WP3: Climate & non-climate drivers of change

Aim: To compile integrated spatio-temporal climatic & catchment data for sentinel lakes

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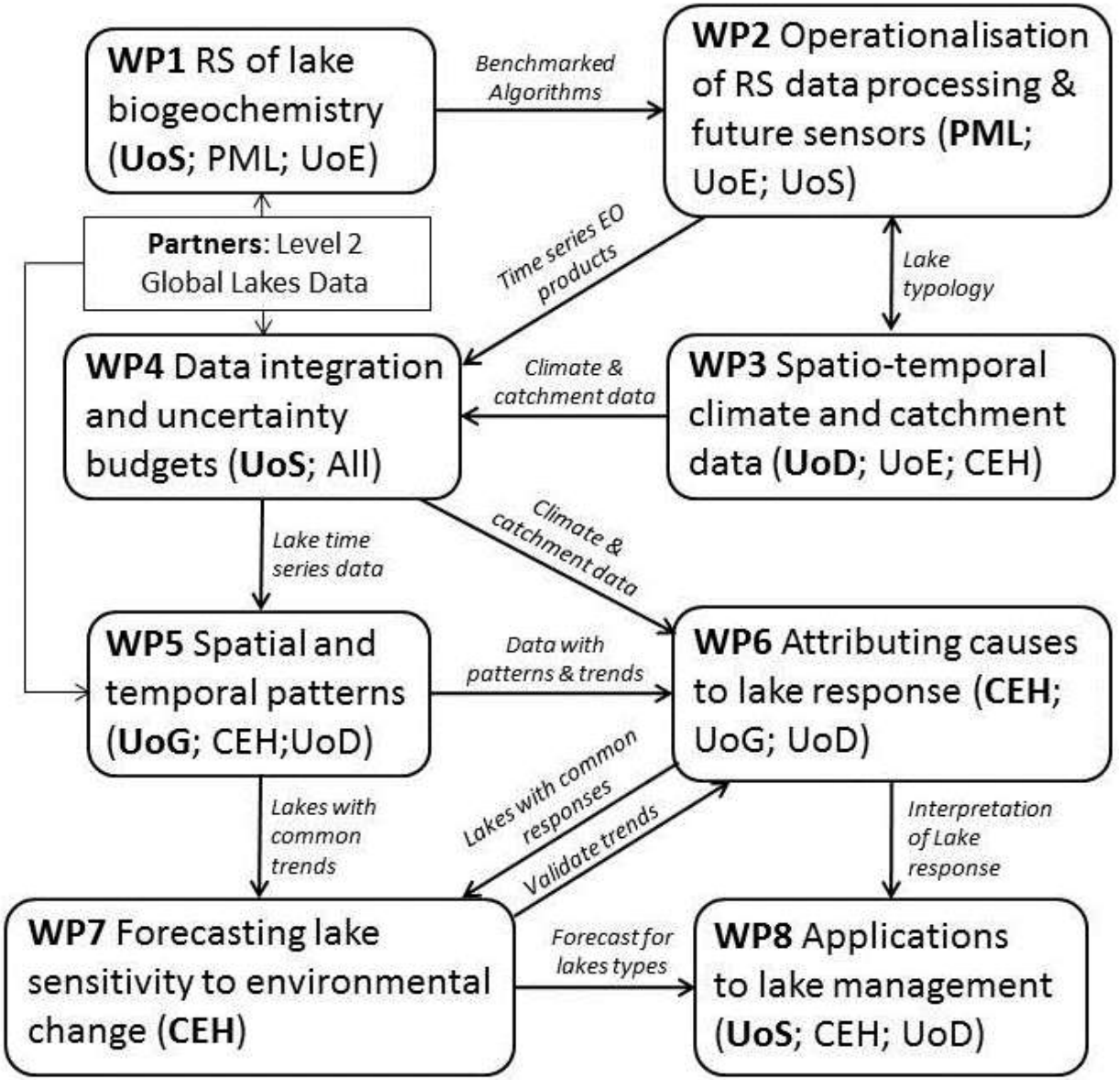
WP3: Climate & non-climate drivers of change

- Lakes respond to multiple exogenous and endogenous drivers of change
- Superimposed on natural variability are human pressures e.g. agriculture, urbanisation, water resources, invasives…
- Understanding the provenance and temporality of drivers of change vital to understanding lake behaviour


WP1 RS of lake biogeochemistry (UoS; PML; UoE)
Benchmarked Algorithms
WP2 Operationalisation of RS data processing & future sensors (PML; UoE; UoS)
Partners: Level 2 Global Lakes Data
Time series EO products
Lake typology
WP4 Data integration and uncertainty budgets (UoS; All)
Climate & catchment data
WP3 Spatio-temporal climate and catchment data (UoD; UoE; CEH)
Lake time series data
Climate & catchment data
WP5 Spatial and temporal patterns (UoG; CEH;UoD)
Data with patterns & trends
WP6 Attributing causes to lake response (CEH; UoG; UoD)
Lakes with common trends
Lakes with common responses
Validate trends
Interpretation of Lake response
WP7 Forecasting lake sensitivity to environmental change (CEH)
Forecast for lakes types
WP8 Applications to lake management (UoS; CEH; UoD)

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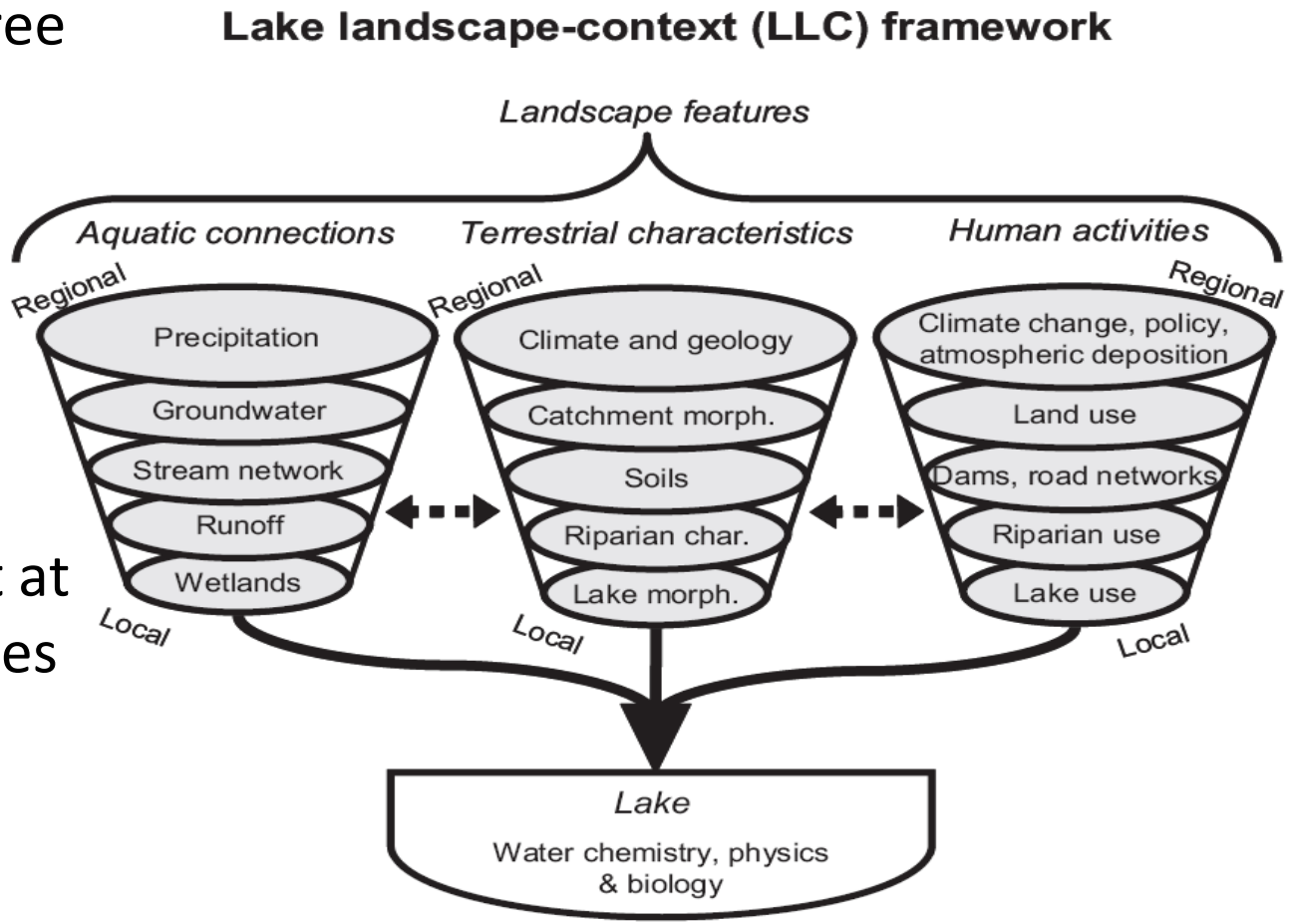
Deliverable 3.1: Selection of 1000 sentinel lakes utilising lake-landscape context principles [M3]

- Largest 1800 lakes selected from Global Lakes & Wetland Database, with further screening relating to shape, morphology etc (UoD & UoE)
- Candidates then selected via Lake Landscape Context Framework (LLC) (Sorrano *et al*., 2009)

Lake-Landscape Context

- LLC recognizes three sets of landscape features
  - *Aquatic*
  - *Terrestrial*
  - *Human*

Influencing lake variations & interact at local to regional scales



Lake-Landscape Context

- Criteria used based upon processes / characteristics of interests:
  - Temperature (ecoregion, altitude, catchment infrastructure, lake morphology etc)
  - Primary production (regional climate, nutrient input, geology, land cover/use etc)
  - Turbidity (primary production, land cover, etc.)
- Once grouped then stratified random selection of lakes, refined further with lakes of 'special interest' from partners etc.

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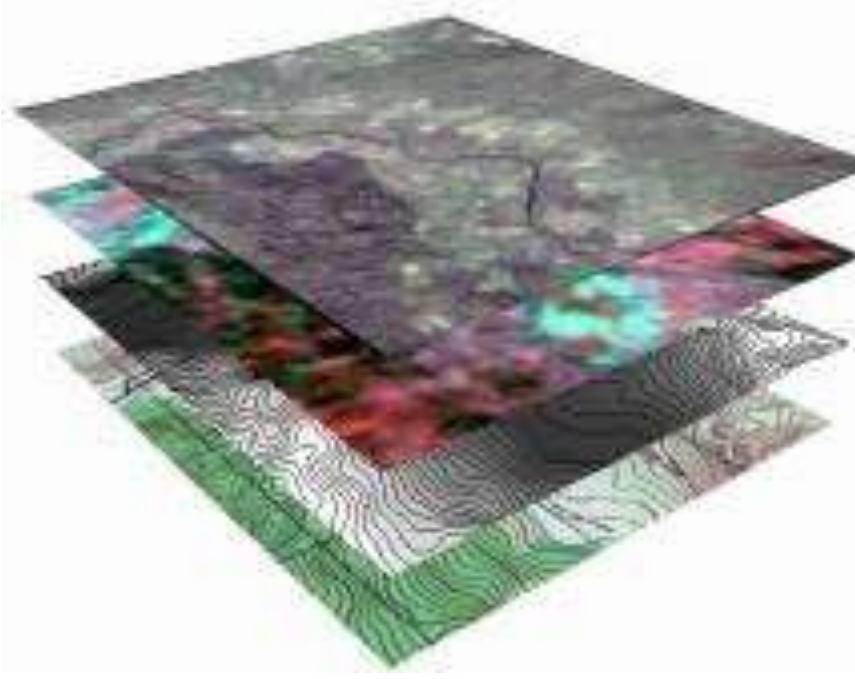
Deliverables 3.2 & 3.3: Collation of standardised datasets relating to climatic trends for the study catchments [M9] AND Characterisation of land cover / land use trends over 30 years in the study catchments [M27]

- Collation of datasets pertaining c. 1000 lakes e from available databases at 30 by 30 arc-sec grid (over 30 year period)
  - Information on climate, land use/cover, catchment morphology, lithology & soil & population, supplemented by additional observations if appropriate
- Populated additionally by datasets & information from project participants, partners and affiliated organisations
- Finer spatial/temporal resolution database required/available for candidate UK / EU validation lakes
- Data made available online via standard project protocols



Catchment Data sets

- 1 km^2 grid (22 $x10^6$ cells) represent global land mass and framework to map changes in catchment attributes (climate/non-climate signatures);
- *Climate* regionalized time series e.g. CRU-TS 3.1 (1901-2009); extracted time series from ECMWF re-analyses; locally downscaling for UK lakes
- *Catchment morphology* from NOAA Global Land 1-km Grid Base Elevation data augmented with the USGS Hydrosheds database;
- *Lithology* and *soil* properties - Harmonized World Soil Database (HWSD);
- *Land cover* (e.g. GLC2000 database; FAO's Global Forest Resources Assessment 2000);
- *Population density* for the year 2000 developed by FAO-SDRN
- For the UK/EU lakes compile a separate database at a finer spatial resolution e.g. UK Land Cover Map series, NEXTMap-derived topography and UK Met. Office climate data combined with hydrometric and water quality data from EA, SEPA and NIEA.

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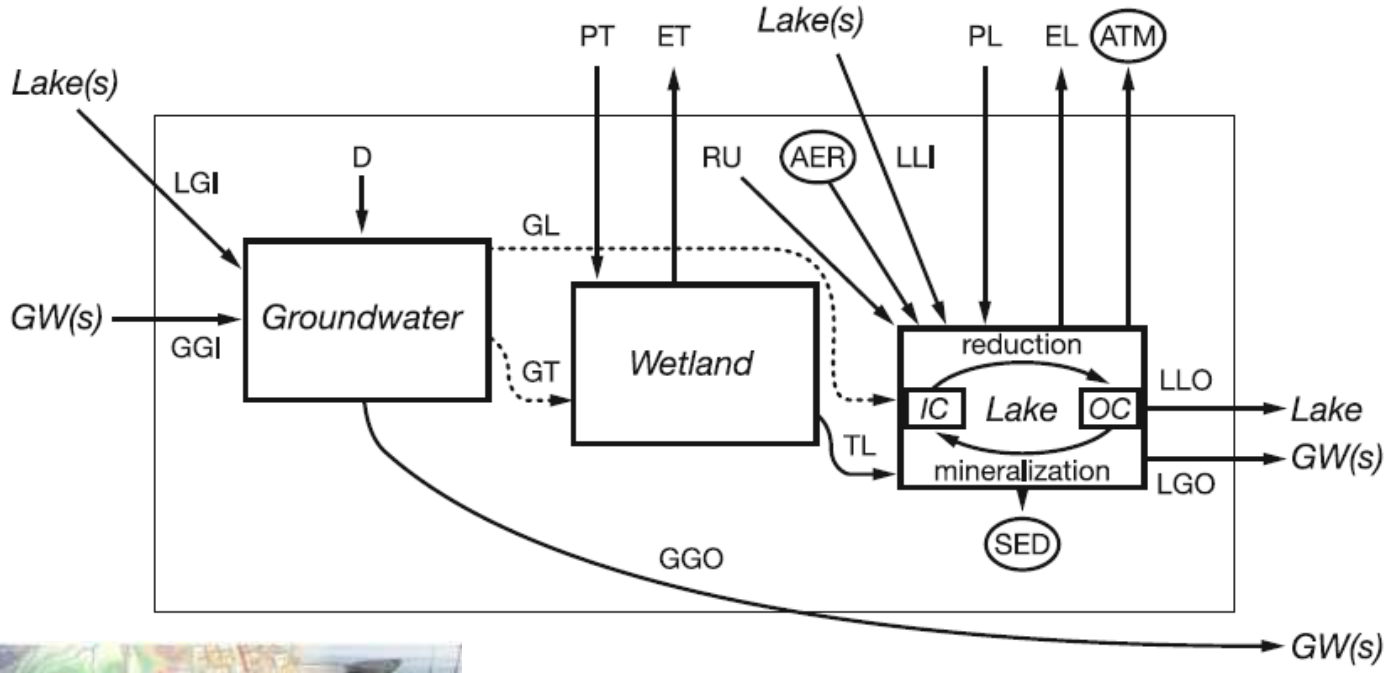
Deliverable 3.4: Modelling trends in runoff, sed. and nutrient loads for the study catchments [M36]

- Trends to be modelled at different resolutions:
  - For a smaller number of lakes where high spatial and temporal resolution observations exist: LUWI (Lakes, Uplands, and Wetlands Integrator) model.
  - For all lakes, using freely available datasets of land cover etc., trends in lake inputs modelled using: e.g. WaterWorld (Mulligan 2012).

LUWI model

- Revise the GIS-based LUWI (Lakes, Uplands & Wetlands Integrator)
- Account for the stocks and fluxes of water, carbon and nutrients for a given lake based upon the catchment area
- Determine the spatial dependency of catchment processes & impacts to inform use and selection of models for rest of lakes.



WaterWorld

- For anywhere in the world, produces a hydrological baseline for a 1950-2000 baseline using some 140+ input maps and a spatial physically based model
- *1-hectare or 1-square-km* spatial resolution and monthly temporal resolution
- Focused on water *quantity, quality* and some regulation ecosystem services
  - Based on FIESTA model (Mulligan and Burke, 2005; Bruijnzeel *et al*., 2011)
  - Not calibrated (e.g. to observed flows)
  - Gridded representation of water balance (wind-driven rainfall+fog-evapotranspiration)
  - Positive water balances cumulate downstream as flows

Summary of WaterWorld Outputs

Annual:

Total annual actual evapo-transpiration (mm/yr)
Per capita water availability (Mm^3/person)
Annual total water balance (mm/yr)
Annual total soil deposition (mm/yr)
Total fog deposition (mm/yr)
Annual total gross soil erosion (mm/yr)
Fog inputs as a percentage of water balance (%)
Fog inputs as a percentage of total precipitation
Total annual fog runoff (m^3)
Total annual fog runoff (mm/yr)
Total fog inputs (mm/yr)
Annual total gross hillslope soil erosion (mm/yr)
Annual total hillslope net soil erosion (mm/yr)
Total annual hillslope runoff (m^3)
Total fog impaction (mm/yr)
Mean percentage of water may be polluted (%)
Annual total net soil erosion (mm/yr)
Annual % of runoff generated by fog (%)
Runoff ratio by subcatchment (fraction)
Total annual runoff (m^3/s)
Total annual runoff (m^3)
Total annual runoff (mm)
Total annual potential evapo-transpiration (mm/yr)
Total wind-corrected rainfall (mm/yr)
Annual total soil transportation (mm/yr)
Water storage capacity (mm)
Mean annual terrain corrected wind speed (m/s)
Difference between rainfall and wind driven rainfall (mm/yr)
Freq. of potentially condensing conditions (%)
River network (dimensionless)
Total annual rainfall (not wind corrected) (mm/yr)
Mean annual wind exposure (topex scale)

Monthly:

Terrain-corrected wind direction (degrees from N)
Actual evapo-transpiration (mm/hr)
Water balance (mm/hr)
Water storage (mm)
River flow generated from fog inputs (mm/hr)
Hillslope Runoff (mm/hr)
Percentage of runoff derived from fog (%)
Percent of water that may be polluted (%)
Wind-corrected rainfall (mm/hr)
Runoff (mm/hr)
Snow Pack Water Equivalent (mm)
Fog inputs as a % of total precipitation (%)
Meltwater production (mm/hr)
Mean terrain-corrected wind speed (m/s)

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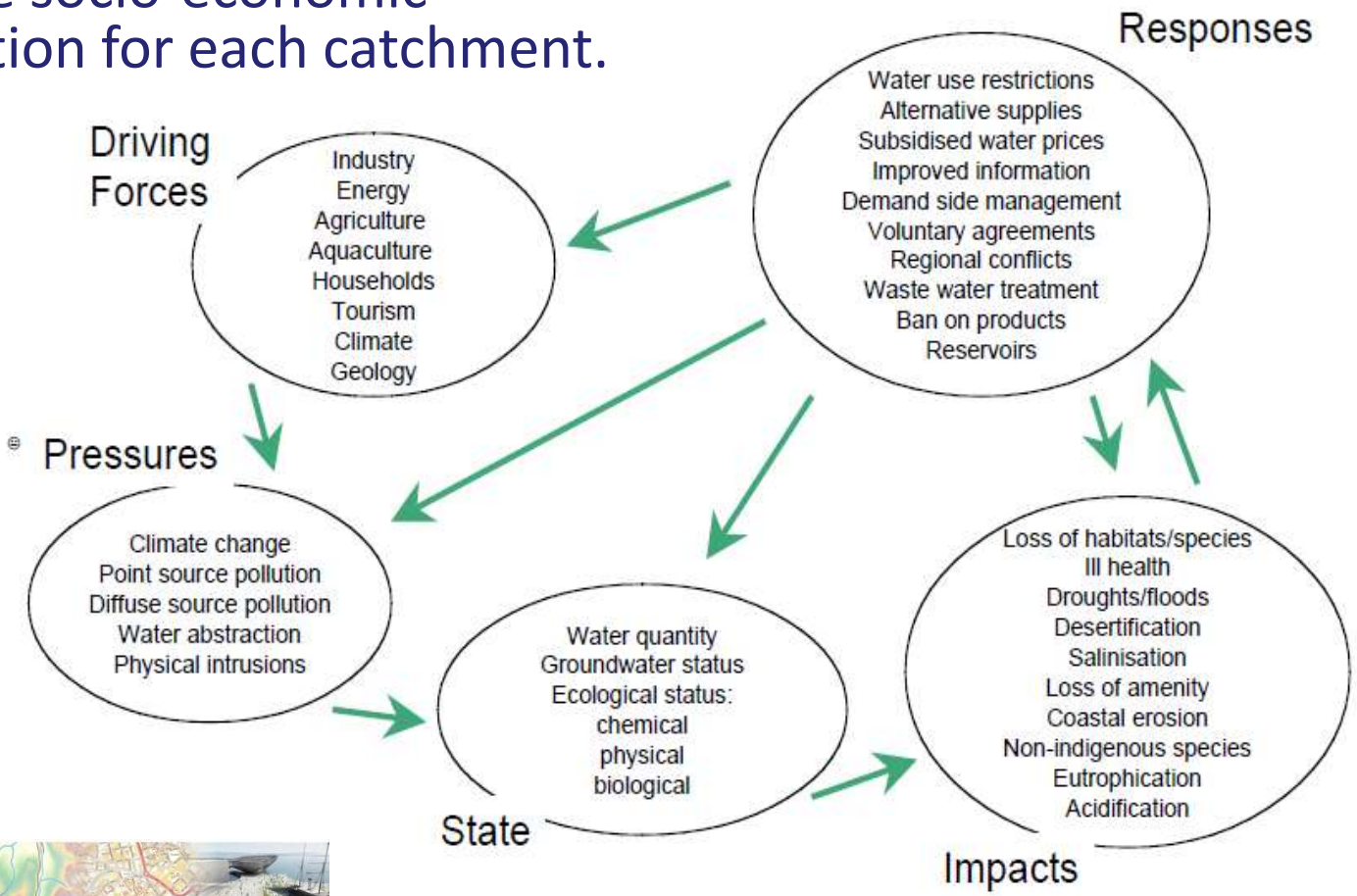
Deliverable 3.4: Modelling trends in runoff, sed. and nutrient loads for the study catchments [M36]

- DIPSR framework used to integrate socio-economic information for each catchment.



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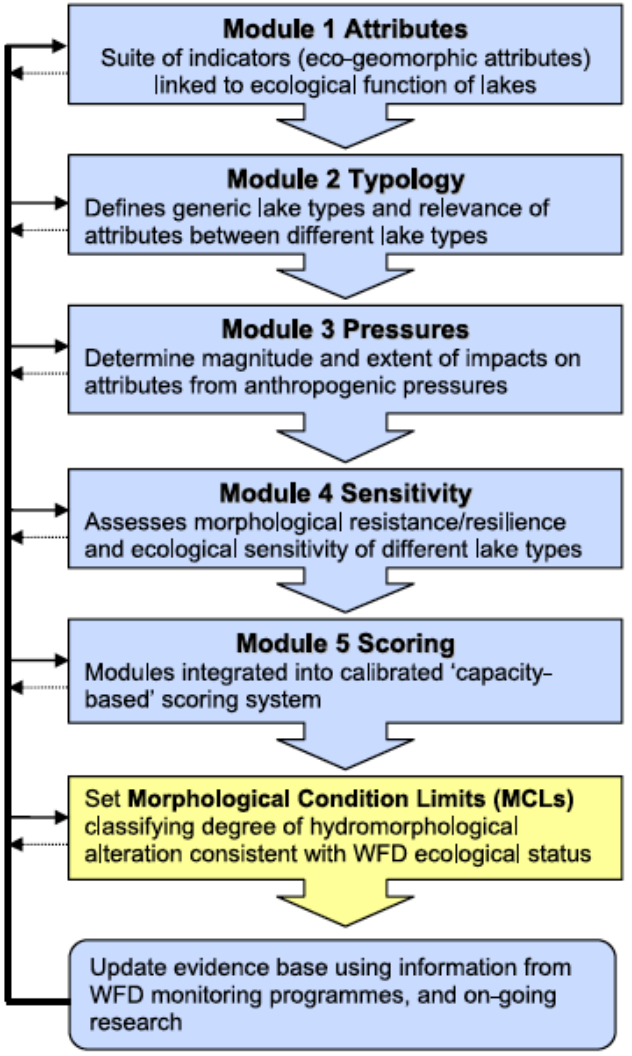
Deliverable 3.5: Assessment of hydromorphological alteration based on population and development (GDP) indices along with structural interventions [M21]

- Lake-MImAS characterise nature and extent of hydro-morphological alteration
- Develop and test standardised proxies for hydrological regime and structural modifications in lakes/catchments, based upon NOAA AVHRR and population data



Summary

- Major informatics drive to harmonise existing climate, topography, lithology, land cover etc. data for study catchments
- Characterise trends and dynamics of catchment drivers of lake change for all 1000 lakes
- Cloud-based database required