UiO : Department of Chemistry
University of Oslo

# SinoTropia

## Watershed Eutrophication management in China through system oriented process modelling of Pressures, Impacts and Abatement actions

- CAS/RCN Bilateral Project
  2011 – 2014


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# The main point

- There is a lack of a coherent research where catchment processes governing eutrophication are linked to societal response

# Understand the links

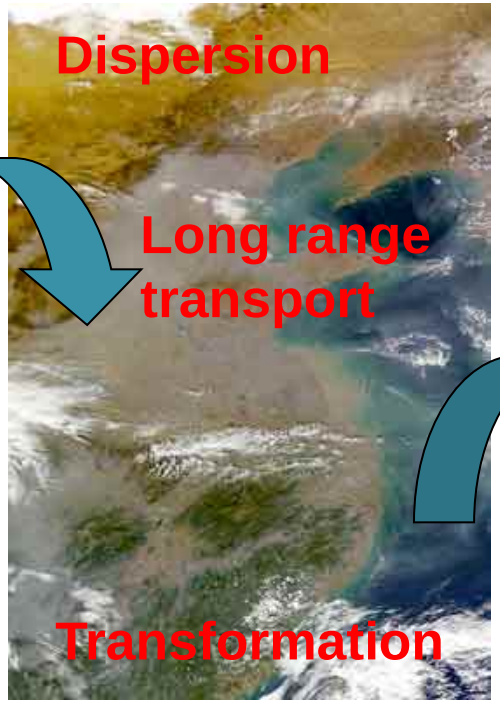
Drivers

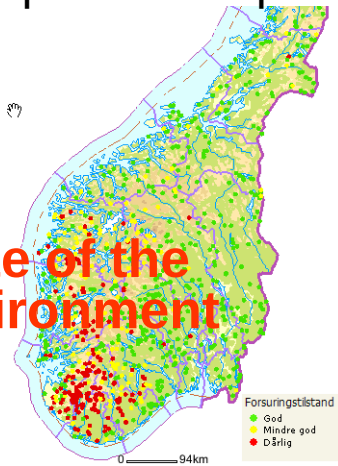
Pressures

Dispersion

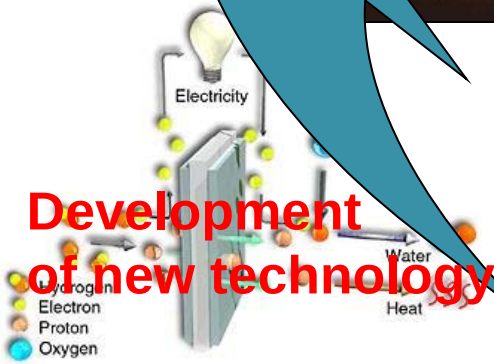
Long range transport

Transformation





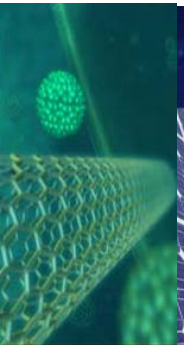

State of the environment




Development of new technology

Responces

Effects & Interactions

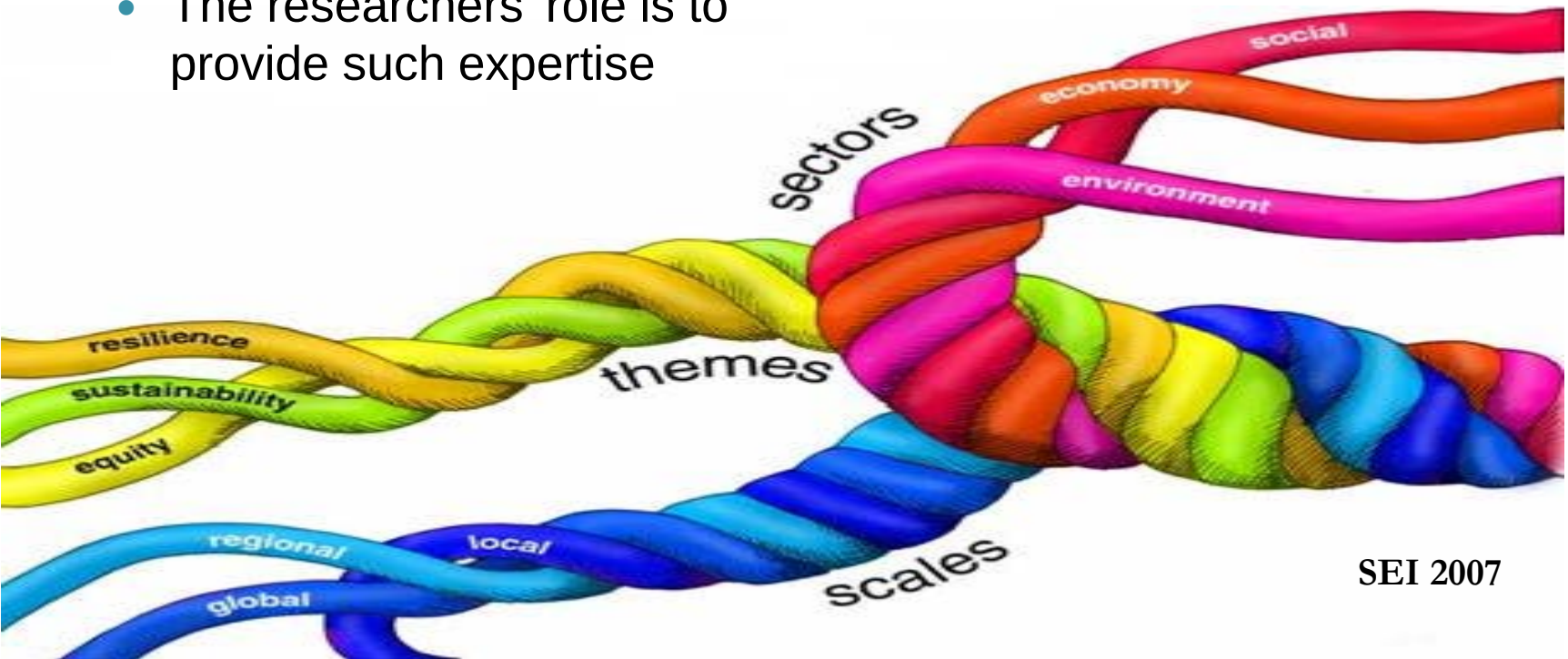


Abatement measures

Legislation

# Holistic approach

- A necessary basis for good decision-making and effective environmental policies on our increasingly complex and integrated environmental challenges
- The researchers' role is to provide such expertise

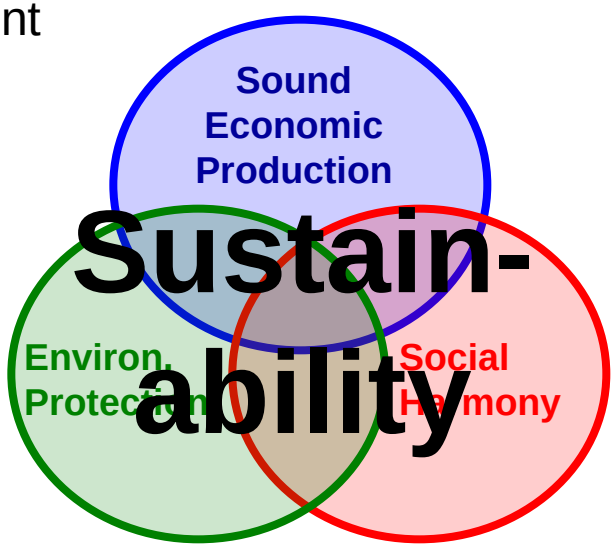



SEI 2007


# Sustainable development

- Enable decision makers
  to establish **knowledge** based abatement strategies
  on environmental challenges
  thereby **ensuring** a sustainable development

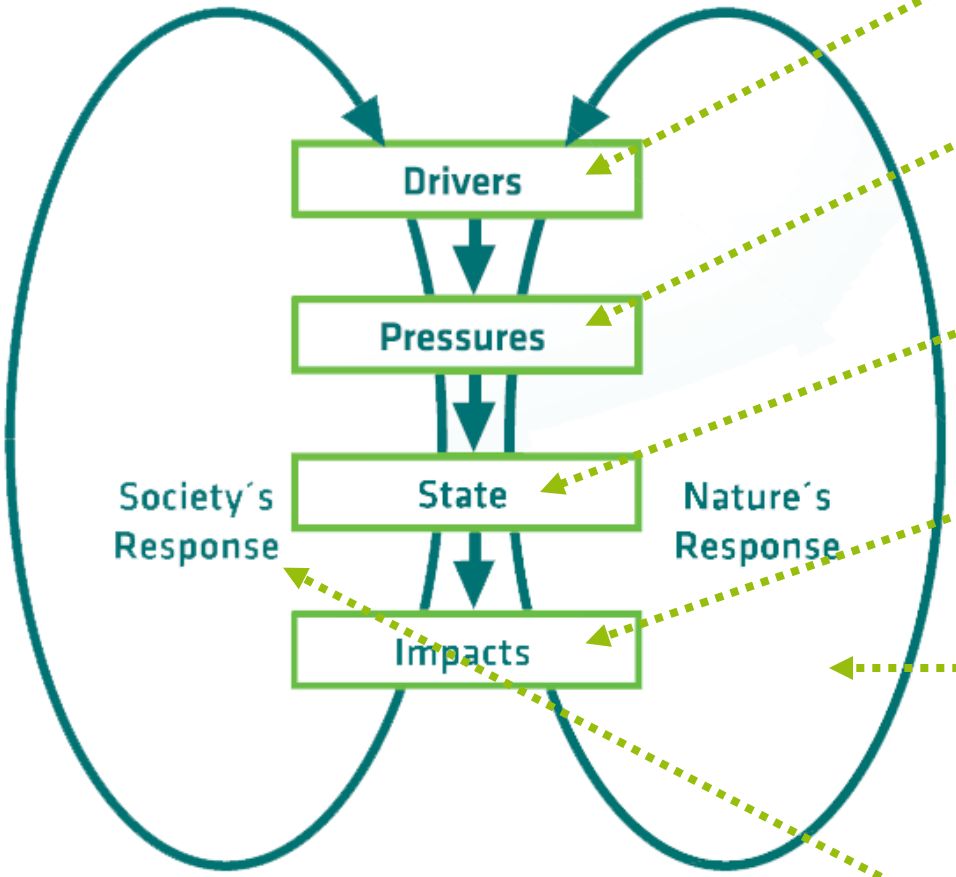
- Needs for environmental protection
  are balanced against limitation
  posed by social harmony and
  economic production




Sustainability implies
positive solutions for all components

# Outline

## DPSIR - Conceptual framework




**D**rivers: Population growth, consumption

**P**ressures: Pollution to air and water (Side effects of drivers)

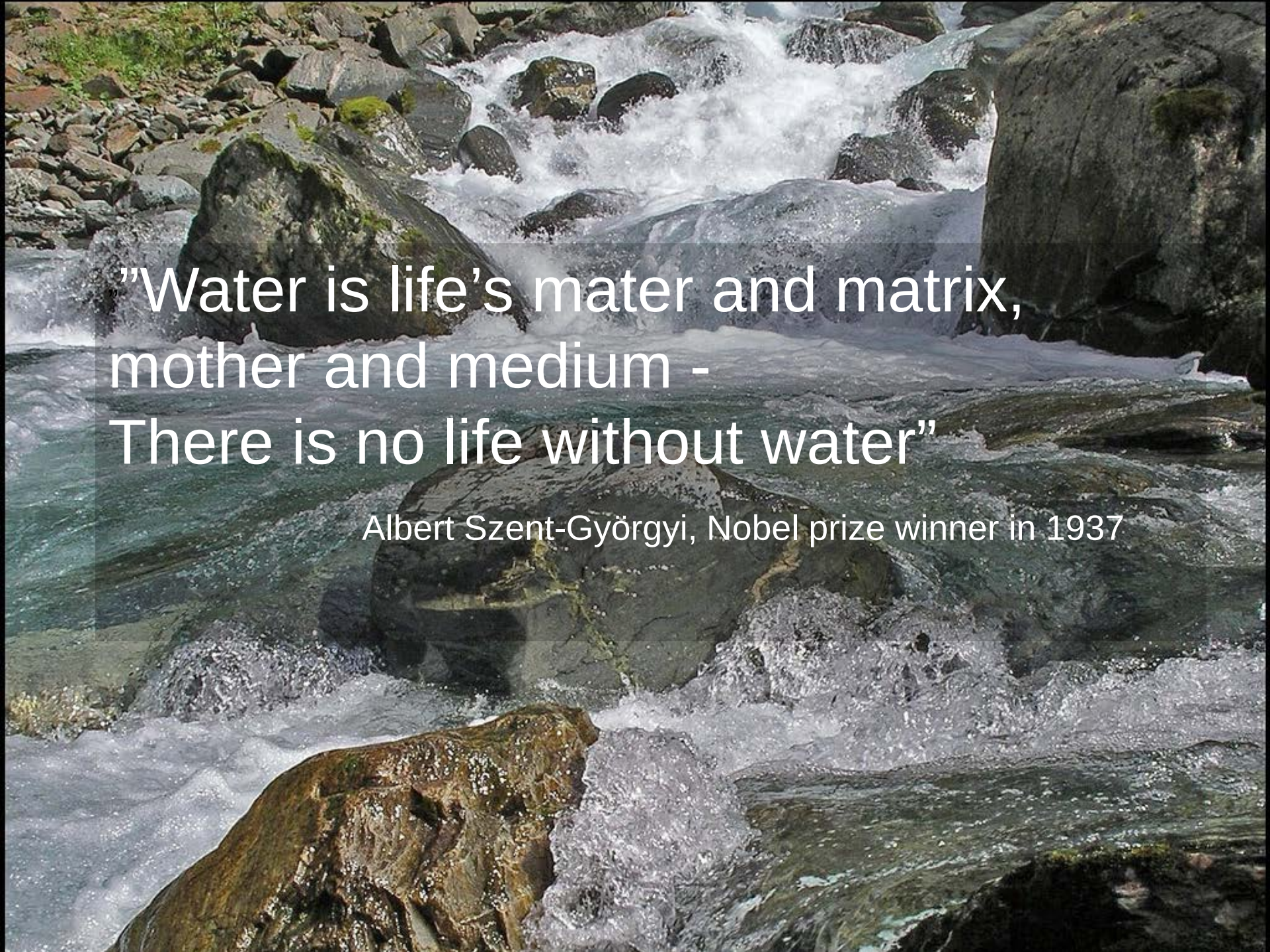
**S**tate: Chemical & Biological state of Water, Air, Soil

**I**mpacts: Climate change, eutrophication, vegetation damage

Nature's **R**esponse: Changed biodiversity, change in eco-system services, feedback mechanisms

Society's **R**esponse: Adjustments, environmental protection, adaptation, environmental technology, policy, legislations, taxes

CIENS
Oslo Centre for Interdisciplinary Environmental and Social Research

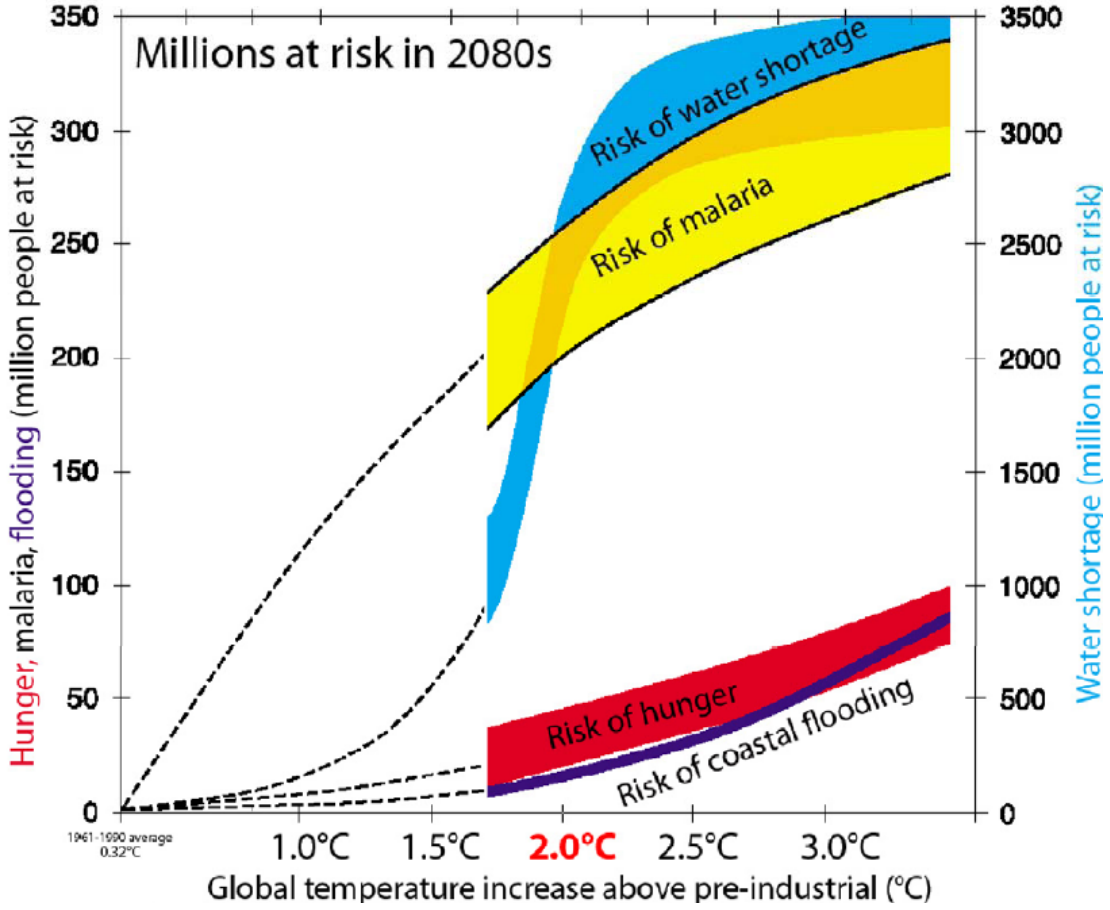

”Water is life’s mater and matrix,
mother and medium -
There is no life without water”
Albert Szent-Györgyi, Nobel prize winner in 1937

# The main problem

- *Eutrophication can be the main cause for poor ecological quality*

- *Lakes throughout China are commonly undergoing the process of eutrophication:*
  - *Most of urban lakes are facing hypertrophication*
  - *Many medium sized lakes are of eutrophic state.*
  - *The five large freshwater lakes are in the condition of eutrophication.*
- *Water quality is deteriorating and ecosystem is destroyed*
  - JIN XIANGCAN, 2003

# Effect of climate change on water supply




- Water shortage is what will inflict most people

# The research needs

- **Goal:**

  Increase our ability to **predict the effects** of changes in the environment and effect of abatement measures

- **Need:**

  Improve the underlying models **reliability** and **relevance**

- **Strategy:**

  Specifically targeting the **bioavailable** P-fraction and supplement empirical assessments with conceptual knowledge based **process understanding**

- **Prerequisite:**

  Need to **link** geochemical and physio-hydrological processes in the **catchment** with the **in-lake** biochemical processes controlling the level of nutrients (P, N, C) and its effect on water quality

# Thesis

- Adopting a **trans-disciplinary** approach on the eutrophication challenge, integrating natural science and social science with policy will improve the:
  - policy-making process and
  - implementation of relevant policies

  eventually achieving a water resource management meeting society's needs

# Hypothesis - Methods

- P-fractionation will enhance our ability to identify the:
  - source of P
  - processes governing fluxes
  - fate of the P
  - effect of bioactive P-fractions and thereby algal growth

# Hypothesis - Processes

- It will be possible to assess the processes governing mobilization and transport of nutrient (P, N and C) from soil and sediments by determining their soil pools and fractions in water
- More frequent intensive rain episodes enhance eutrophication through increased erosion and leaching of nutrients
- Continued flux of P from over-fertilized soils and sediments will maintain eutrophication of lakes in agricultural regions despite appropriate abatement measures
- The role of particle transport of nutrients is overestimated as most of this material is irreversibly buried in the sediments

# Hypothesis - Models

- Models developed elsewhere need to be adopted to Chinese environment
  - The main governing processes may not be the same
- It is possible to adequately **parameterize** processes governing nutrient fluxes
  to improve performance of the conceptual models

# Hypothesis – Societal responce

- Knowledge -
  - of stakeholder interests and learning processes are essential for the success of the public policies abating eutrophication
  - constitute a necessary basis for sound environmental management through facilitating collective action and public policies

ultimately contributing to sustainable environmental development.

# Research Strategy

- The hypotheses are tested through integrated works packages

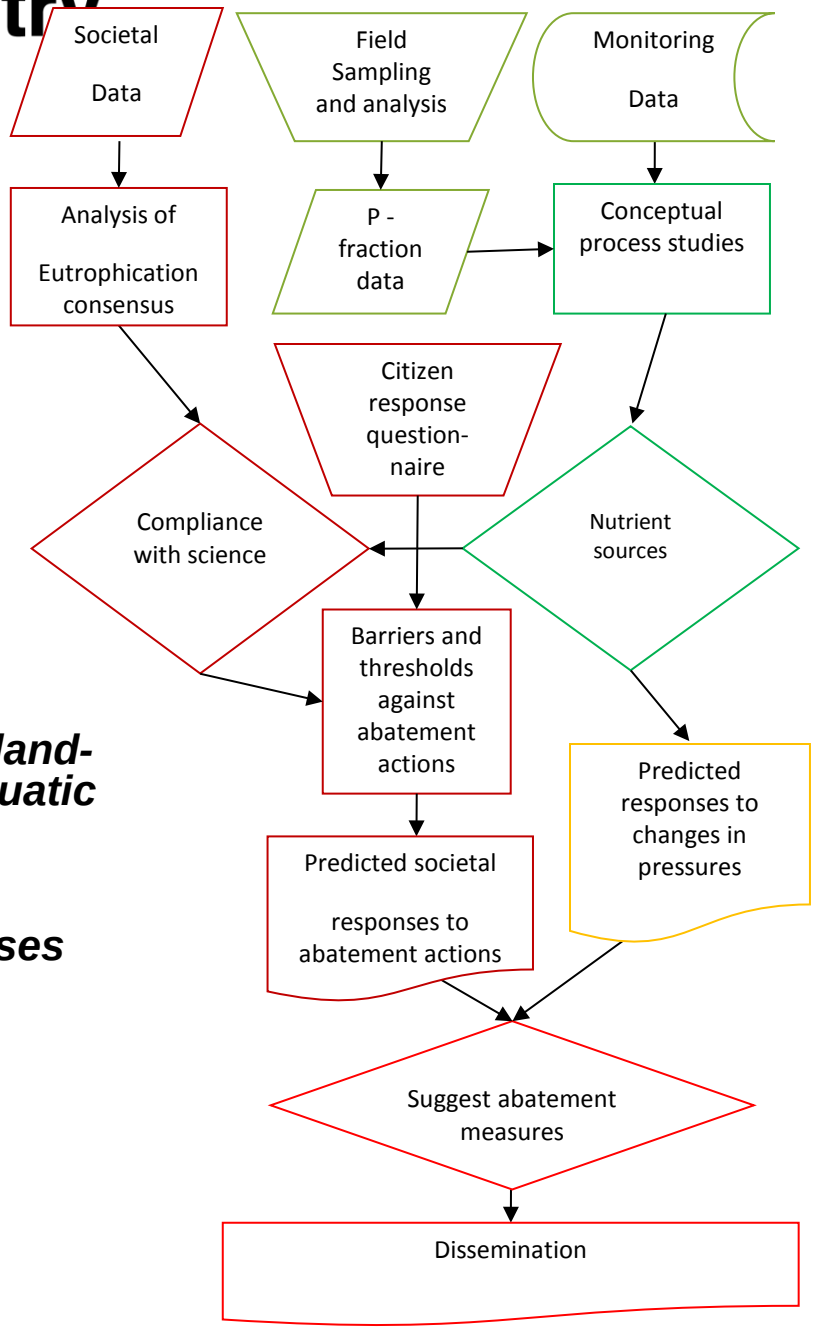
***WP1*** ***Field sampling and chemical analysis***

***WP2*** ***Catchment processes - the influence of land-use and climate on nutrient fluxes into aquatic systems.***

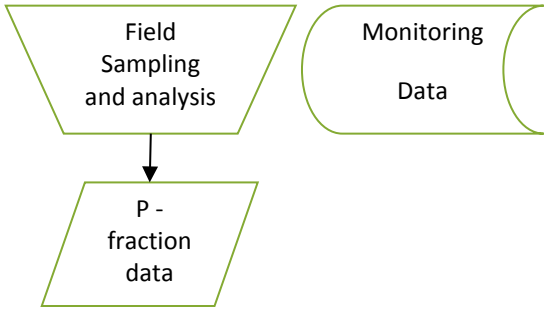
***WP3*** ***Modelling of catchment and lake processes***

***WP4*** ***Societal processes and management procedures***

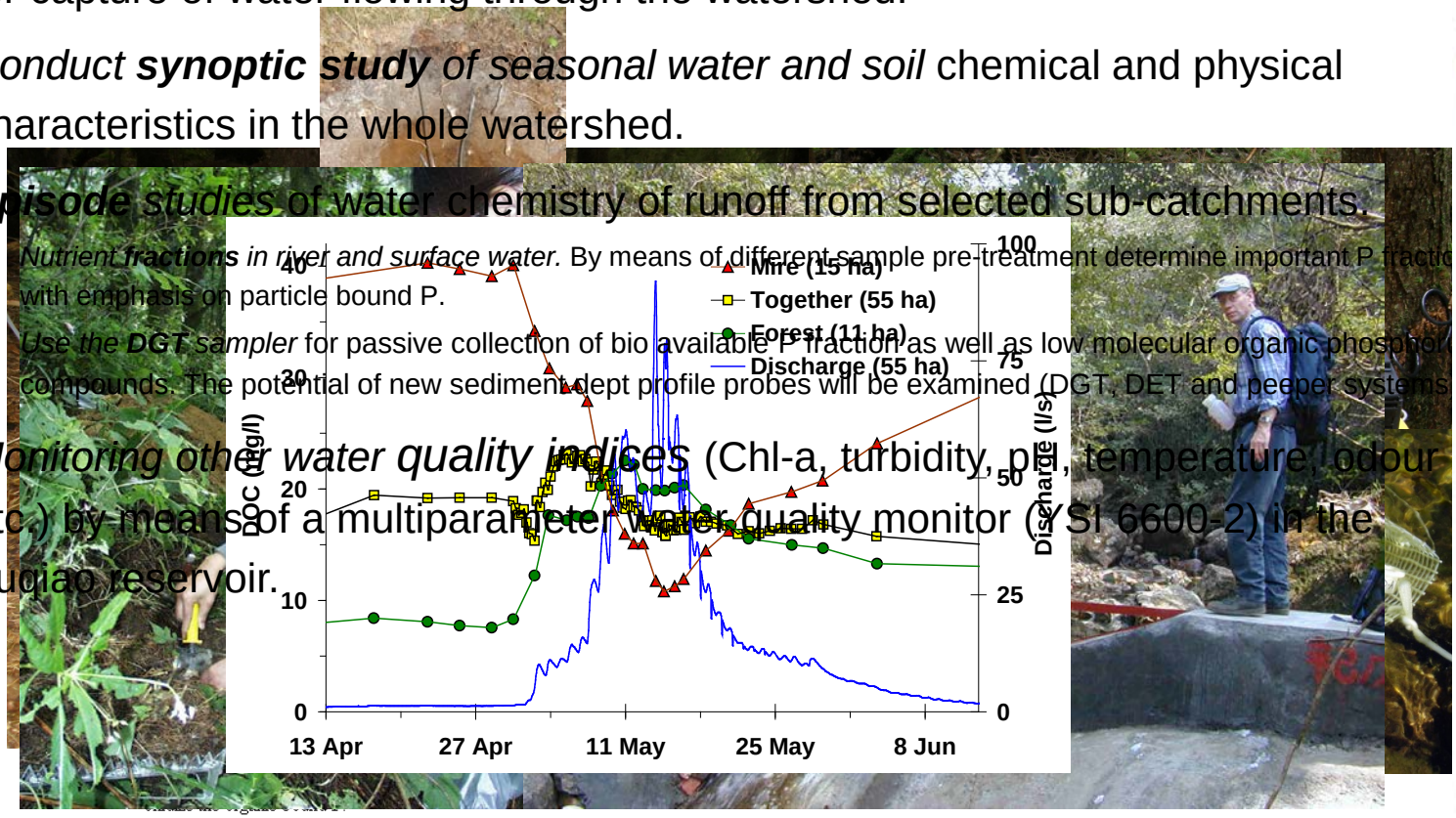
***WP5*** ***Nutrient management plan for Yuqiao reservoir***



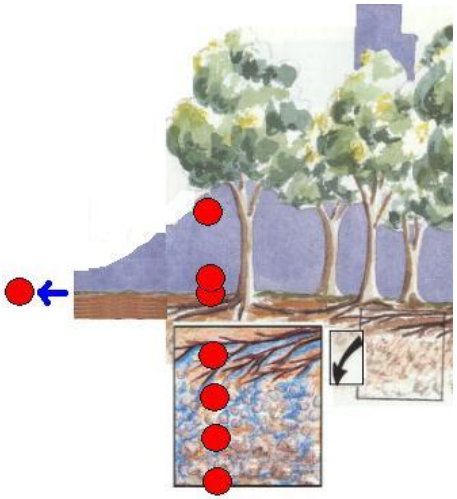
# Tasks

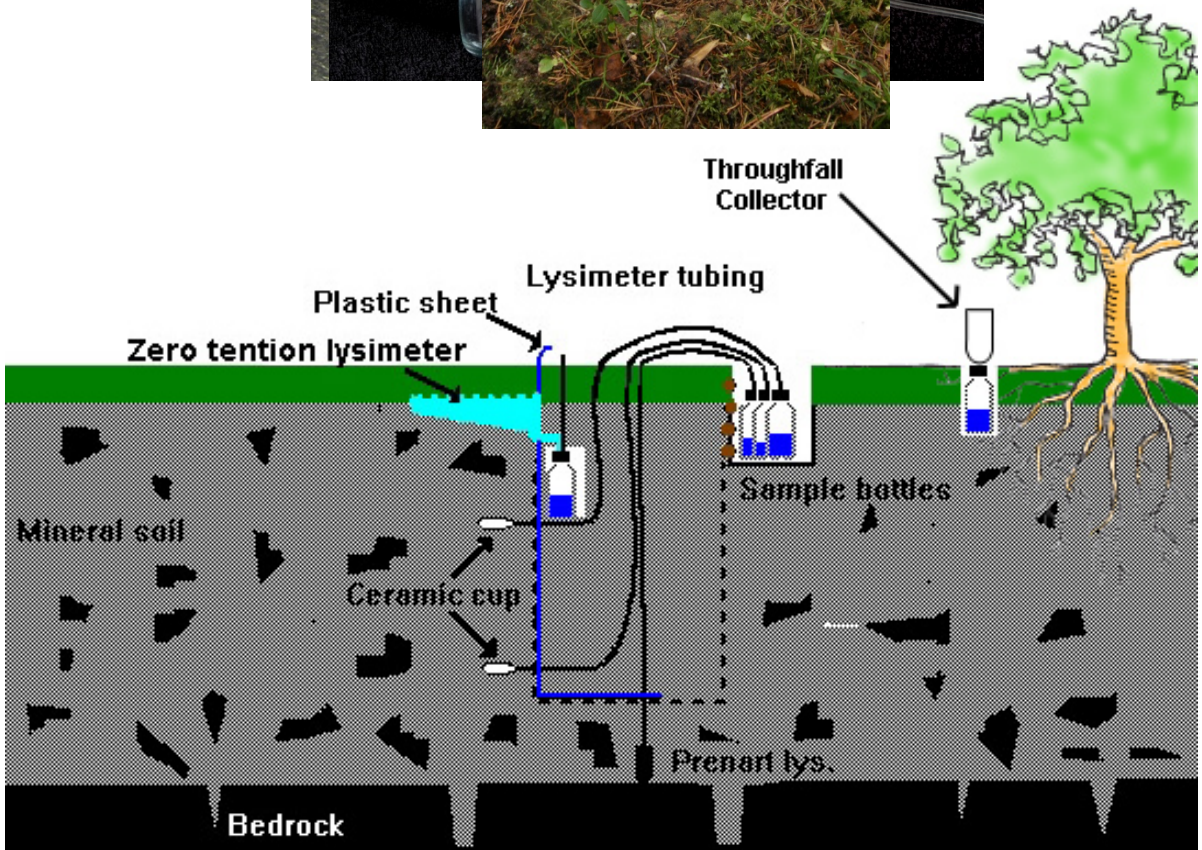



- WP1 Field sampling and chemical analysis
  - ***Instrument*** *soil plots in sub-catchments* and their perennial streams for capture of water flowing through the watershed.
  - *Conduct **synoptic study** of seasonal water and soil* chemical and physical characteristics in the whole watershed.
  - ***Episode** studies* of water chemistry of runoff from selected sub-catchments.
    - *Nutrient **fractions** in river and surface water.* By means of different sample pre-treatment determine important P fractio with emphasis on particle bound P.
    - *Use the **DGT** sampler* for passive collection of bio available P fraction as well as low molecular organic phosphor compounds. The potential of new sediment dept profile probes will be examined (DGT, DET and peeper systems
  - *Monitoring other water quality indices* (Chl-a, turbidity, pH, temperature, odour etc.) by means of a multiparameter water quality monitor (YSI 6600-2) in the Yuqiao reservoir.



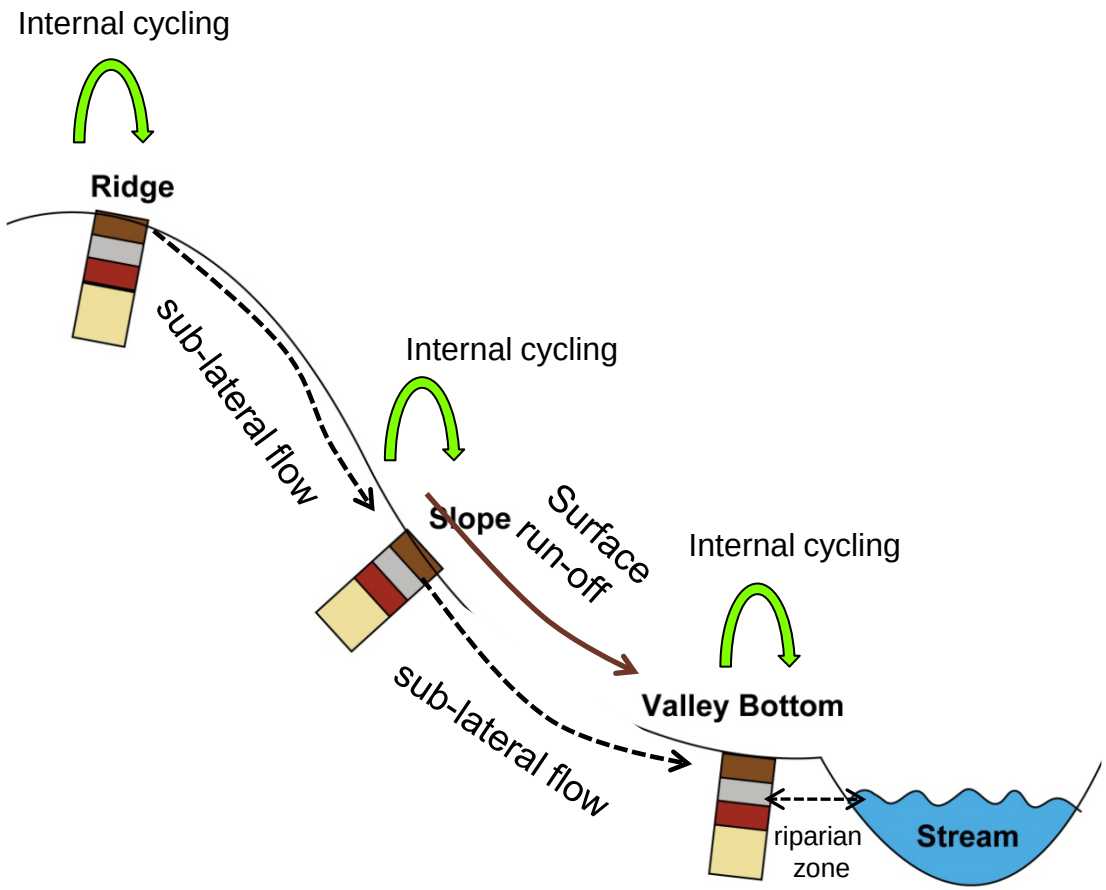

# Sampling equipment





# Plots along a topographic gradient

- Three plots:
  - Ridge
  - Slope
  - Valley bottom
    - adjacent the stream
- Plots represent a topographic gradient
- Hydro-geochemical processes
  - Sub-lateral flow
  - Surface run-off
  - Internal cycling

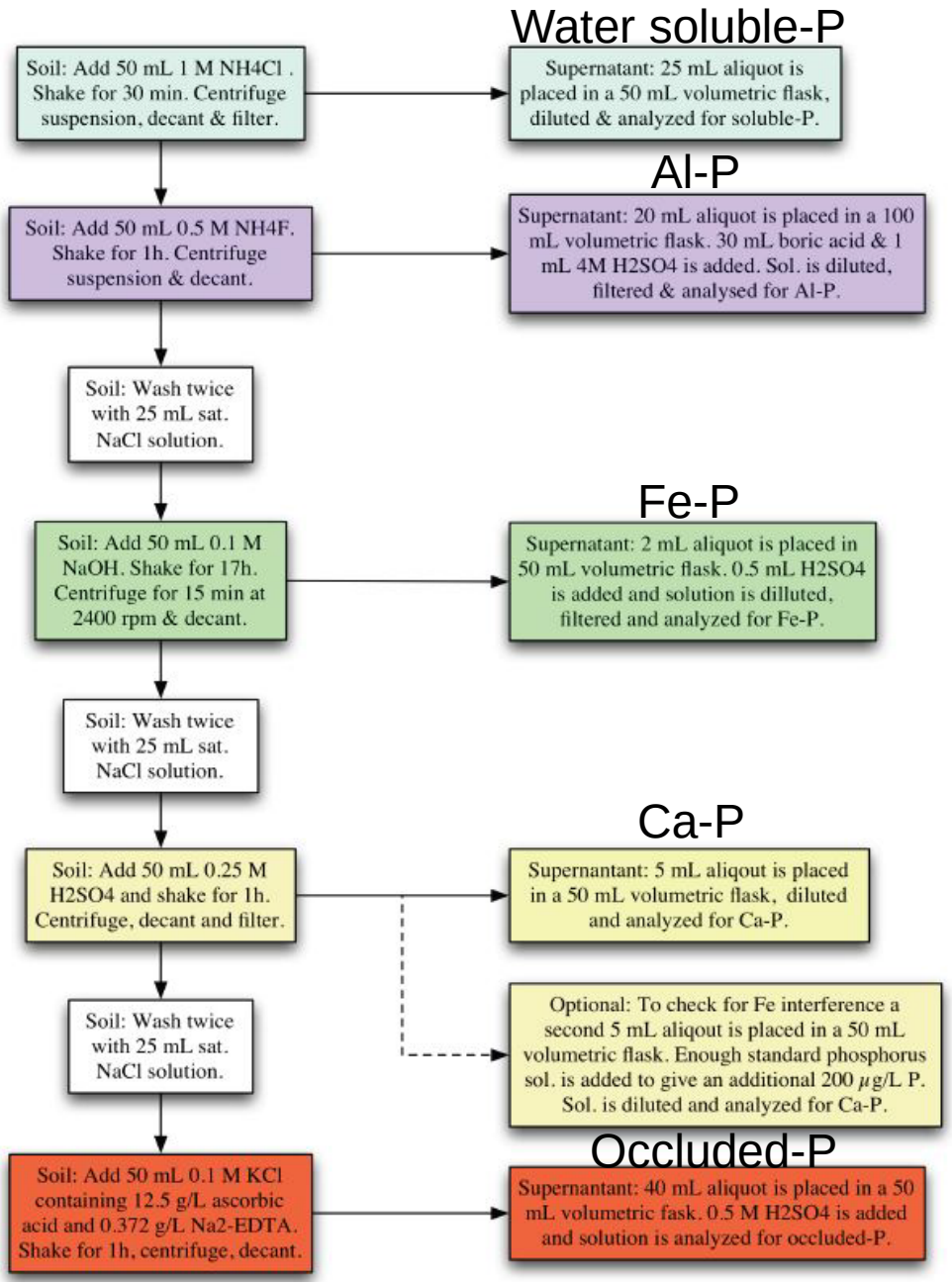


# Soil Analysis

- Samples from soil horizons in the three plots
  - ✓ Bulk density
  - ✓ Soil pH
    - Water
    - 0.01 M $CaCl_2$
  - ✓ Organic matter content (Loss on Ignition)
  - ✓ Soil P fractionation
    - Inorganic & organic P fraction (Møberg & Petersen, 1982)
    - Sequential extraction of inorganic P pools (Chang & Jackson, 1956)
      - Soluble P
      - Al-P
      - Fe-P
      - Ca-P
      - Occluded P
    - Determination of P done by molbydate blue method

# Soil P pools

- Sequential extraction of different inorganic P pools



# Water Analysis

- Throughfall water
- Soil water from
  - O, A, B & C horizon
- Stream water


- ✓ Conductivity
- ✓ pH
- ✓ Alkalinity
- ✓ DOC
  - 254 nm & 400 nm
- ✓ Particulate matter in stream
- ✓ Major cations & anions (ICP-OES & IC)
  - $Na^{+}$, $K^{+}$, $Mg^{2+}$, $Ca^{2+}$, $Fe^{3+/2+}$, $Cl^{-}$, $SO_4^{2-}$, $F^{-}$
- ✓ CNP analysis (performed at NIVA)
  - TOC, Tot-N, Tot-P, NO3/NO2, NH4, PO4

# Nutrient fractionation

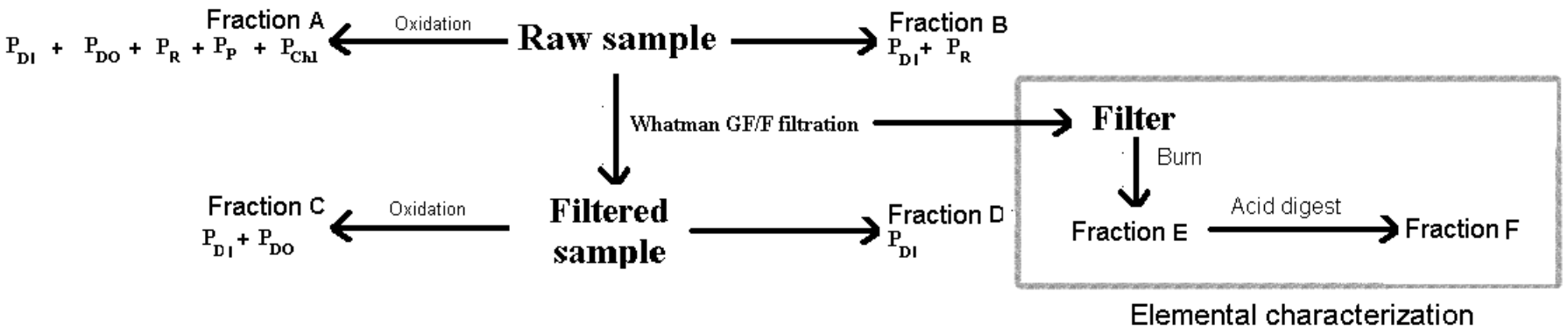
Fraction A - Fraction B = Non-labile P = $P_{DO} + P_P + P_{Chl}$

Fraction A - Fraction C = Particulate P = $P_R + P_P + P_{Chl}$

Fraction B - Fraction D = $P_R$

Fraction C - Fraction D = $P_{DO}$

$P_{DI}$ = Orthophosphate
$P_{DO}$ = Dissolved organic P
$P_R$ = Reactive pool of P
$P_{IP}$ = Inorganic particulate P
$P_{Chl}$ = Alga P



# Tasks

- WP2 Catchment processes
  - the influence of land-use and climate on nutrient fluxes
    - ***Hydro-Biogeochemical processes*** governing the nutrient mobilization

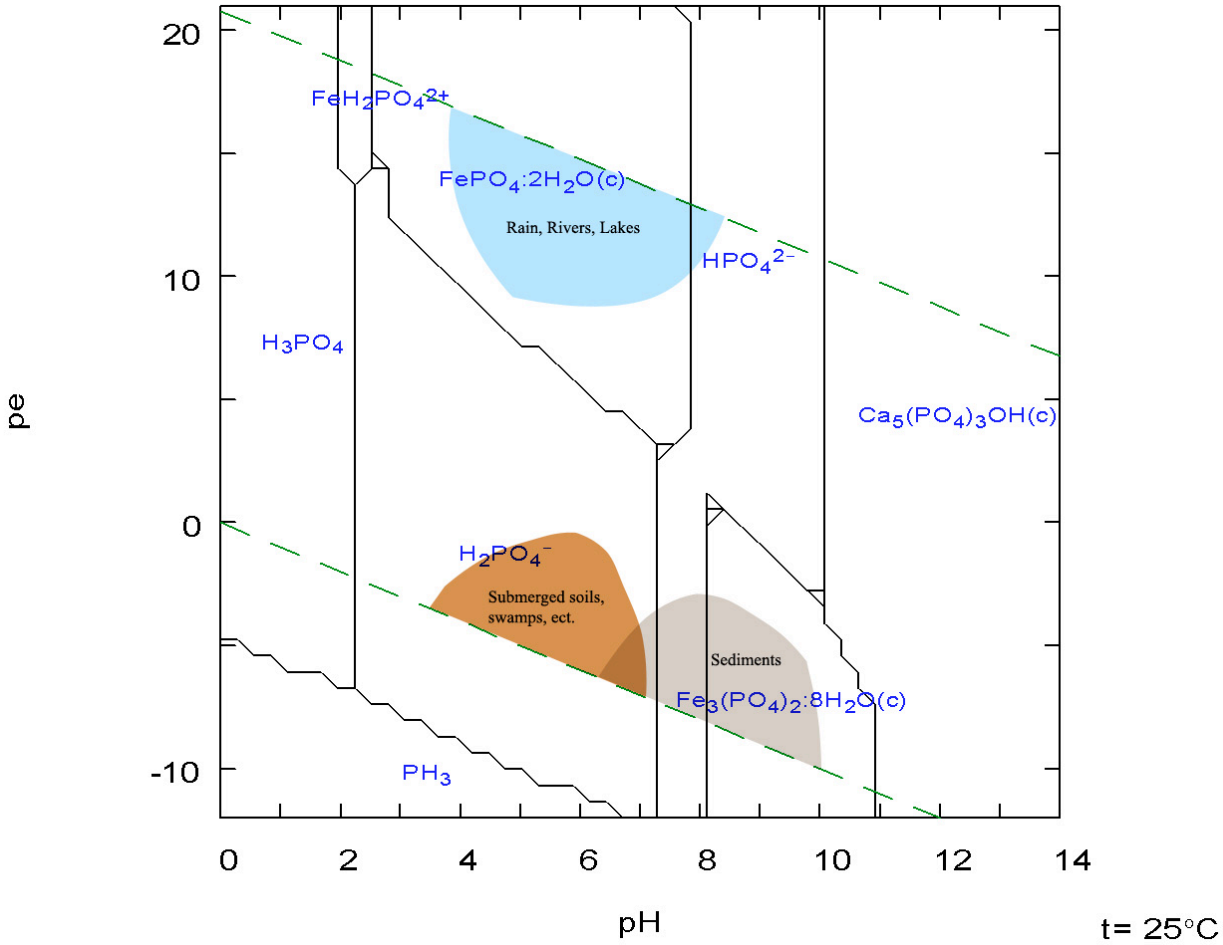



nutrient species in the lake

***Comparative study*** between Western Vansjø in Norway and Yuqiao reservoir.

# Inorganic Phosphorus

- Low in concentration due to:
  - Very low solubility together with $Fe^{3+}$, $Al^{3+}$ and $Ca^{2+}$
  - Rapid uptake by algae



# Conceptual idea of P leaching from forest soils

## Atmospheric deposition

Internal circulation

Snow
Melting periods

Throughfall
$P_{DI}$, $P_{DO}$

Assimilation

O horizon
Humification

Sub-lateral throughflow during saturated conditions
$P_{DI}$

$P_{DI}$

Bhs horizon
PAL, Org.mat., CEC, PSD

Sub-lateral throughflow during saturated conditions
$P_{DI}$, $P_{DO}$

$P_{DI}$

C horizon
CEC, PSD

Groundwater seepege
$P_{DI}$

$P_{DI}$, $P_{DO}$

Riverine zone

Water from wetland and bogs along the brook in the valley bottom
$P_{DI}$, $P_{DO}$

## Hydrologic model

Prosesses & Drivers that govern P leaching

Organic decomposition and humifi
Clima M

Desor
Anion
DNOM

Desor
Anion
pH, Al

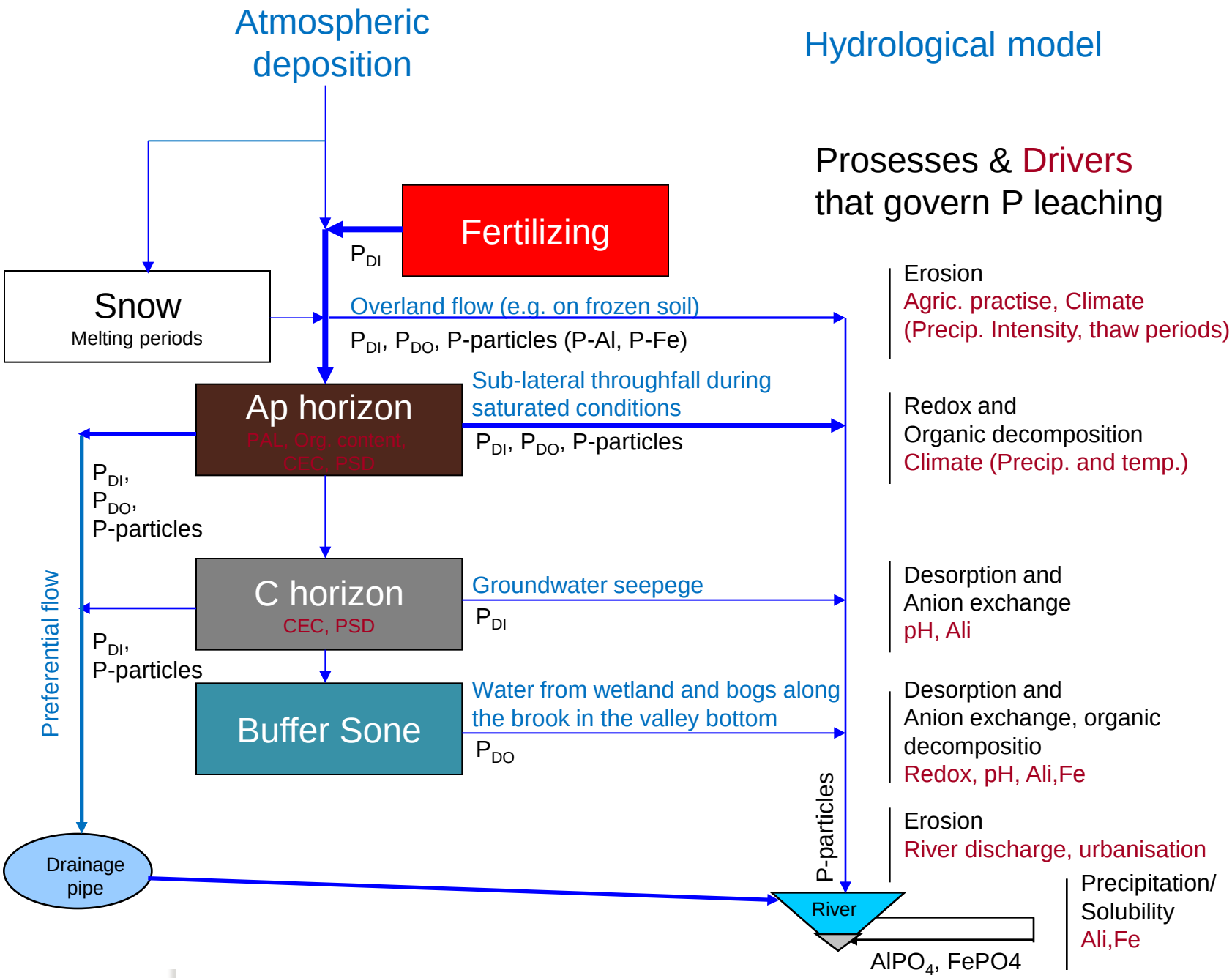
Redox
Anion
Redox

$P_{DI}$ = Orthophosphate
$P_{DO}$ = Dissolved organic P
$P_R$ = Reactive pool of P
$P_{IP}$ = Inorganic particulate P
$P_{Chl}$ = Alga P

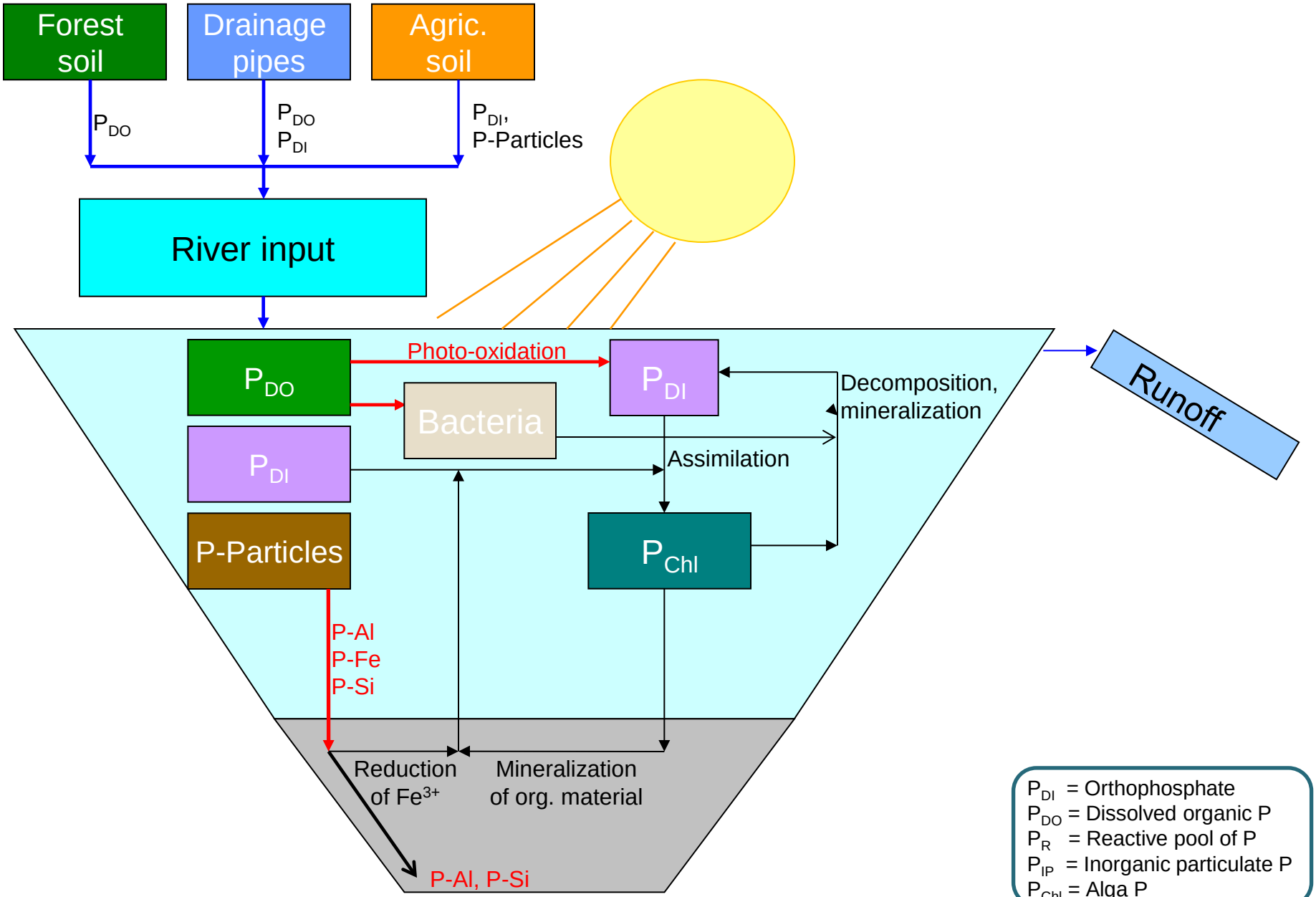
$AlPO_4$, FePO4

Precipitation/ Solubility
Ali, Fe

# Conceptual idea of P leaching from agricultural soils

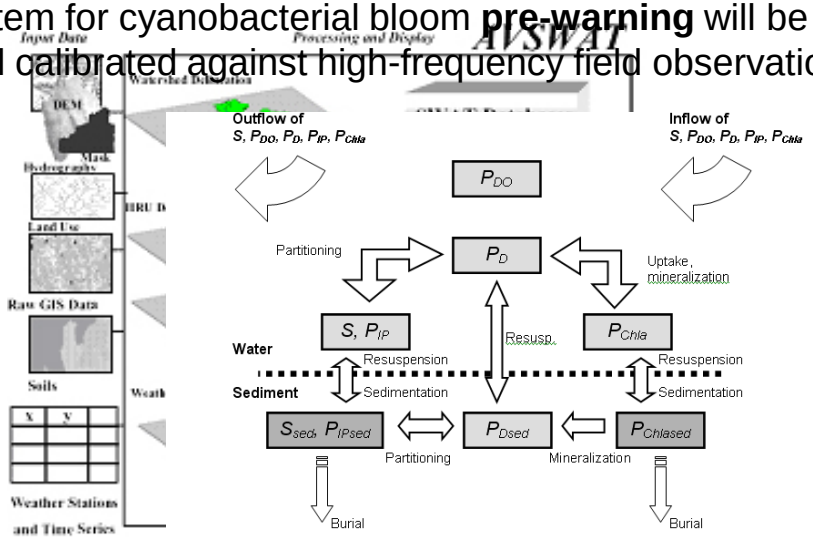


# Conceptual idea of P processes in the lake



# Tasks

- WP3 Modeling of catchment and lake processes
  - The Soil and Water Assessment Tool (**SWAT**) is a river basin scale model that will be adapted and parameterized for the investigated sub-catchment of Yuqiao reservoir.
    - The optimized model will be used to **test hypotheses** of nutrient mobilization and hydrological runoff formation in sloped areas and how it matches observed episodic hydrological and chemical data from field studies.
  - Changes in fluxes of nutrient fractions due to **climate change and land management practices** will be investigated by using downscaled climatologically scenarios.
  - A system for cyanobacterial bloom **pre-warning** will be developed based MyLake model calibrated against high-frequency field observations and satellite imagery




http://swatmodel.tamu.edu/

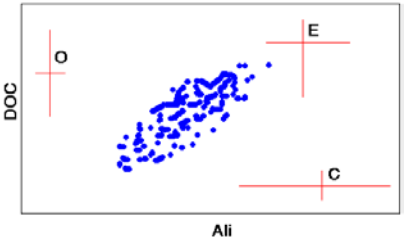
# Modelling

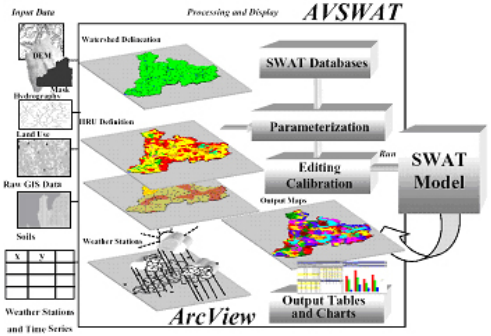
- The SWAT and MyLake models will be adapted and applied for hypothesis testing as well as to identify knowledge gaps

  - **EMMA** relates soil water chemistry (end-members) to lake water chemistry so that water pathways may be determined

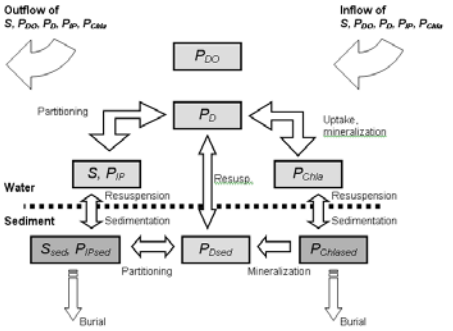
  - **SWAT** is a river basin model developed to quantify the impact of land management practices in large, complex watersheds

  - The **MyLake** (Multi-year Lake) is a process-based lake water model for simulating vertical distribution of lake water temperature, sediment-water interactions, and phosphorus-phytoplankton dynamics




SWAT;
www.brc.tamus.edu/swat/




Saloranta & Andersen, 2007

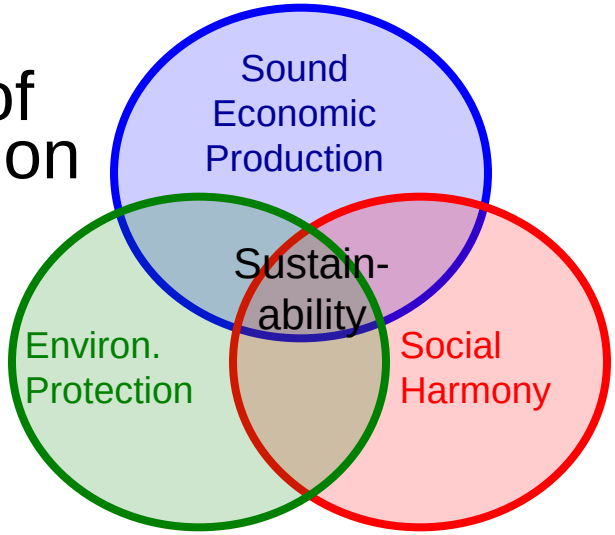
# Tasks

- WP4 Societal processes and management procedures
  - **Map** demographic and industrial patterns and urbanisation; land use pattern and agricultural production methods
  - Contextualise overall **driving forces/processes** and development patterns into regional and local conditions
  - **Identify actor categories and field structures**, with the main focus on water and agricultural related fields, including production, policy-making, and management
  - Conduct a **survey** and **in-depth interviews** covering different actor groups.
  - Analyse the **role of knowledge** and learning processes and how this creates particular practices
  - Analyse **management procedures** at different administrative levels and how they are interacting. Identify bottlenecks and contradictions that might function as obstacles for an efficient water resource policy, and consider how they can be solved
  - Consider the **legitimacy of possible polices** that can contribute to improve the water quality and facilitate a sustainable and harmonious development – paying attention to the role of trust, distributive factors, and fairness and justice.

# Sustainable management

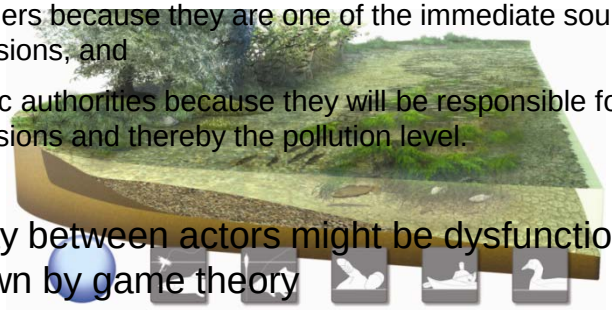
- *Abatement measures need to be assessed in regards to **cost-effectiveness** and an analysis of land **users'/farmers' response** to the these measures*

  - Especially an assessment of **probability** of implementation is lacking from previous assessments of measures

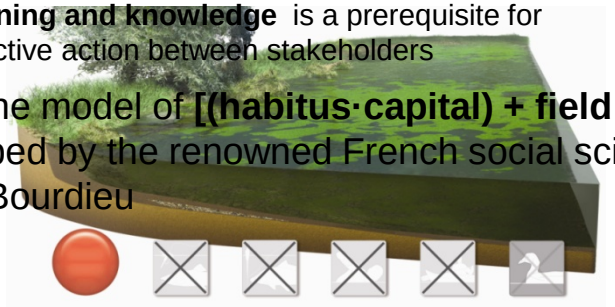


# The societal response

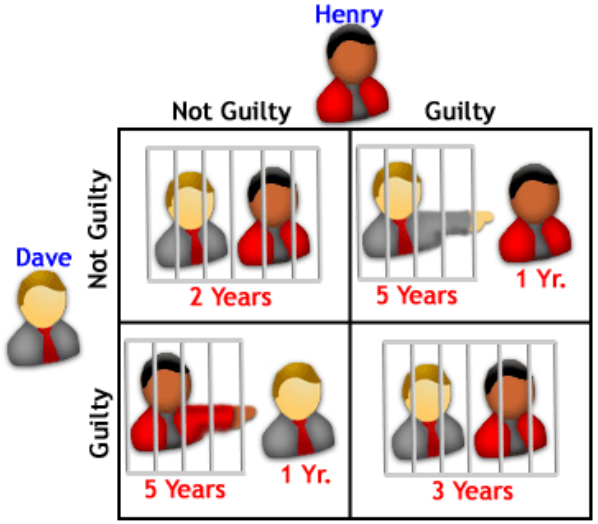
- There are many conflicting interests
  - Agricultural productivity, leisure time activities, general environmental concerns, public drinking water provision
- Focus mainly on *farmers and the public authorities*
  - Farmers because they are one of the immediate source of emissions, and
  - Public authorities because they will be responsible for regulating emissions and thereby the pollution level.



- Interplay between actors might be dysfunctional, as shown by game theory
  - **Learning and knowledge** is a prerequisite for collective action between stakeholders



- Apply the model of **[(habitus·capital) + field = practice]** developed by the renowned French social scientist Pierre Bourdieu



# Tasks

- WP5 Nutrient management plan for Yuqiao reservoir
  - Apply the **Circular Economy** approach with nutrient at its cores, taking into account fluxes and reservoirs of their hydro-biogeochemical cycle.
  - Consideration synergistic and/or antagonistic effect on **greenhouse gas** sequestration of abatement action for reducing eutrophication.
  - Develop a suitable nutrient **management plan** for Yuqiao Reservoir including a conceptual model for pre-warning of algal blooms and technical guidelines for health risk assessment and pollution control for MC in Yuqiao Reservoir .
  - Suggest adaptive measures to reduce the **negative effects of climate change**
  - A **technical guideline** of health risk assessment and pollution control for microcystins (MC) will be developed by physico-chemical and biochemical methods
  - Improve public awareness for nutrient pollution by means of a citizen training **brochure** for “What you can do to prevent nutrient pollution” to inform individuals/organizations about causes of and actions against eutrophication locally. This will be complemented by **education and training courses** for preventing eutrophication
  - Give comprehensive and targeted **presentations** about the process of eutrophication, and governance/management issues for government officials at different levels.

# Thank you for your attention