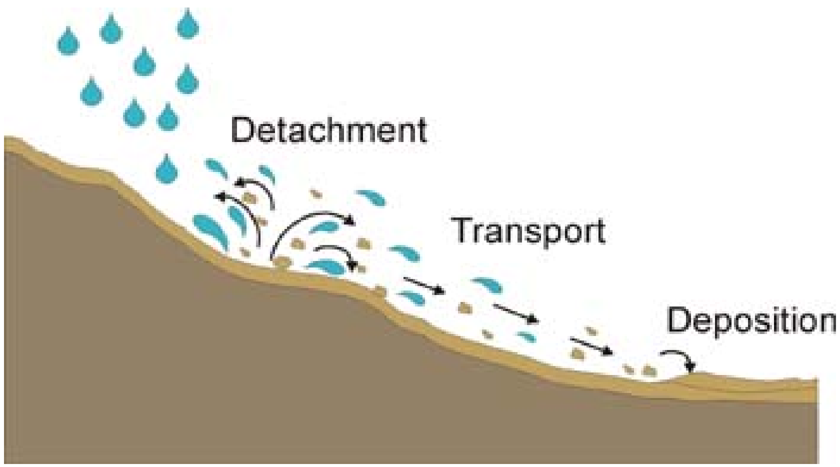
Phosphorus in soil



- **Bioavailable Phosphorus (BAP)**

■ Soil Erosion

➢ The natural process where rocks and soil are removed from the surface of earth by exogenic processes,

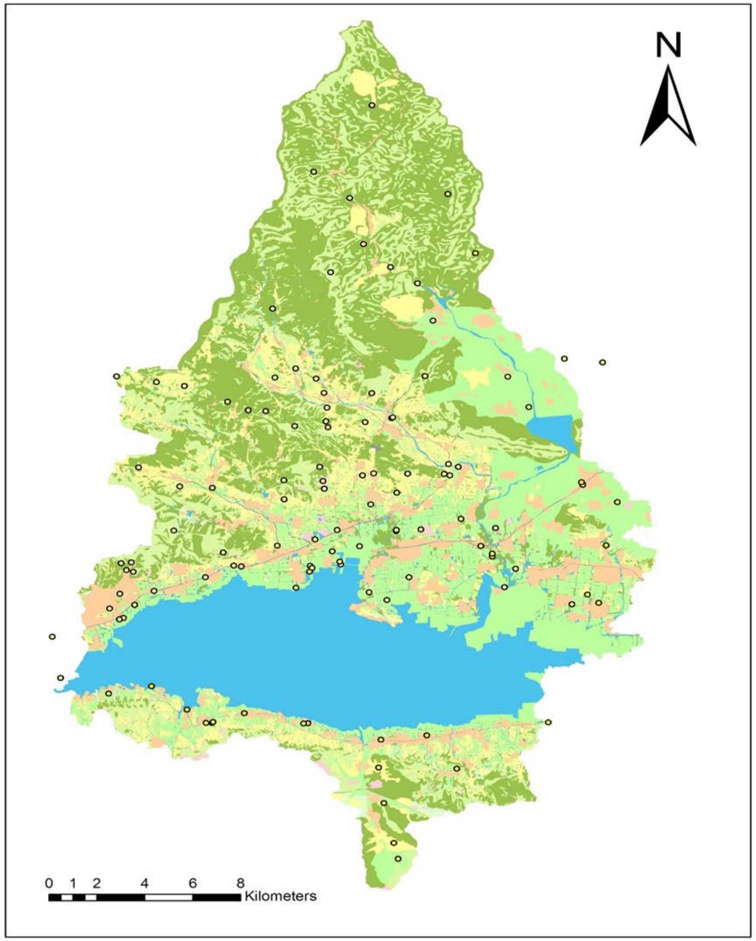


➢ Soil erosion is considered as the most important process involving P transfer in particulate form from agricultural areas

➢RUSLE is a widely used mathematical model that describes soil erosion processes

Distribution of Samples

- 126 samples in two phase



Parameters

pH,Water content and LOI

P Pools

PSI

BAP

DPS%

pH - 10390 (1998)

Organic Content (LOI, Krogstad 1992)

P pools (TP, TIP, TOP- møberg and Peterson 1982) (Murphy and Riley (1962) and ISO 6878:2004)

PSI (Bache and Williams 1971)

Based on pH BAP divided into two parts

DPS(%)= [BAP/(PSI+BAP)]X100

Bioavailable Phosphorus (BAP)

Method	Extracting agent	Extraction Method	Quantitative analysis	Suggested soil type
Olsen	NaHCO3 (0.5M)	pH:8.5 25±2degree 1:20 (w/v) 30 min 200rpm	molybdate blue method	medium weak acid alkaline soil
Bray-1	NH4F(0.03M) HCl(0.025M)	pH:2.6±0.05 2:20(w/v) 5min 200rpm	molybdate blue method	acid strong acid soil

Olsen P (Olsen et al., 1954) and
Bray P (Bray and Kurtz P-1 (Bray and Kurtz 1945)

Phosphorus sorption index (PSI)

The PSI is highly correlated with adsorption maxima, and thus can be used as a simple tool for the estimation of P adsorption capacity.

From the work of

Mozaffari and Sims,1994; Eghball et al.,1996.

Degree of Phosphorus Saturation (DPS%)

The degree of phosphorus saturation (DPS) is an environmental index to assess the potential of soil for the release of P to runoff and leaching

Degree of P sorbed in the soil relative to the P sorption index of the soil and can be calculated as.

$$DPS\% = \frac{BAP}{BAP + PSI} x100$$

(Allen and mallarino 2006).

Simplified Phosphorus Index Model

Source part

↓

DPS(%)

Transportation part

↓

Soil erosion

↓

USLE Model

$$T = R \times K \times LS \times C \times P$$

Transportation Part

USLE model

Developed by Wischmeier and Smith 1965
Calculates long-term average annual soil loss from the product of six factors.

$$T = R \times K \times LS \times C \times P$$

R=Rainfall erosivity factor

K=Soil erodibility factor

LS=Slope length and slope gradient factor

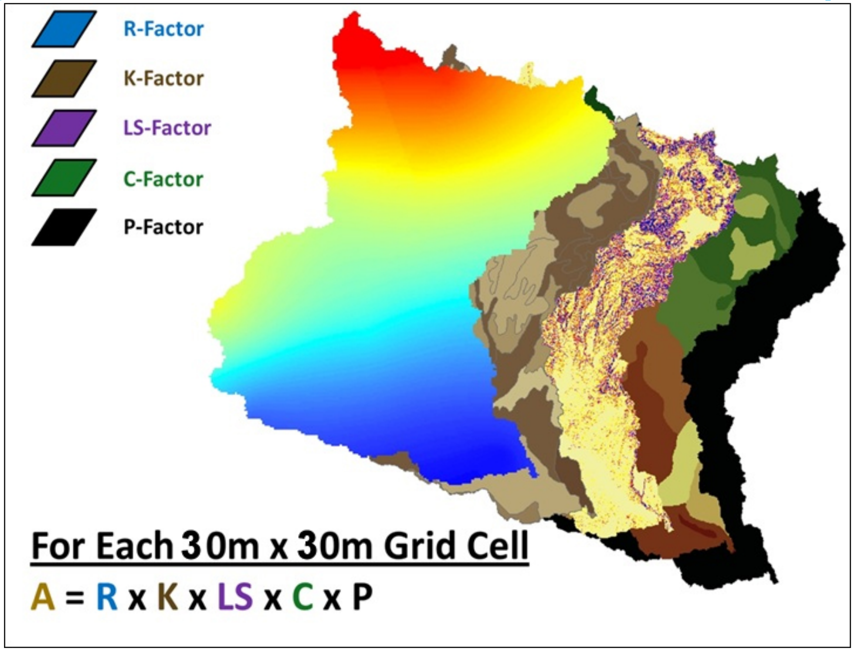
C=Crop management factor

and P=Conservation practices factor

USLE and GIS

GIS is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

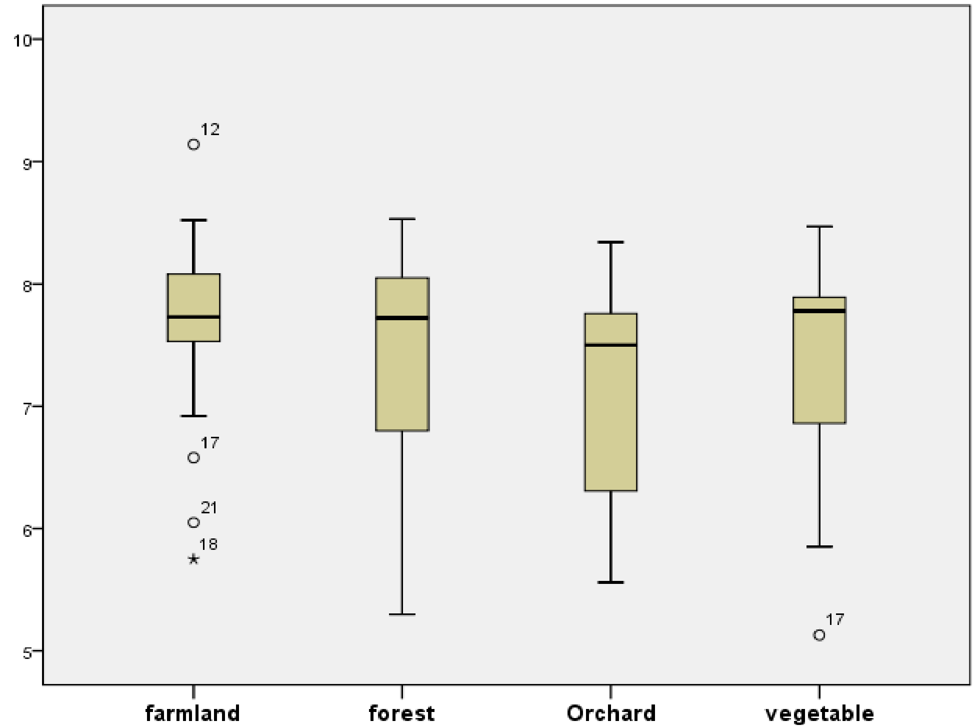
In GIS the USLE factors are structured as individual digital layers and multiplied together to create the soil erosion potential map.



pH (H2O)

pH of soil sample range from 5.5 to 8.5.

Around 80% of soil samples have pH 6.0 to 8.0 therefore optimal for the mobility of orthophosphate ion.

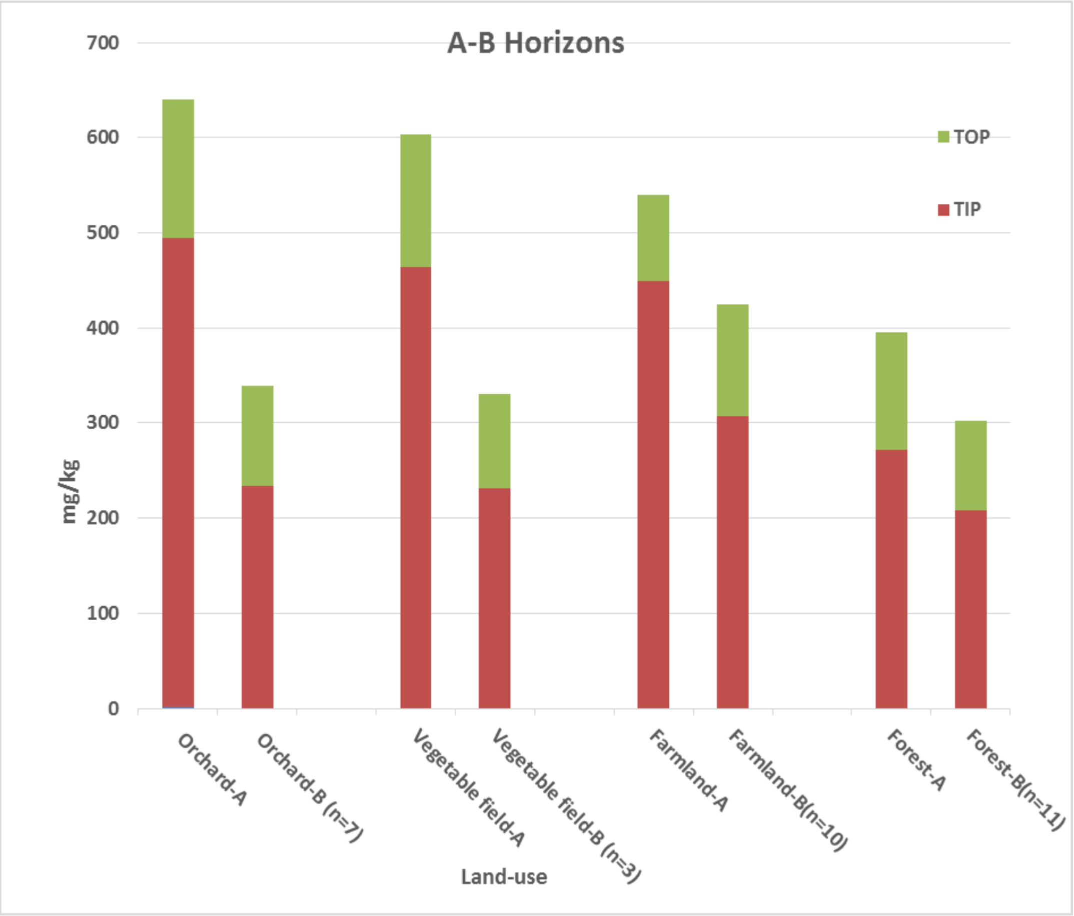


Phosphorus

The amount of TIP and TOP from A and B horizons from 31 plots with different land use.

TIP for A and B horizons in farmland and forest shows less variations as compare to other land-use.

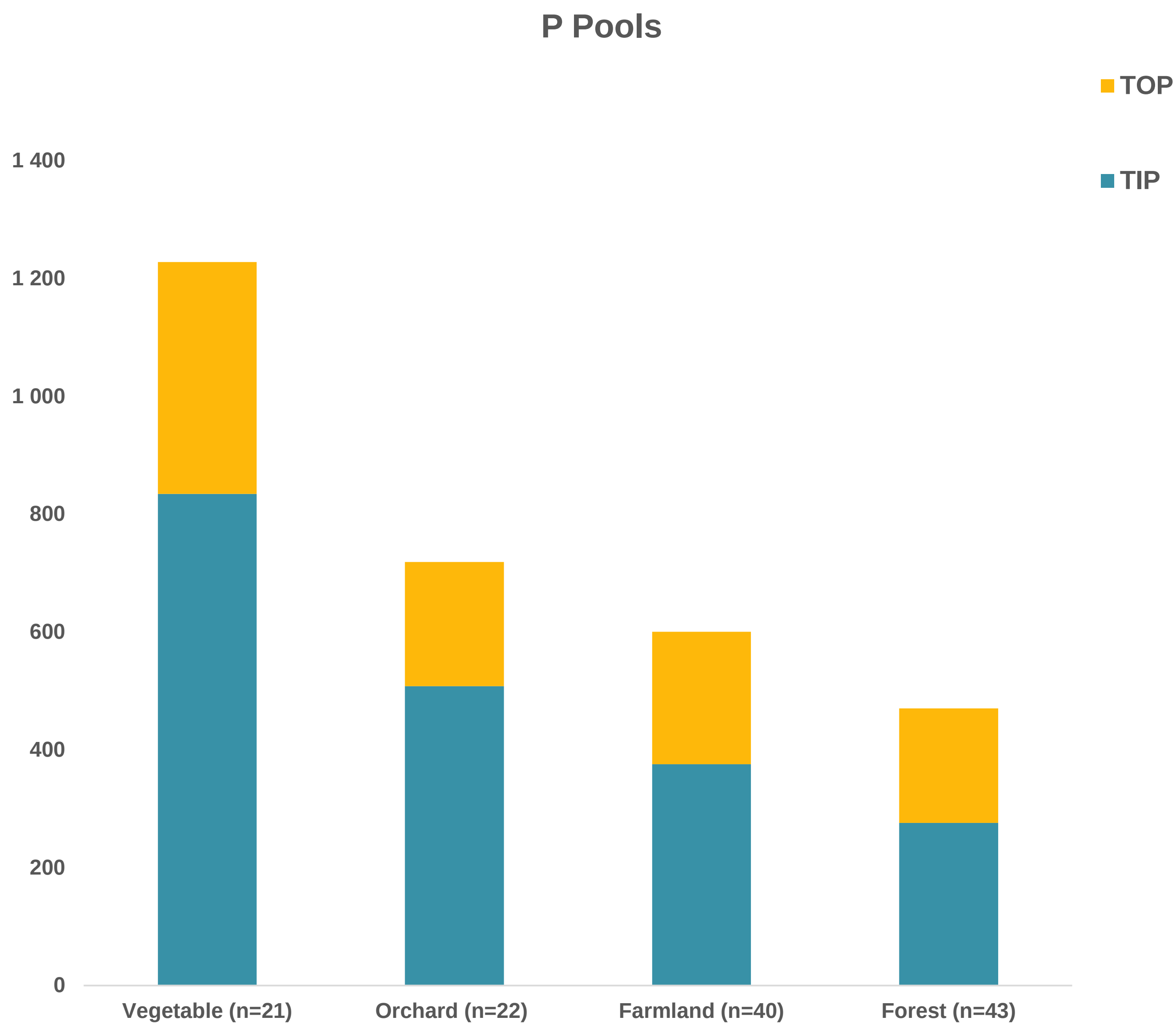
The TOP content is higher in A horizon except in Farmland, due to faster decomposition rate of organic matter.



Phosphorus For A-horizons

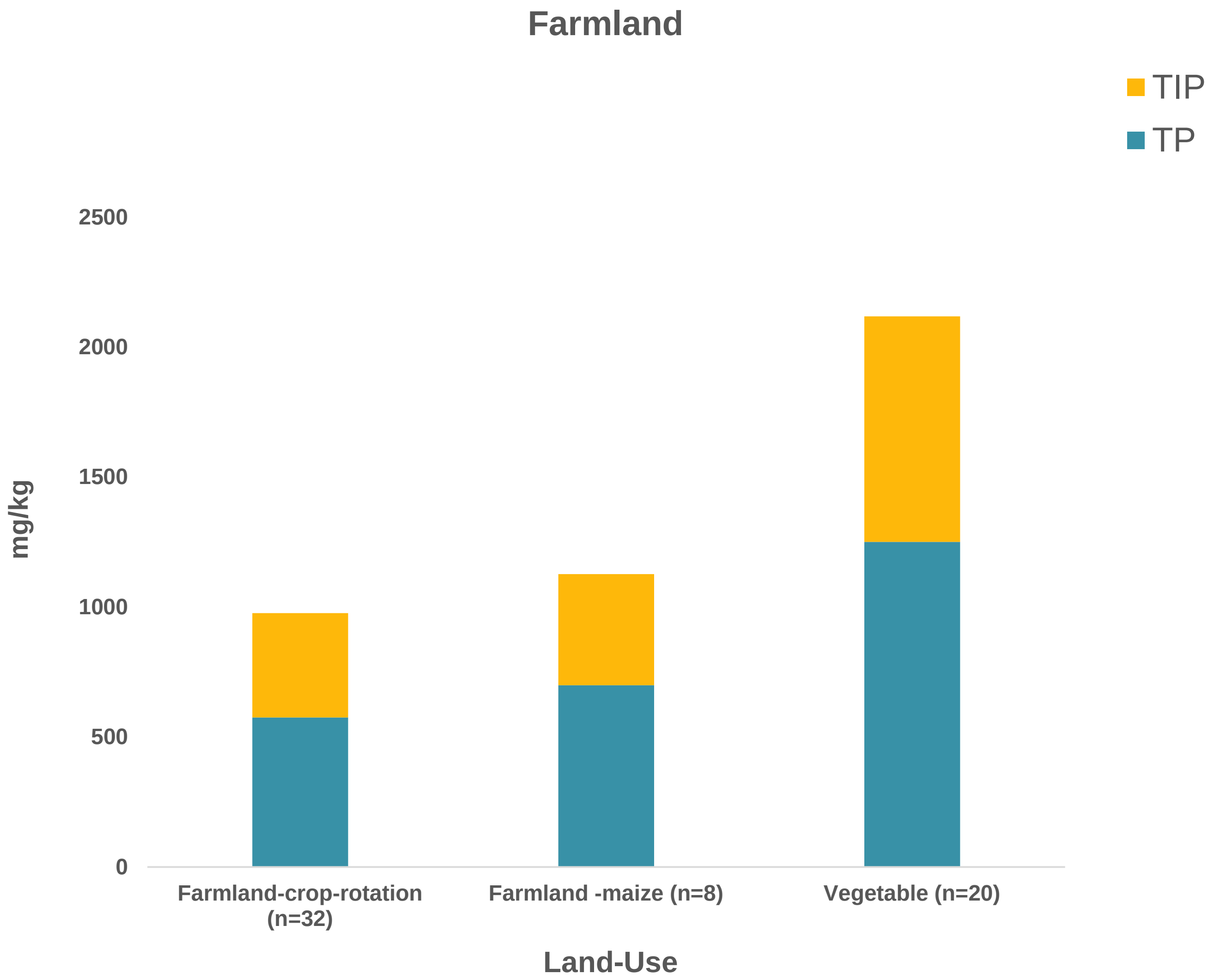
Average 60-70% of TIP and 20-30% of TOP contributes to TP for different land-use

The forest soil has higher percentage of TOP as compare to other land-use



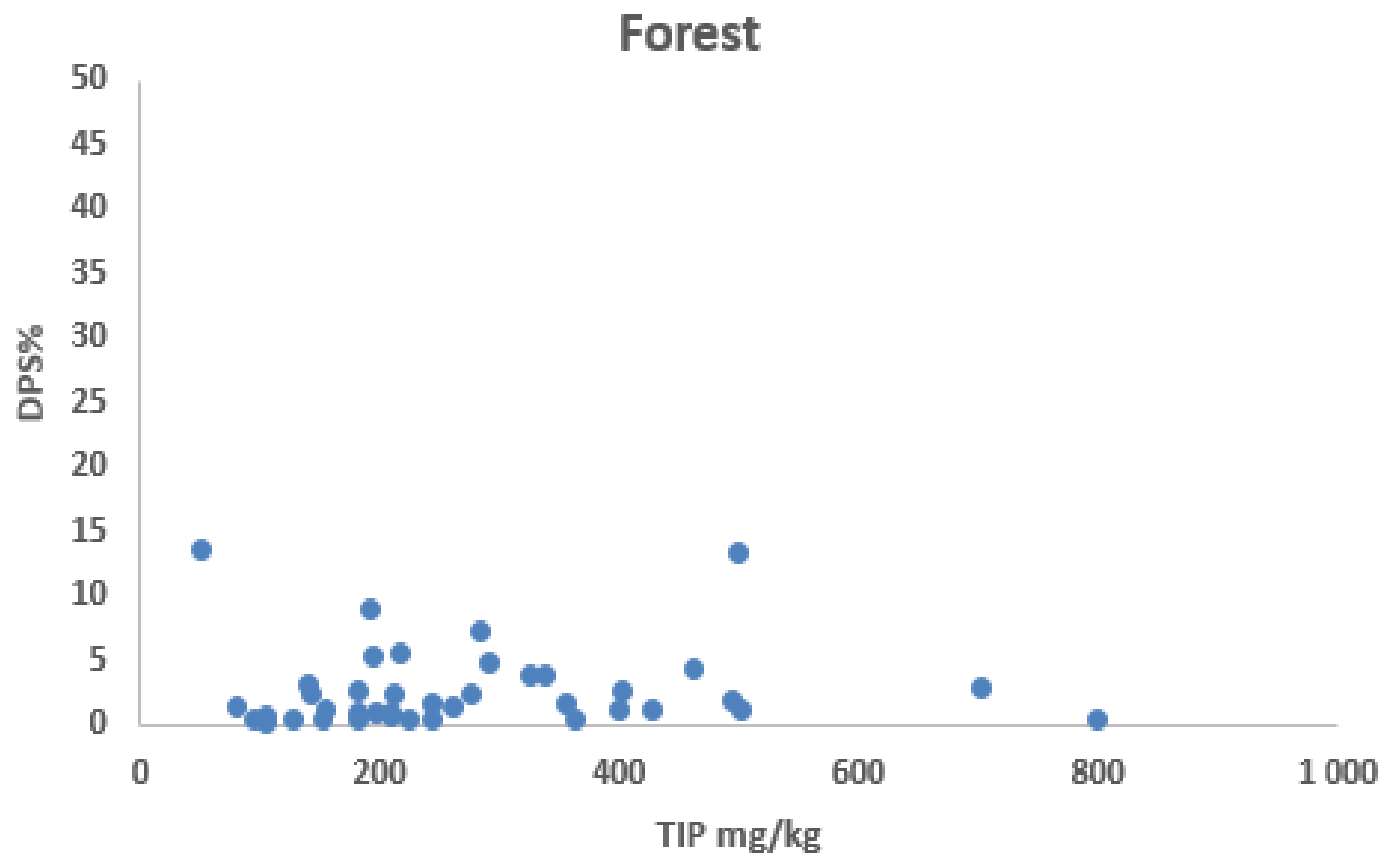
Farmland With Different Crop Practice

- Maize and wheat are main crops.
- People use manure to their field during dry season.
- For maize crop they use manure and chemical Fertilizer during crop grow.



DPS % and TIP

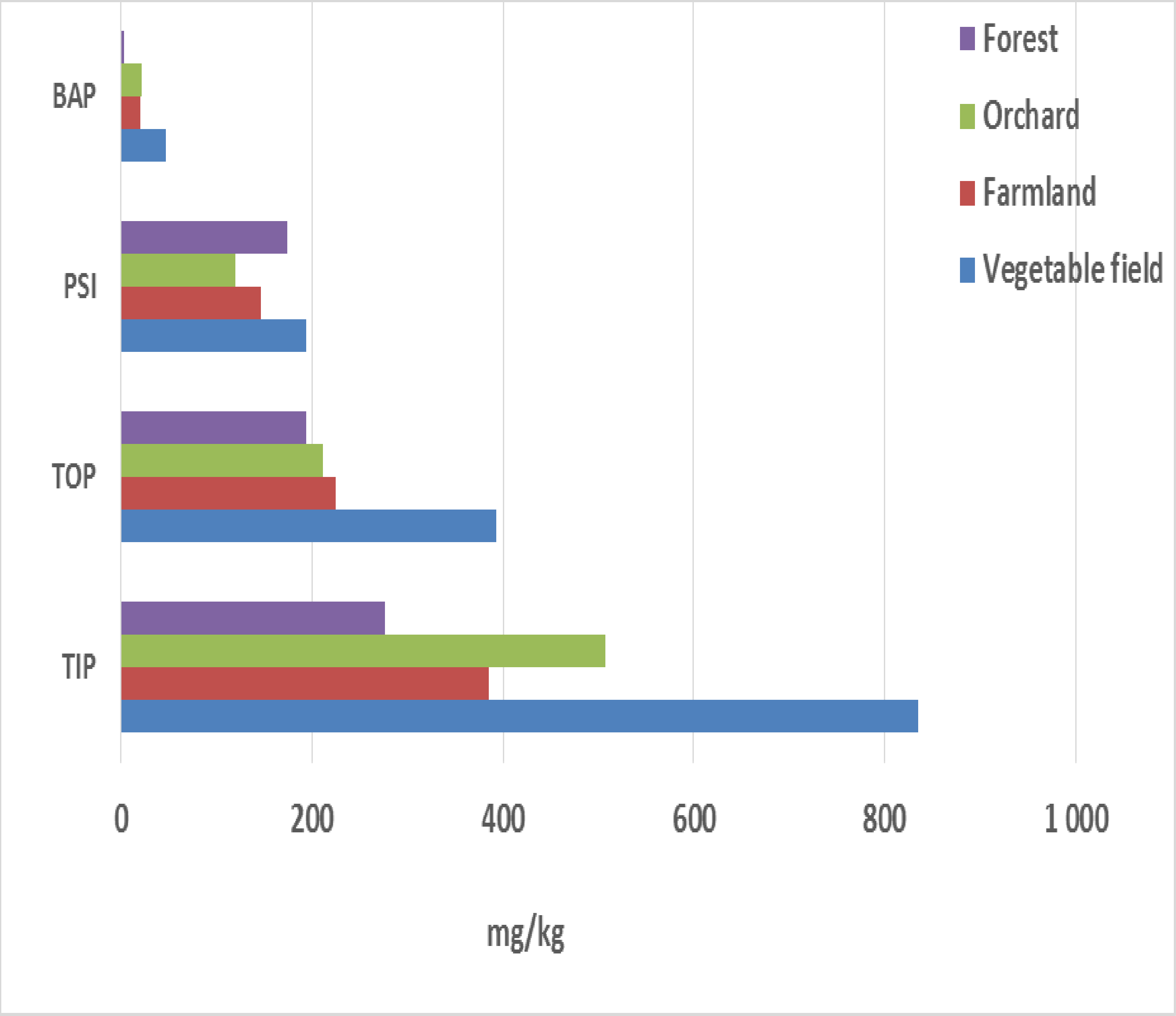
Soil with
DPS%
Value of 20-
40%
Are commonly
Associated
with
Greater risks
of
P loss.
(Breeuwsma
et al., 1995)



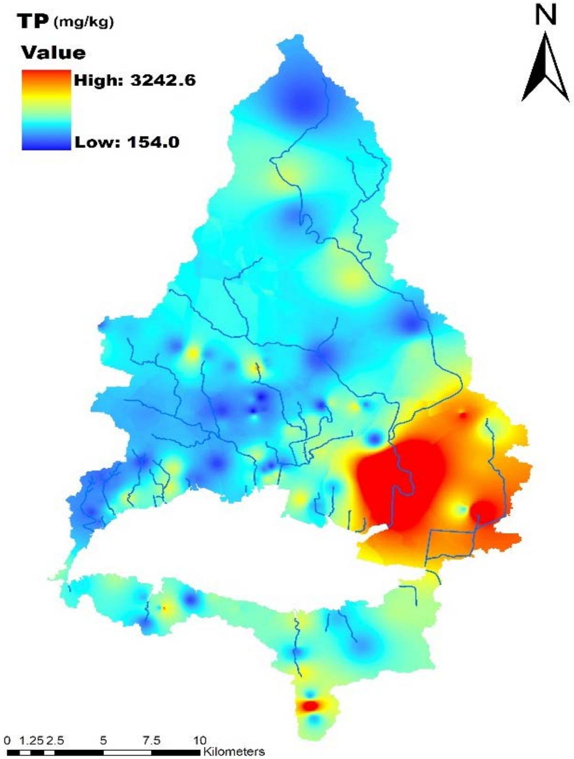
Comparision of P-pools for different Land-use

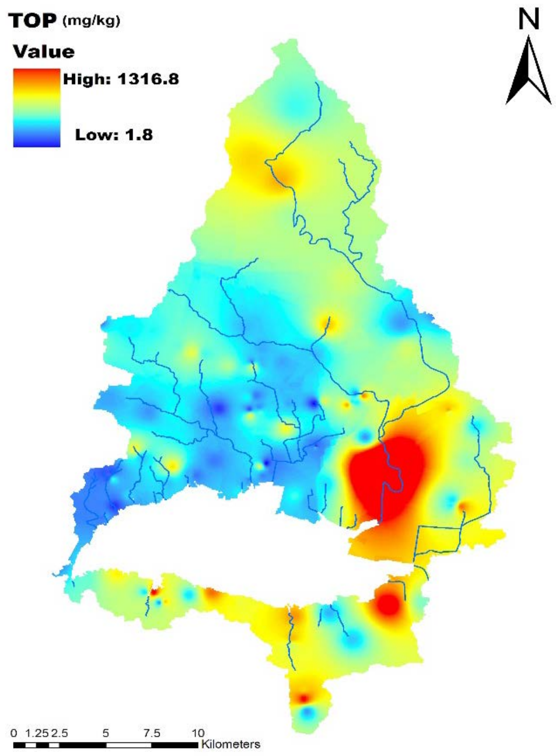
- The concentration of TIP and BAP is high in agricultural land-use where as high PSI is high in Forest soil

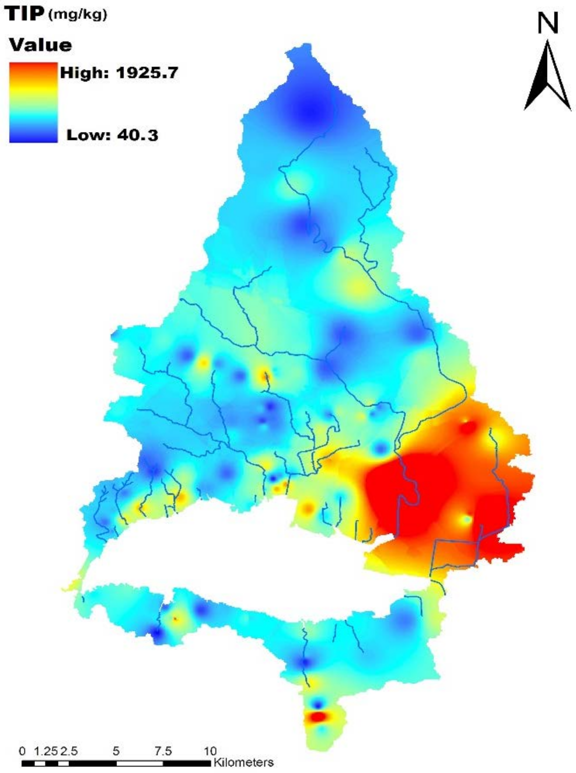
  The runoff from Agricultural soil enriched with desorbable P and the forest soil potentially with particulate P



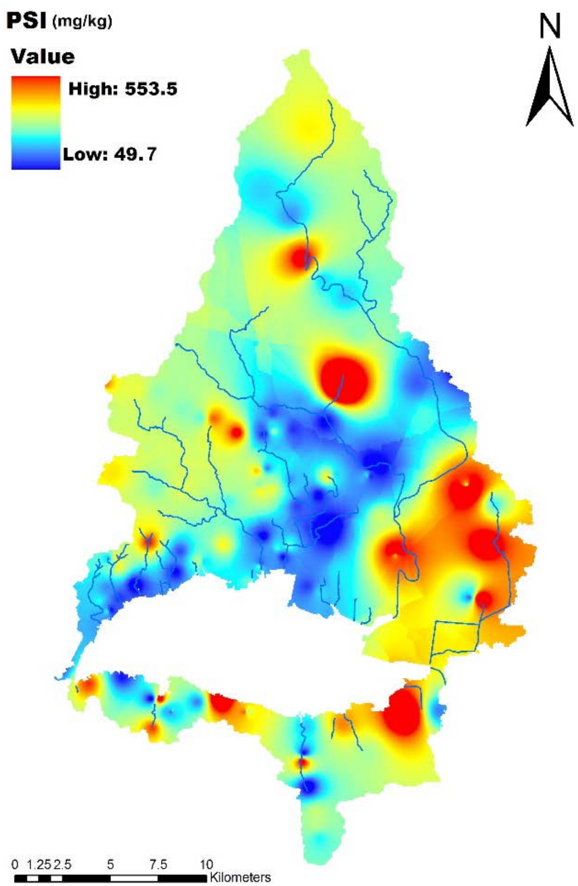
Spatial distribution of TP, TIP and TOP

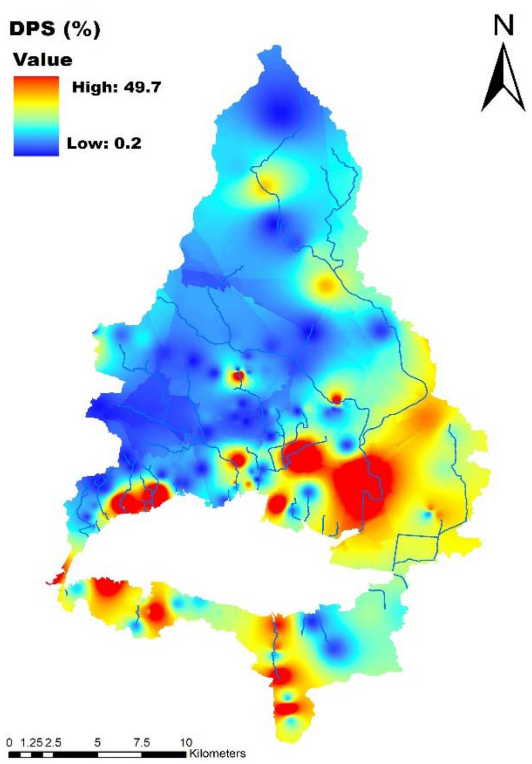


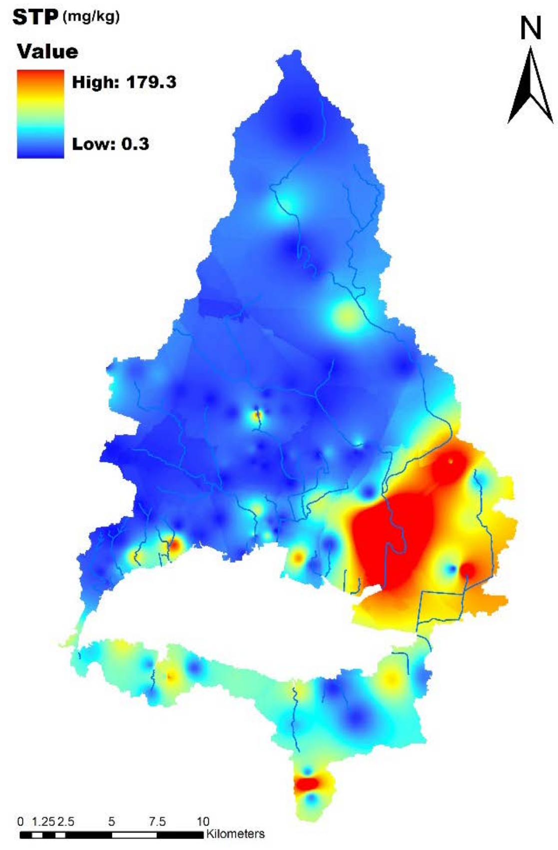




Spatial distribution of BAP, PSI and DPS%





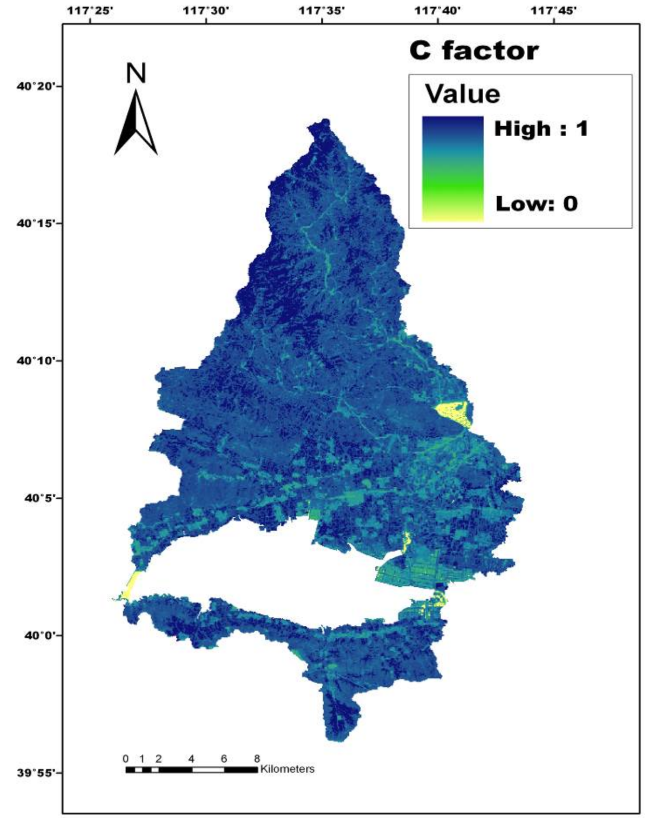


Evaluating risk of potential soil P losses

■ C factor
Based on NDVI (Normalised Difference Vegetation Index)

■ K factor
Soil texture data from Ji county soil database 1982

■ R factor
Metrological rainfall data from Ji county weather Station



Evaluating risk of potential soil P losses

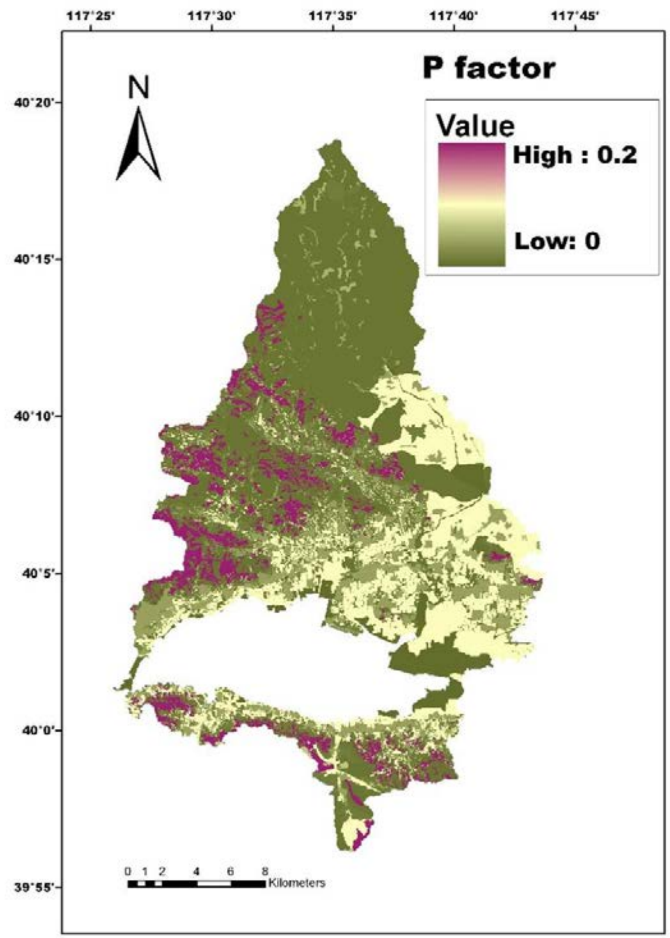
■ LS factor

Both the length (L) and steepness of the land slope (S), based on Digital Elevation Model have a substantial effect on the rate of soil Erosion by water

■ P factor

The support practice factor based on remote sensing landsat ETM image from satellite.

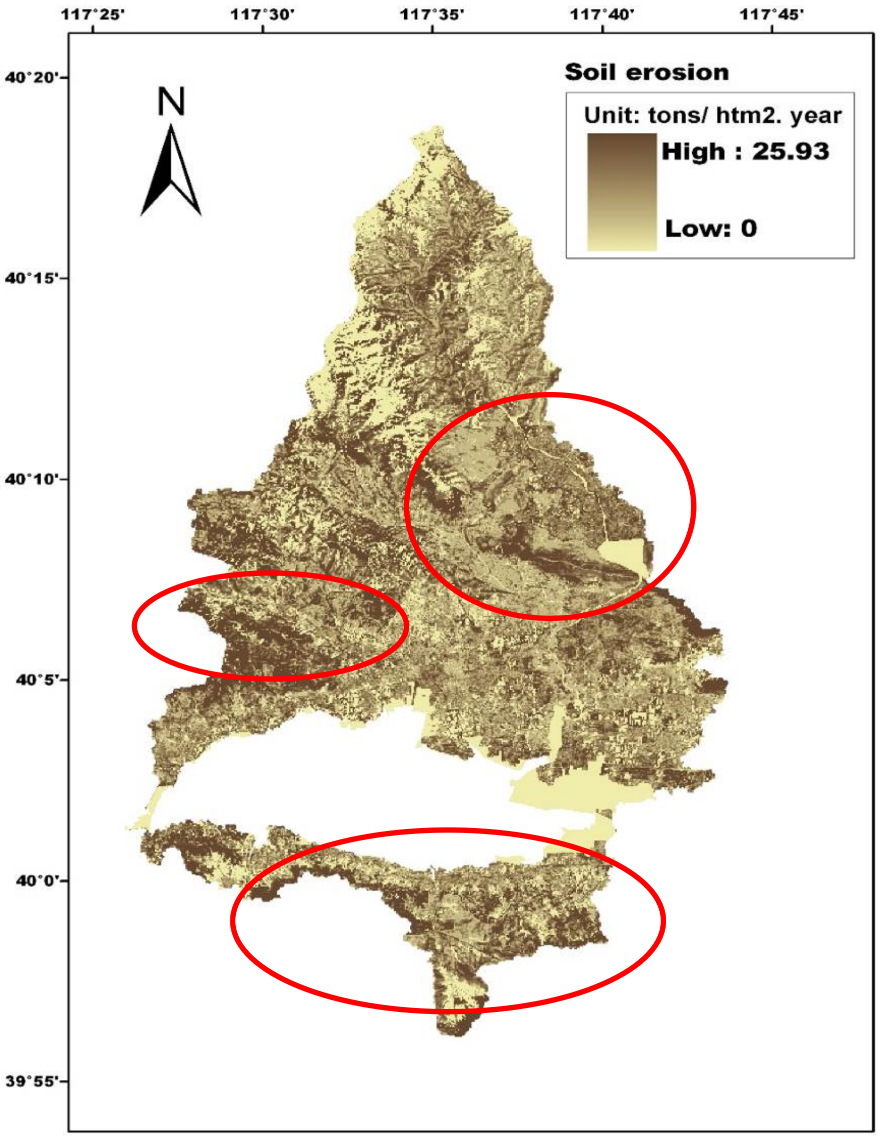
The management practice to reduce runoff velocity



Spatial distribution of Soil Erosion

- Erosion map of the local catchment was obtained based on USLE and interpolation of six soil erosion factors.

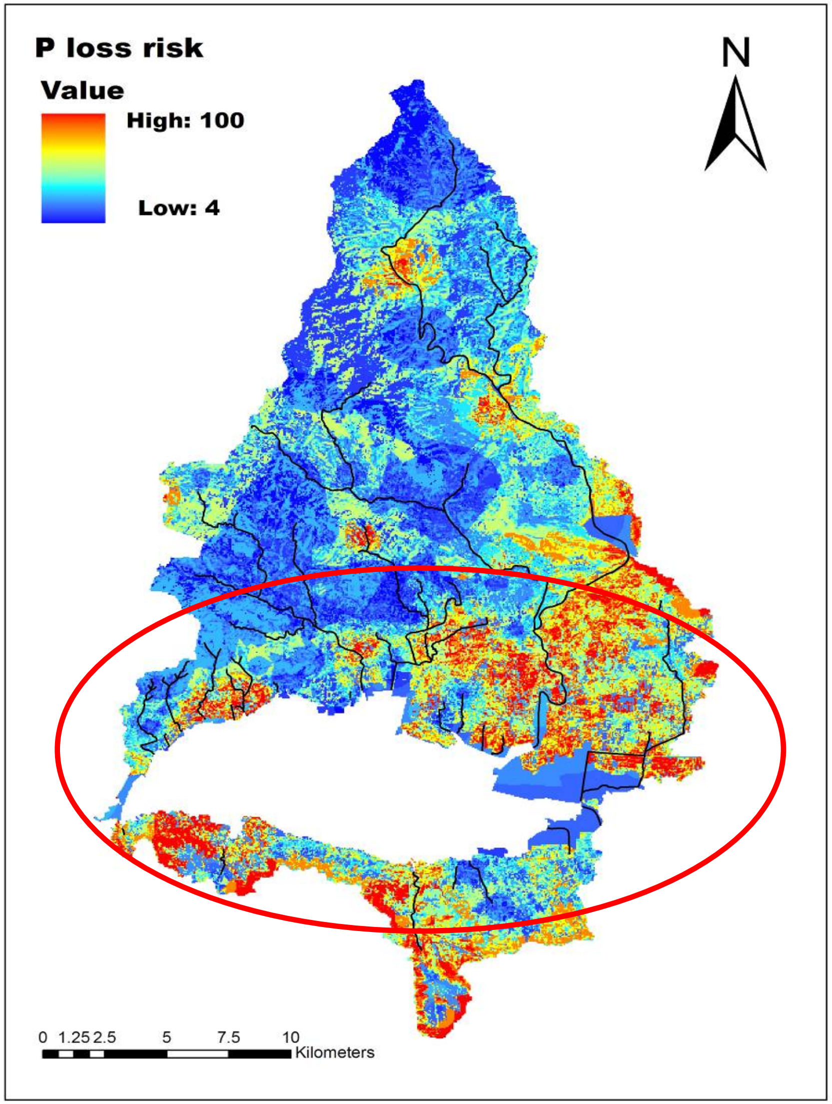
- The highest soil erosion are seen in North-east, north-west and south of Yuqiao reservoir



Identification of Critical Source Area's (CSA's)

- Product of DPS% and Soil erosion using spatial analysis based on ArcGIS, the high risk area as critical source area's has been reveal

- The area 21.6 km2 accout for extremely high risk and 76 km2 account for high risk of P loss



Conclusion and outlook

1) Inorganic P is the primary soil P pool in the study zone, even in the natural forest soil.

2) Soil P in the vegetable and orchard fields show higher bio-availability due to possessing relatively high BAP. While, the forest soil represent higher phosphorus sorption capacity (PSC) than other land-use types.

3) The area at vicinity of Yuqiao reservoir have relatively high DPS%, in which human influnced land-use are main land-use types

4) The regions with extremely high and high risk of phosphorus loss comprise 18 % of the local catchment.

Further research is needed in order to determine which chemical processes are governing the mobility of phosphorous in the soils, including specific binding creating phosphate esters, precipitation and dissolution reactions with Al, Fe, Mg and Ca, and adsorption/desorption by anion exchange


Thank you