UiO : Department of Chemistry
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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

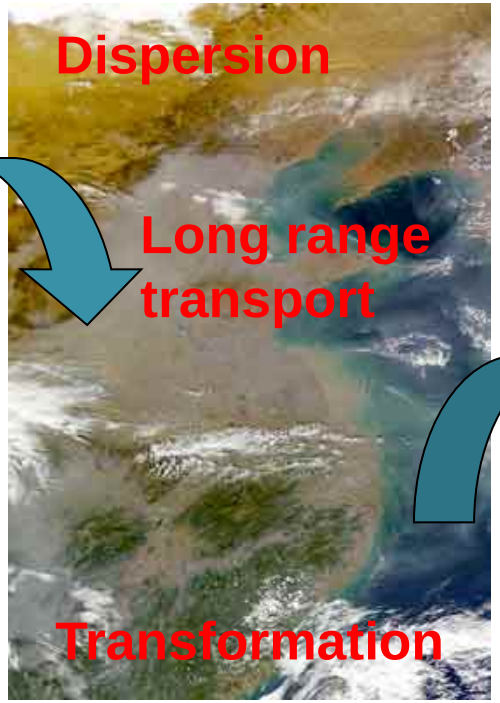
Understand the links

Drivers

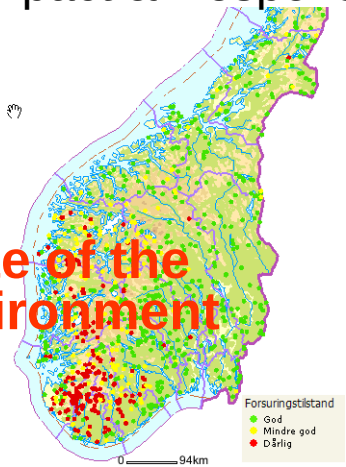
Pressures

Dispersion

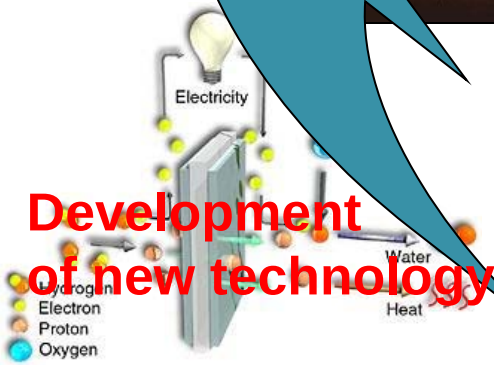
Long range transport



Transformation



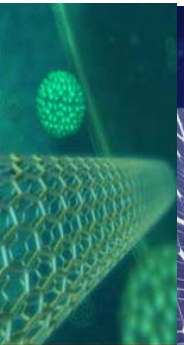
State of the environment

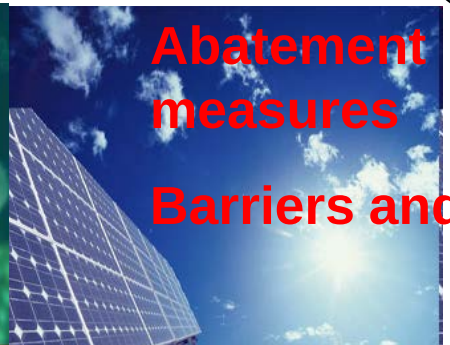


Development of new technology

Effects & Interactions

Responces





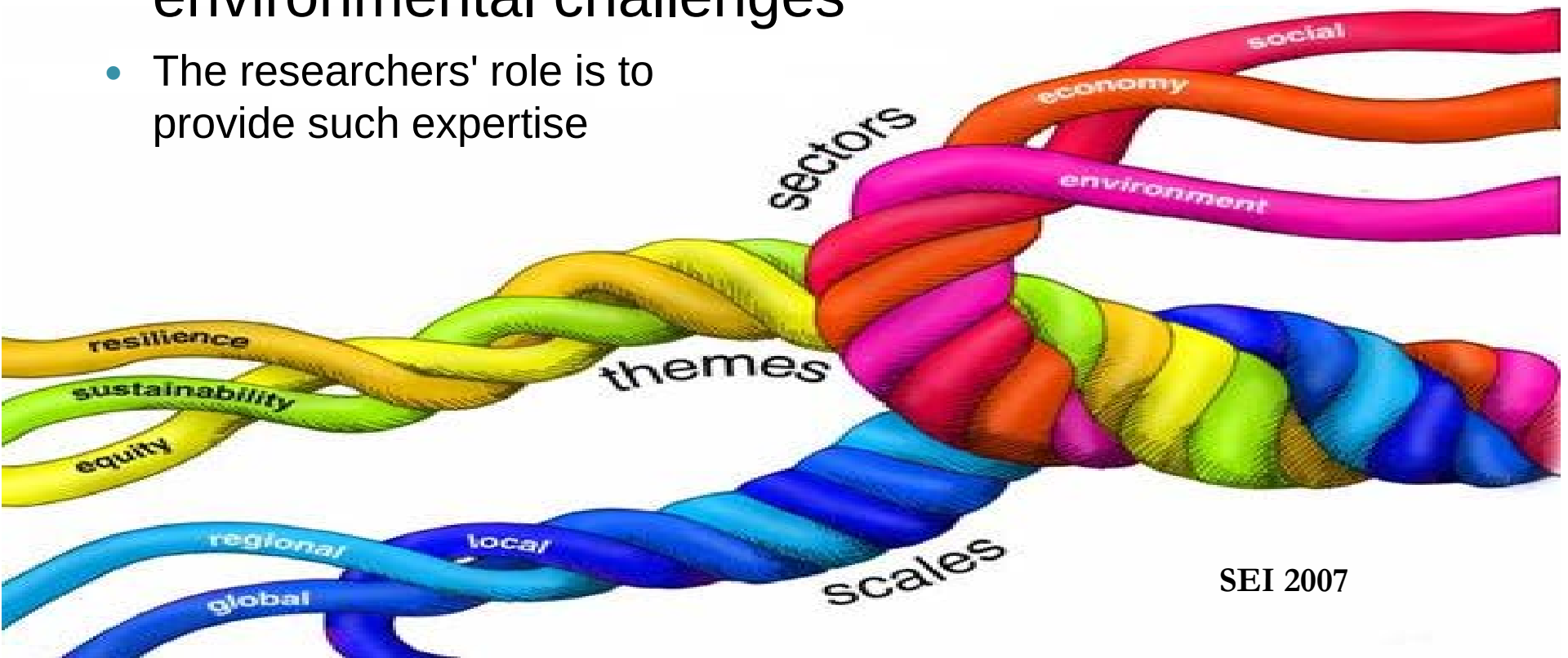
Abatement measures

Barriers and Thresholds

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

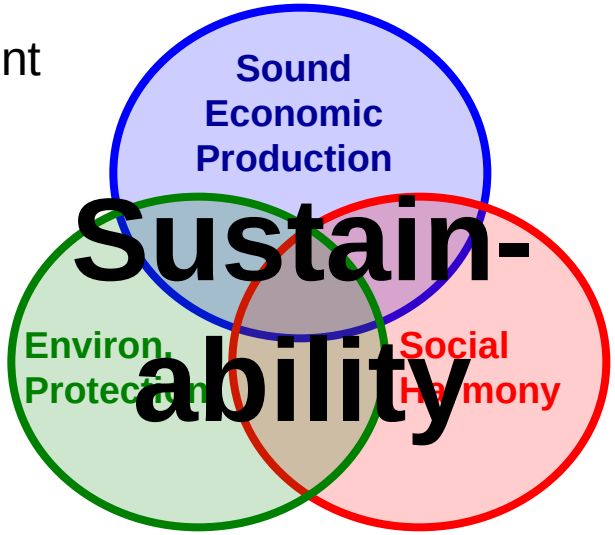


SEI 2007

Sustainable development

- Enable decision makers
  to establish **knowledge** based abatement strategies
  on environmental challenges
  that are political and societal feasible
  thereby **ensuring** a sustainable development

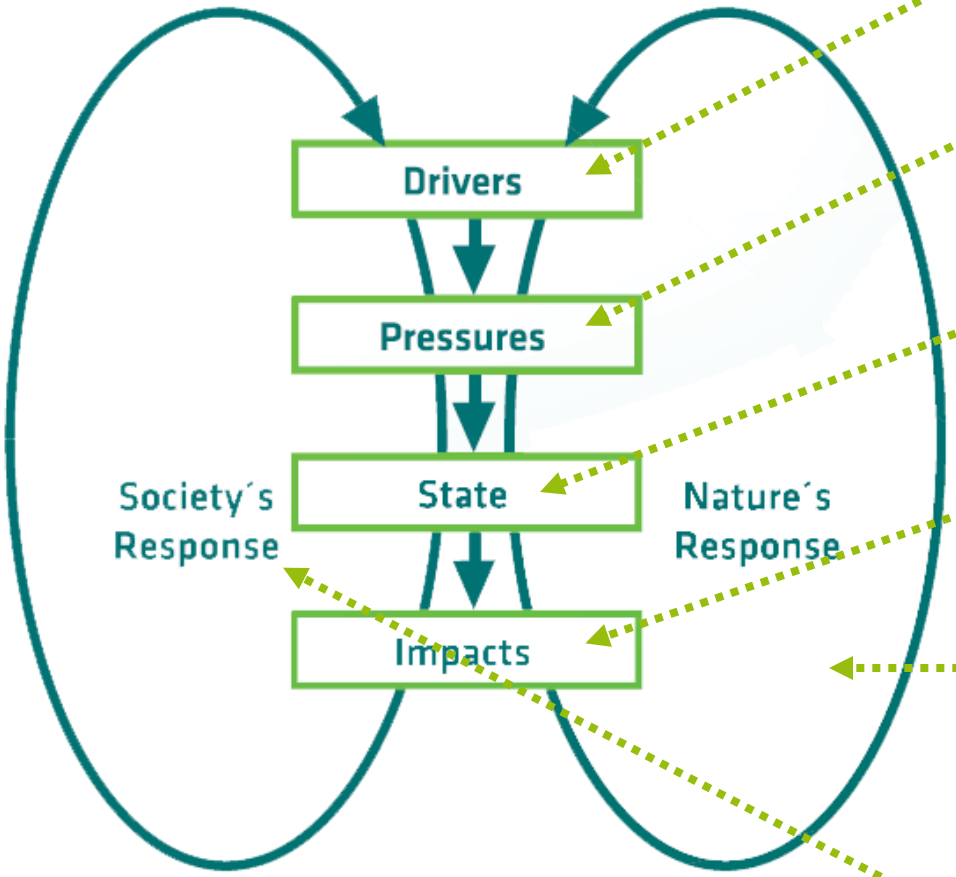
- Demand for environmental protection
  need to be balanced against limitation
  posed by social harmony and
  economic production



Sustainability implies
positive solutions for all components

Outline

DPSIR - Conceptual framework



Drivers: Population growth, consumption

Pressures: Pollution to air and water (Side effects of drivers)

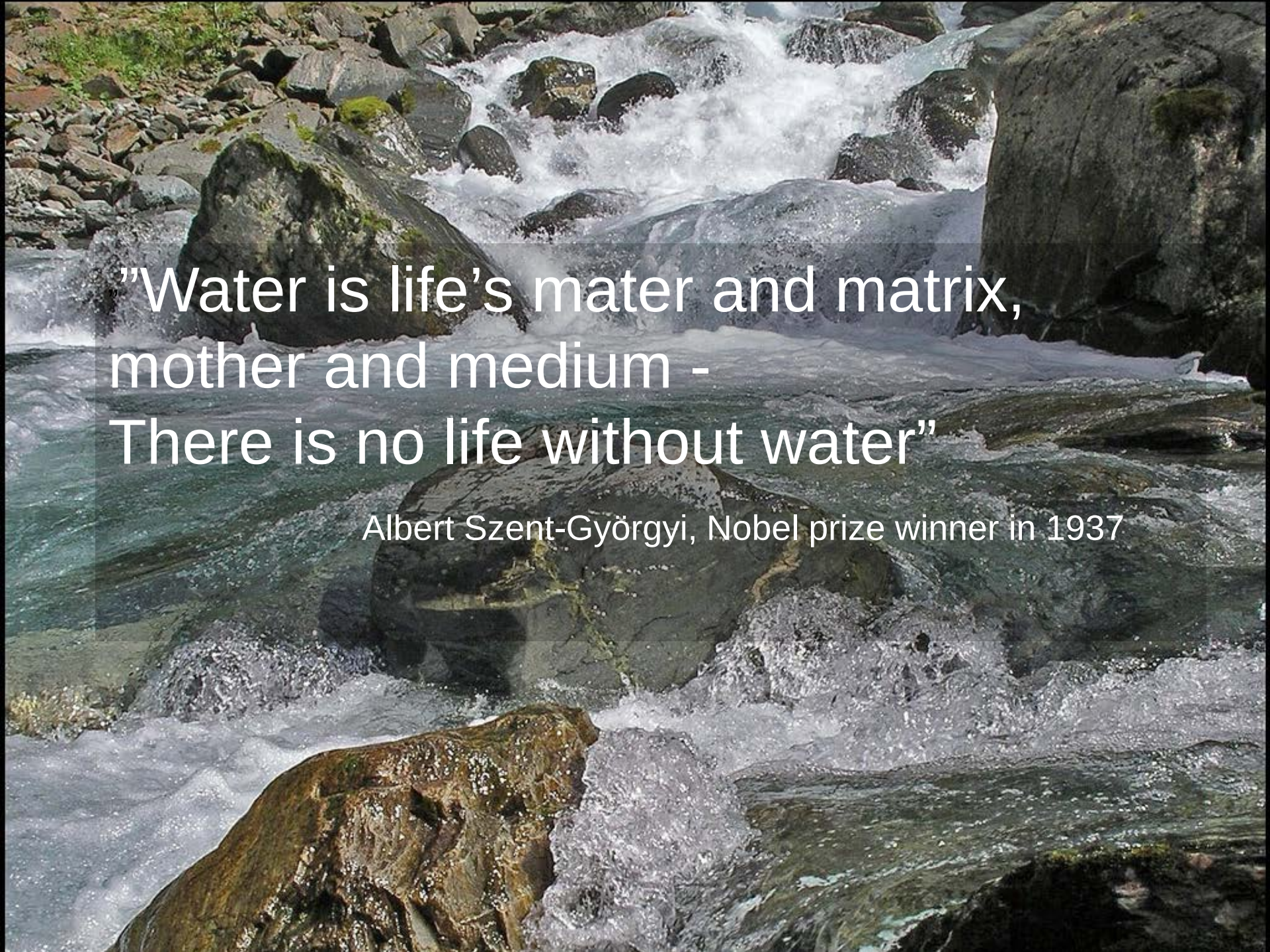
State: Chemical & Biological state of Water, Air, Soil

Impacts: 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

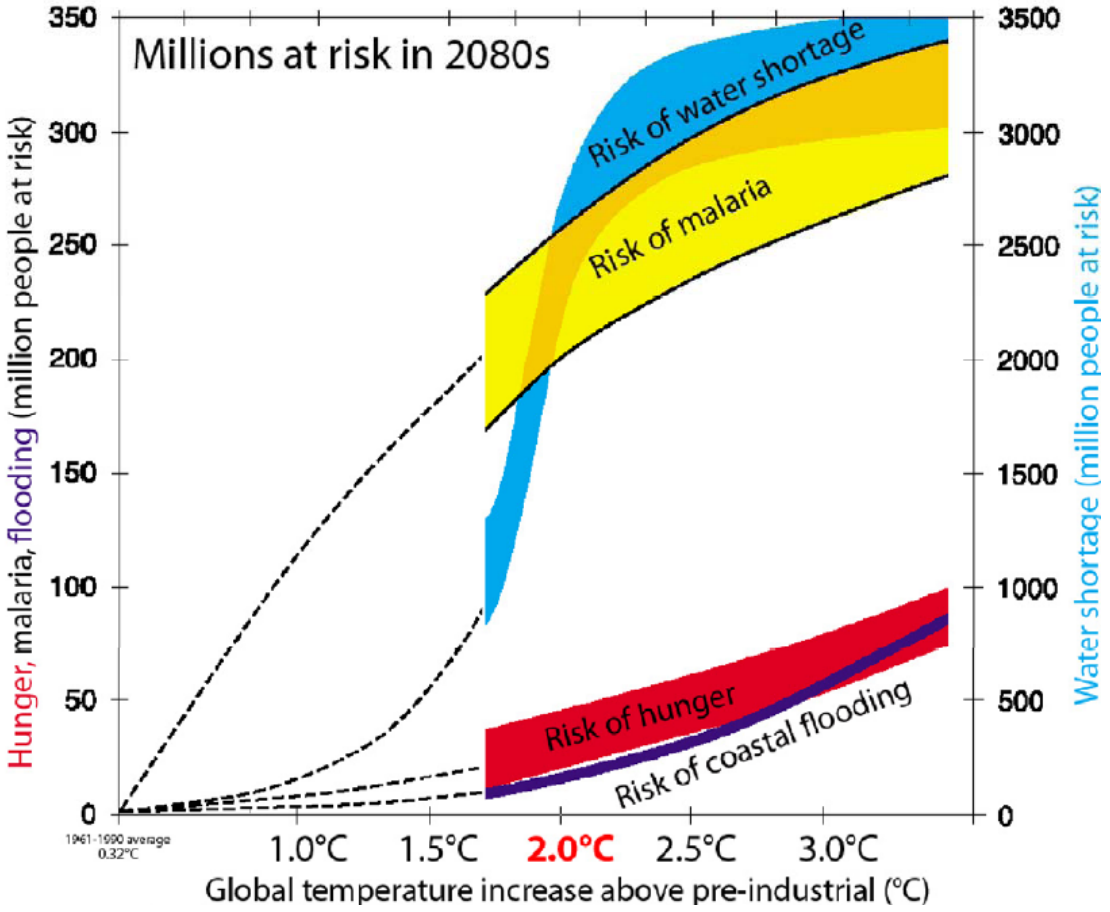

”Water is life’s mater and matrix,
mother and medium -
There is no life without water”
Albert Szent-Györgyi, Nobel prize winner in 1937

The main issue

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

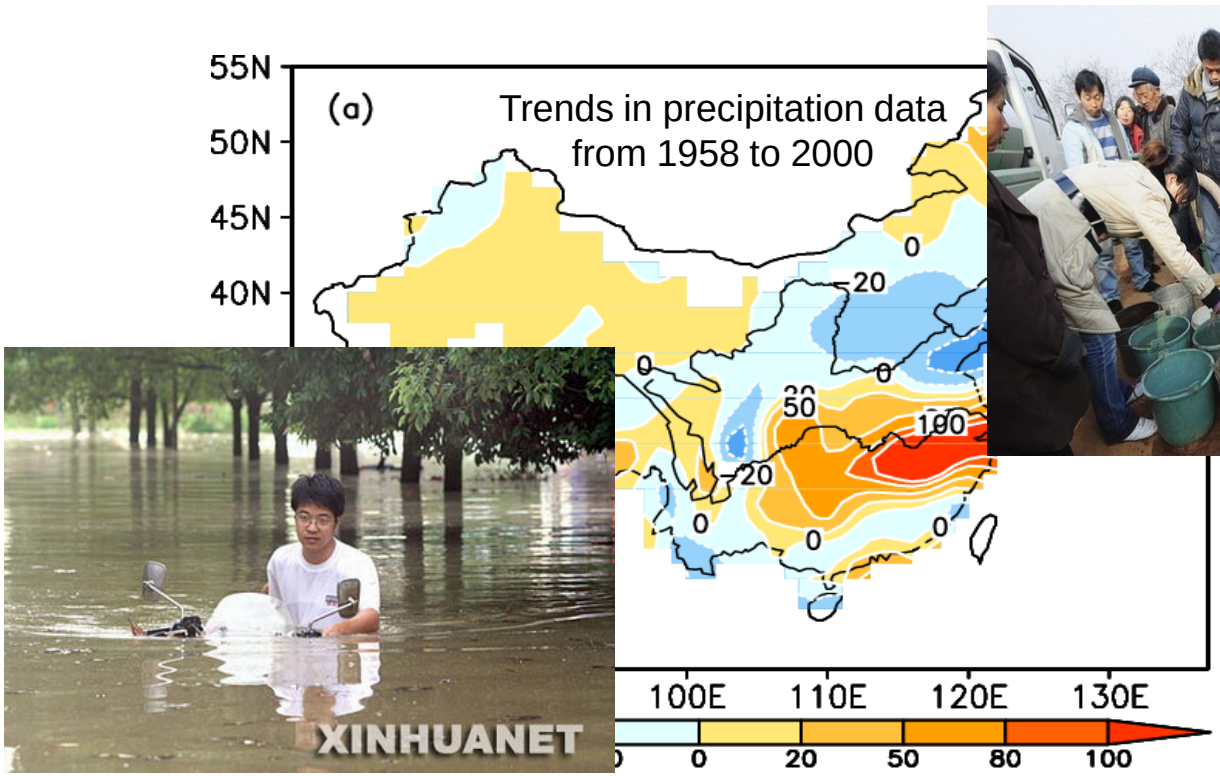
- *Lakes throughout China are commonly undergoing the process of eutrophication:*
  - *Most of urban lakes are facing hypertrophication*
  - *Many medium sized lakes are of eutrophic state*
  - *The five large freshwater lakes are in the condition of eutrophication*
- *Water quality is deteriorating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

Effect of climate change on water supply



- Water shortage is what will inflict most people

Climate change in China will lead to more drought in the north and more floods in the south



T.J. Zhou, IAP/CAS

- Water consumption in China is 5 doubled since 1949
- Overconsuption of ground water resources – empty within 30 years?

What is the problem..?

- Why are we not able to deal with eutrophication?
  - Are the abatement actions inappropriate?
    - Are we targeting the wrong sources of nutrients and form of nutrients?
    - Are the effect of our abatement actions disguised by changes in other environmental pressures?
  - Are the abatement actions not political or societal feasible?
    - Are there barriers or thresholds in the society hindering the implementation of abatement actions?
    - Is there a lack of knowledge of stakeholder interests and of the problem in the public that is preventing a collective action?

The research needs

- **Goal:**

  Increase our ability to **predict effects**

  of abatement measures and changes in the environment

- **Need:**

  Improve the **reliability** and **relevance** of prediction models

- **Strategy:**

  - Assess temporal and spatial variation in P-fractions
  - Assess societal thresholds and barriers towards abatement actions

  → identifying the most cost-efficient and feasible abatement actions
  by substituting empirical deduced assessments with
  conceptual induced knowledge based process understanding from nature- and social sciences.

- **Prerequisite:**

  Need to **link:**

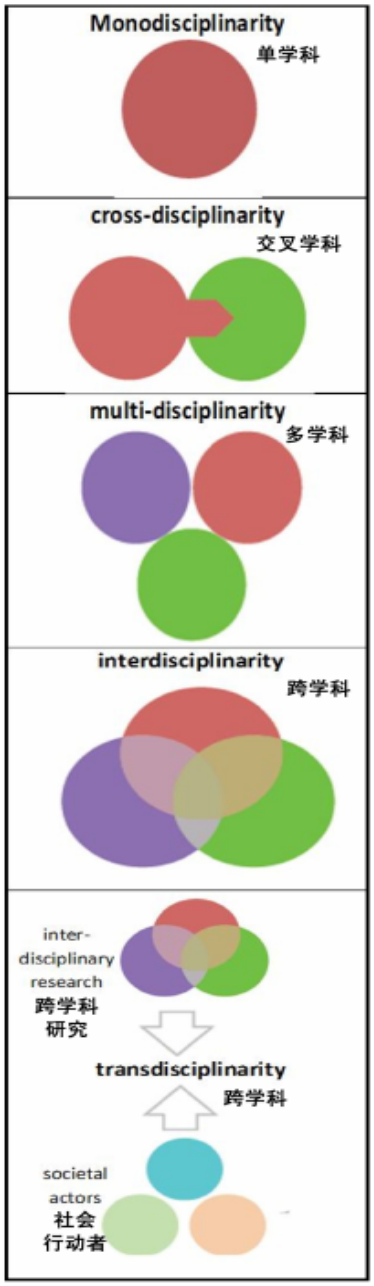
  - geochemical and physio-hydrological processes in the **catchment** with the **in-lake** biochemical processes controlling the level of nutrients (P, N, C) and its effect on water quality

  - **nature-** and **societal** sciences

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 – Analytical 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

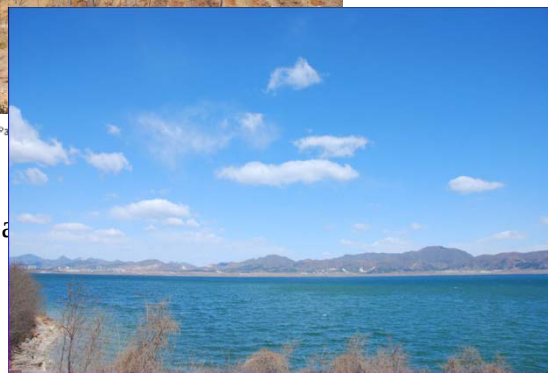
Hypothesis - Processes

- It will be possible to assess the processes governing **mobilization and transport** of nutrient (P, N and C) from soil by determining their soil pools and fractions in water
  - The role of **particle transport** of nutrients is likely overestimated as most of this material is mainly irreversibly buried in the sediments
- 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

FIGURE 4a Soil pools of phosphorous in different genetic soil horizons at the three soil plots at Dalen. O, E, EA, B and C denote genetic soil horizons.

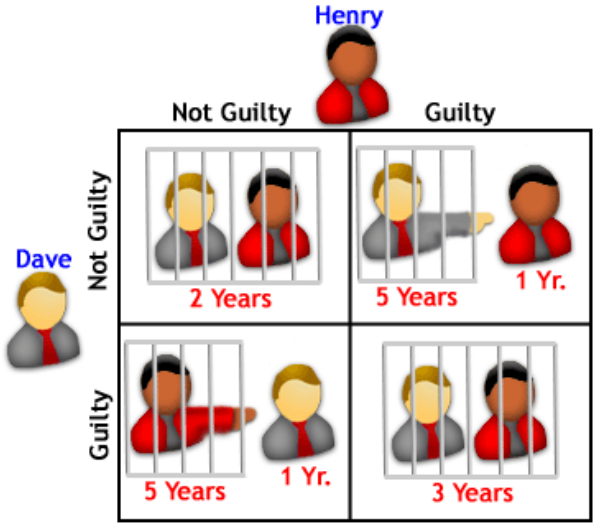
Hypothesis - Models

- 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 response

- 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



Research Strategy

- The hypotheses are tested through integrated works packages

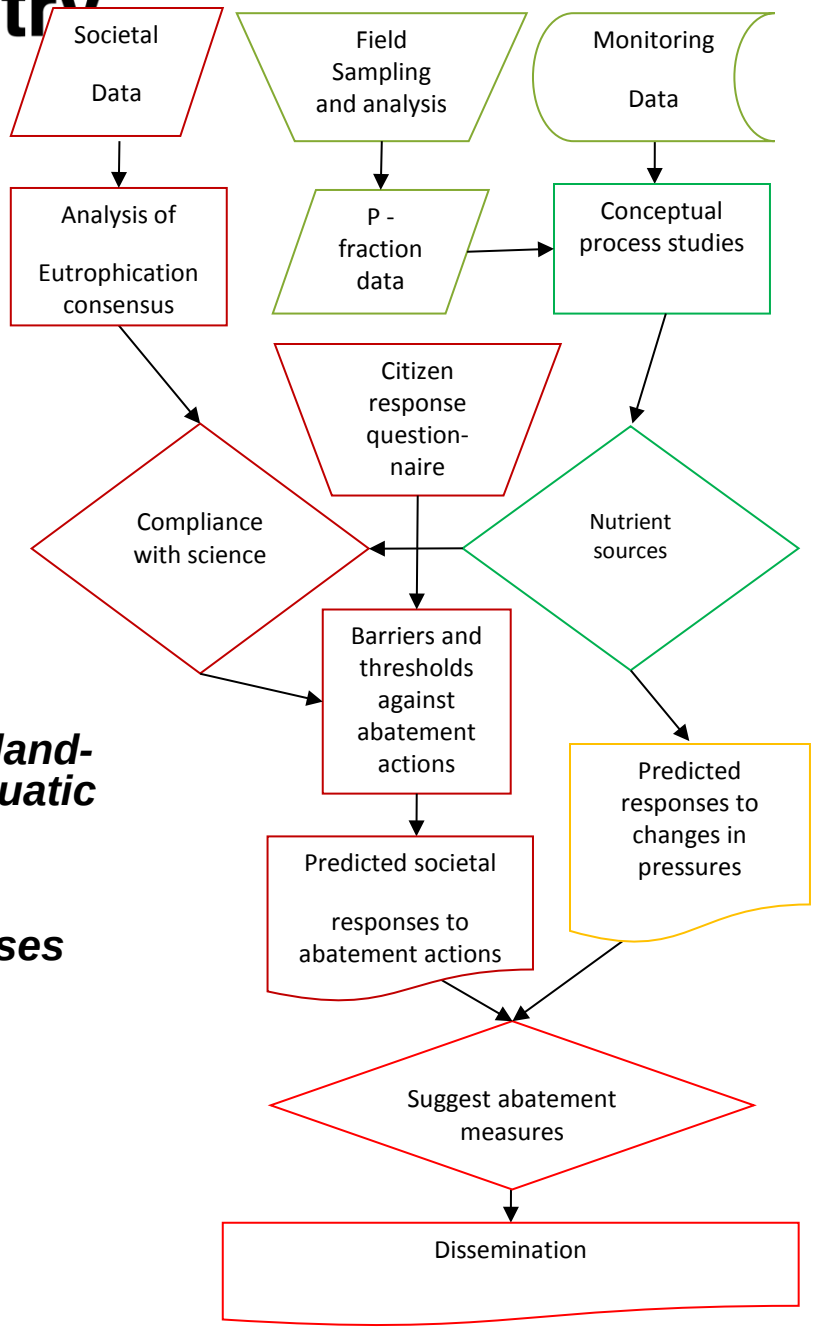
WP1 ***Field sampling and chemical analysis***

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

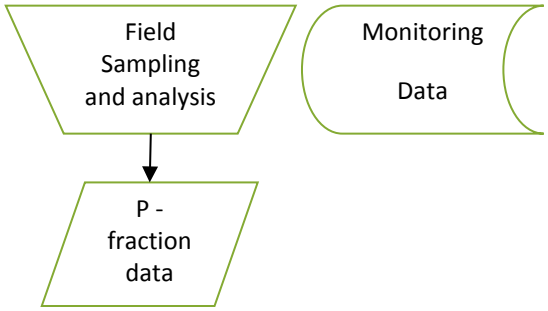
WP3 ***Modelling of catchment and lake processes***

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

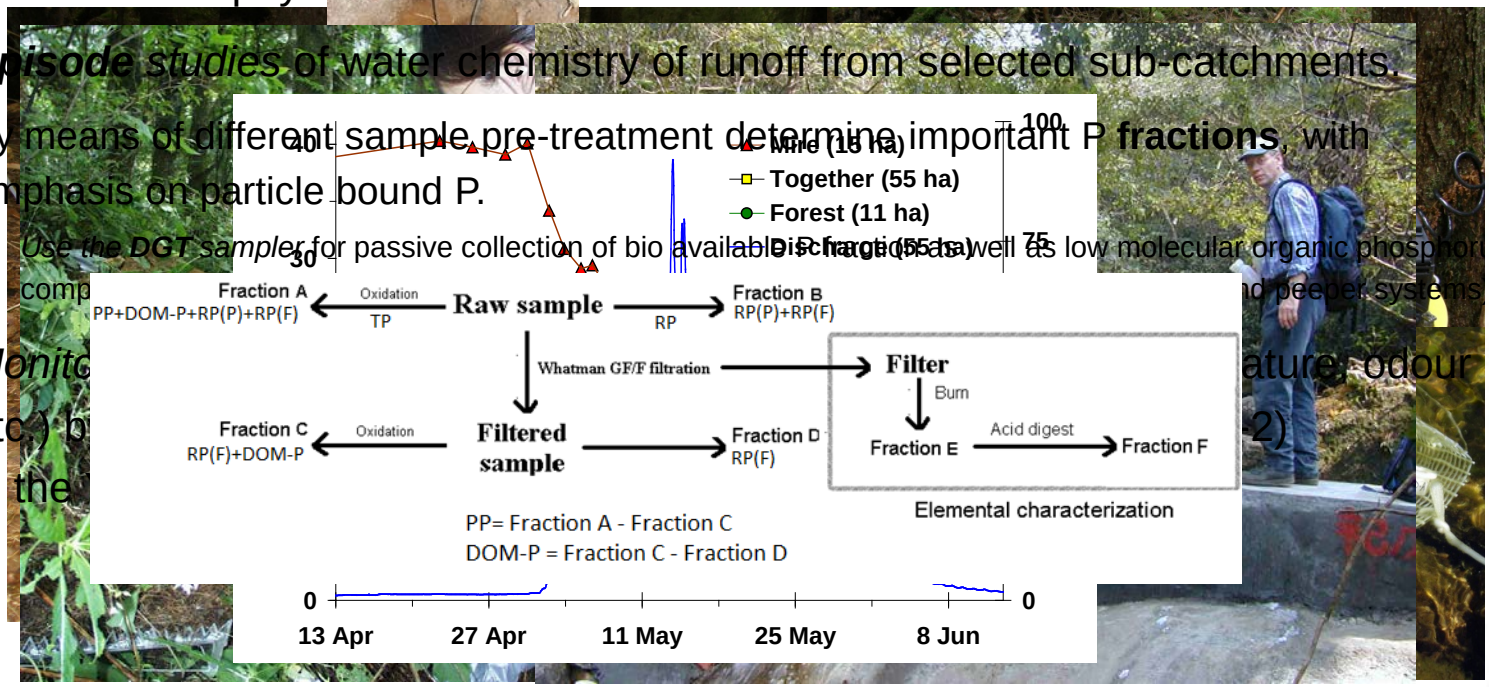
WP5 ***Nutrient management plan for Yuqiao reservoir***



Tasks

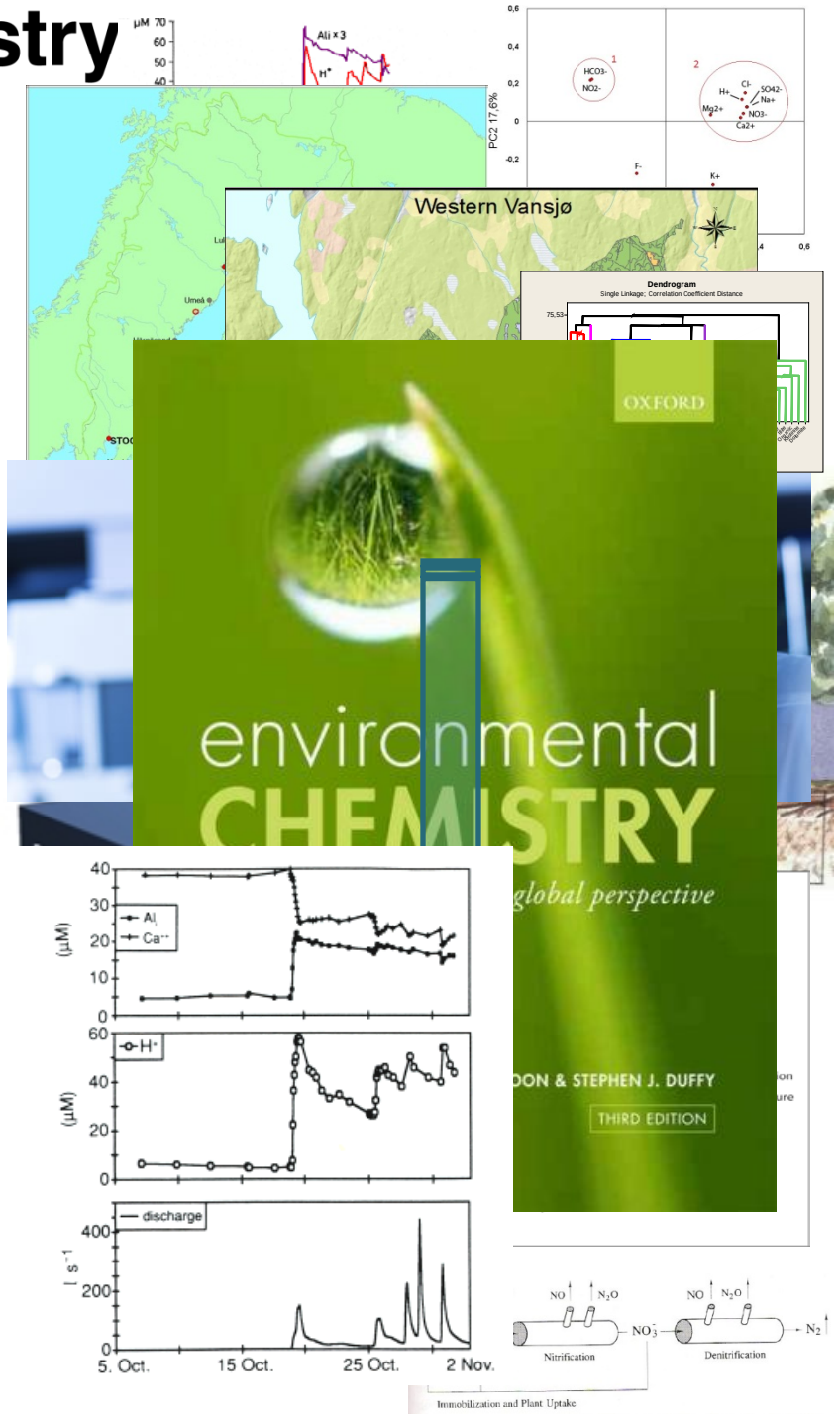


- WP1 Field sampling and chemical analysis
  - ***Instrument*** *soil plots in 2 sub-catchments* and their perennial streams for capture of water flowing through the watershed.
  - *Conduct* ***synoptic study*** *of seasonal water and soil* chemical and physical characteristics in the whole watershed.
  - ***Episode*** *studies* of water chemistry of runoff from selected sub-catchments.
  - By means of different sample pre-treatment determine important P **fractions**, with emphasis on particle bound P.
    - *Use the* ***DGT sampler*** for passive collection of bio available P fraction (55 ha) as well as low molecular organic phosphor comp… …d peeper systems
  - *Monitc* …ature, odour etc.) b… …2) in the



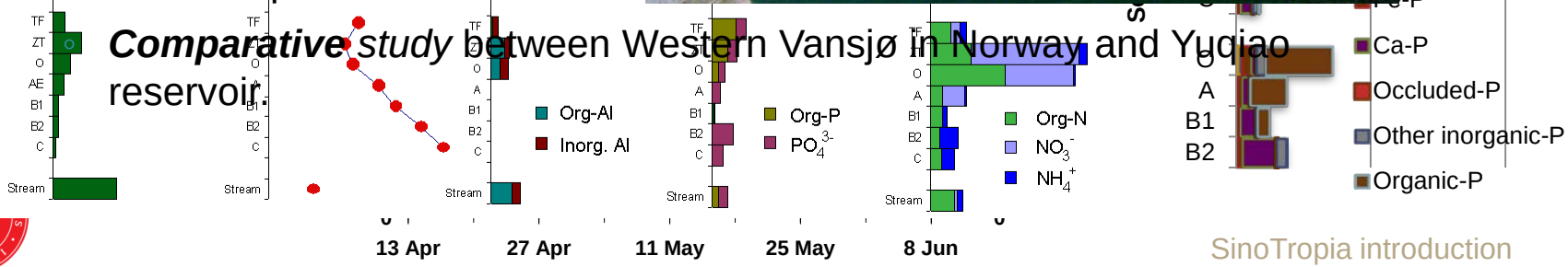
Research strategy

- Collect samples according to a sampling strategy - capturing The span in parameters to be determined
- Conduct chemical analysis
- Compile other explanatory data (e.g. land-use, runoff) that may provide measures for important pressures
- Deduce empirical relationships between environmental parameters describing the system being studied
  - Assess especially the relationships between explanatory- and response variables
  - Correlation, cluster and PCA
- Induce chemical concepts in the interpretation of the empirical relationships



Tasks

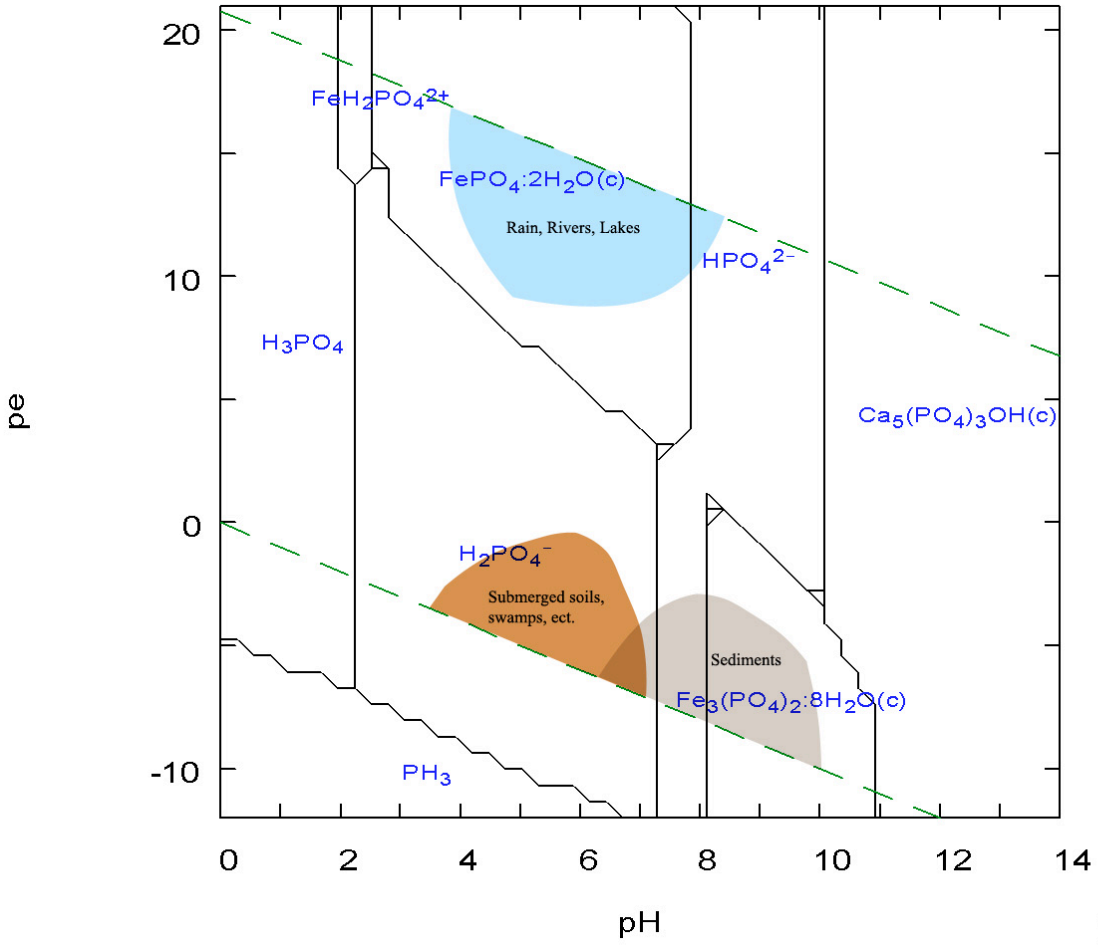
- WP2 Catchment processes
  - the influence of land-use and climate on nutrient fluxes



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

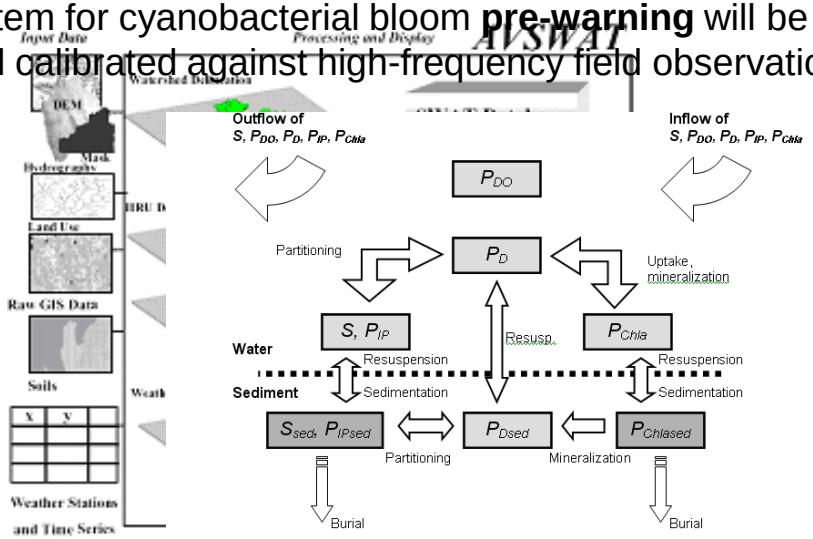
Inorganic Phosphorus

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



Tasks

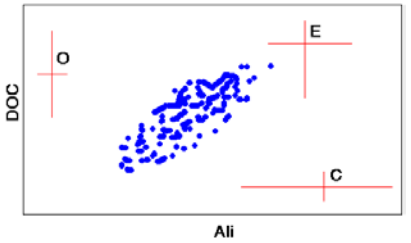
- WP3 Modeling of catchment and lake processes
  - The Soil and Water Assessment Tool (**SWAT**) is a river basin scale model that will be adapted and parameterized for the investigated sub-catchment of Yuqiao reservoir.
    - The optimized model will be used to **test hypotheses** of nutrient mobilization 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

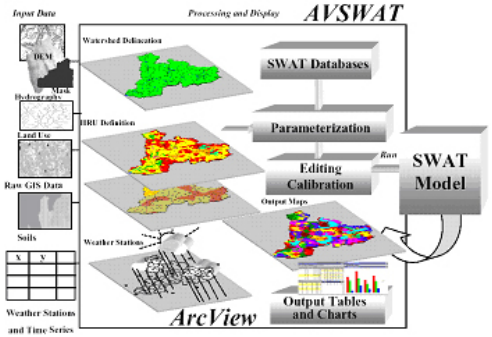


http://swatmodel.tamu.edu/

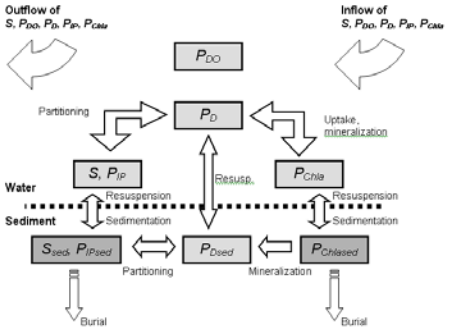
Modelling

- 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.

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