Introduction to the Climate-Land-Energy-Water (CLEWs) modelling framework

and its use in the Nexus Assessment of the Drin River Basin

Day 1 – July 6th, 2021

Agenda

Time	Session	Presenter
9:30-9:45	Welcome and introductions	Tassos Krommydas (GWP), Francesco Gardumi (KTH)
9:45-10:30	Introduction to Nexus assessment methodologies and CLEWS	Francesco Gardumi
10:30-10:45	Break	
10:45-11:15	Climate-Water-Energy nexus issues in the Drin River Basin: what can be modelled?	Francesco Gardumi
11:15-12:00	The water-energy model of the Drin River Basin: methodology	Youssef Almulla
12:00-12:45	Breakout group session: discussion on scenarios with the water-energy model of the Drin River Basin	All, facilitated by KTH
12:45-13:00	Wrap-up and end of session	Youssef Almulla

Day 1 – July 6th, 2021

Learning objectives

- Acquire general knowledge about the assessment of the water-energy-food nexus
- Understand the scope and characteristics of the CLEWs nexus methodology
- Understand the methodology underlying the water-energy model of the Drin River Basin
- Relate the scenario results of the water-energy model of the Drin river basin to key numerical assumptions and to the methodology

Introduction to Nexus assessment methodologies and CLEWS

Vignesh Sridharan, Eunice Ramos, Rebecka Engström, Youssef Almulla, Emir Fejzic, Francesco Gardumi

KTH Royal Institute of Technology

The problem

- Sustainable development means untangling a complex web of interwoven concerns and vested interests.
- Decisions can have far-reaching consequences outside the targeted area, sector, or jurisdiction.
- Impacts can be unintended and unforeseen.
- Cross-sectoral and cross-system impacts may be either positive or negative (or both).

A coordinated and integrated process to develop policies and measures with adequate attention given to cross-cutting aspects is needed to best manage synergies and trade-offs.

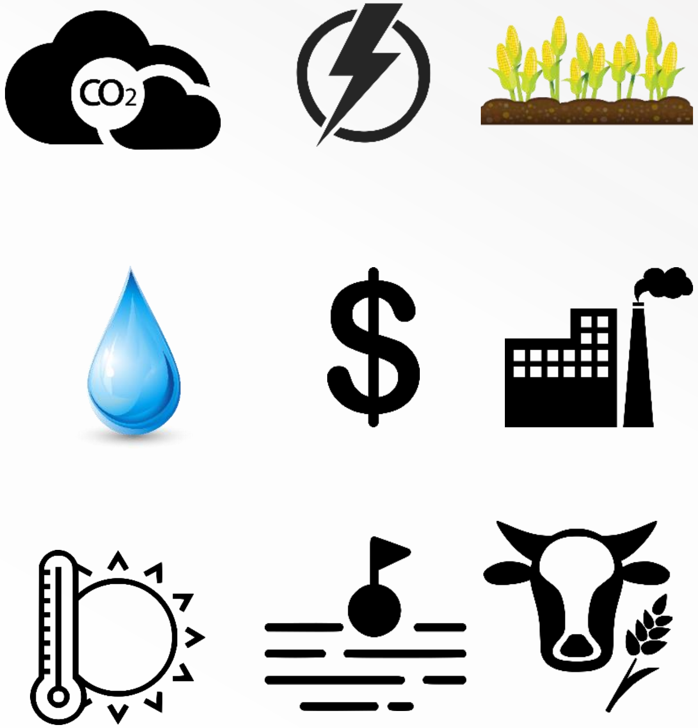
The problem

There is a need for policy coherence

- Systematically identify relevant linkages across the sectors and domains and consider those linkages in design of policies;
- Ensure that policies are consistent across sectors and scales (from local to global);
- Involve relevant stakeholders in design, implementation, monitoring, and evaluation;
- Allocate adequate resources for implementation at all levels and at all scales.

Integrated assessments

- Synergies and trade-offs between systems & sectors need attention
- Resources are finite
- Understanding the consequence of Human actions is paramount
- Integrated assessment is a **blanket term**- takes into consideration more than one system/sector
- Models developed to understand these interactions are called **IAMs (Integrated Assessment Models)**



Integrated assessment - The nexus

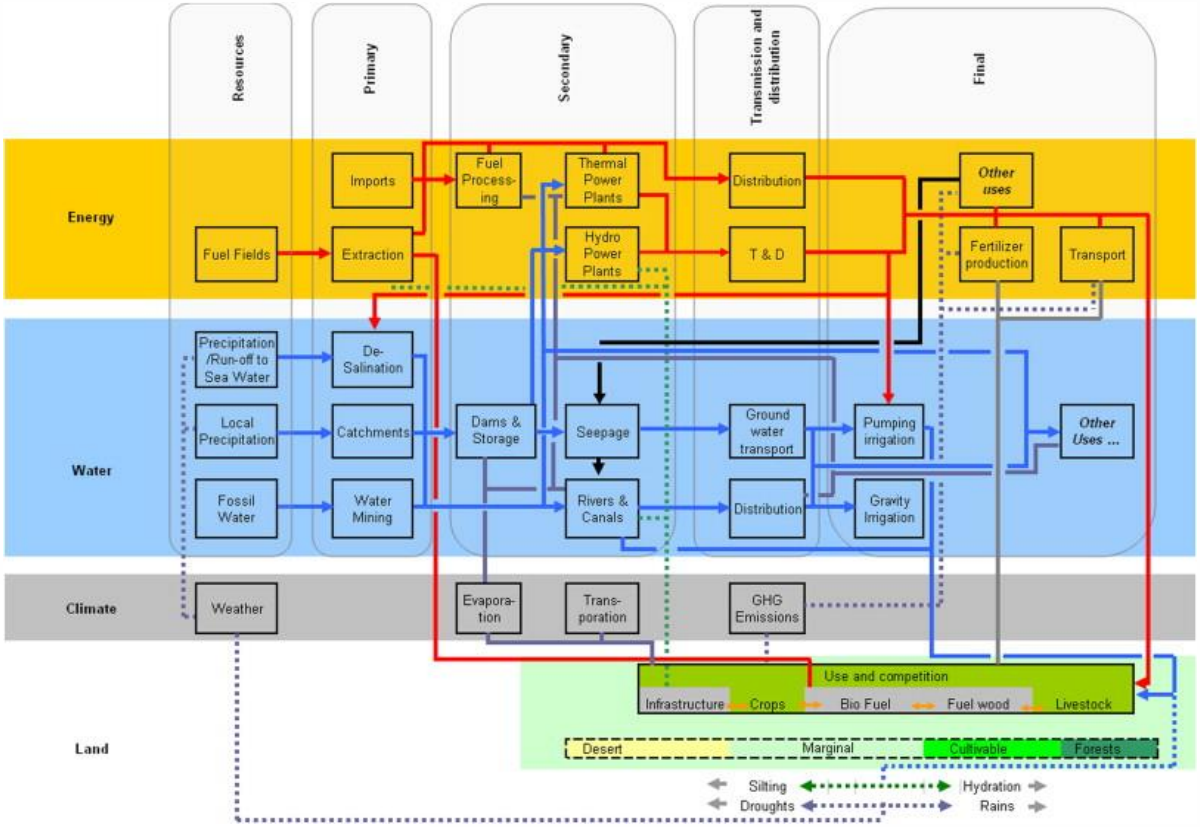
nexus

Interaction and interdependency between selected resource sectors/system/domains [in terms of trade-offs, conflicts, opportunities and synergies].

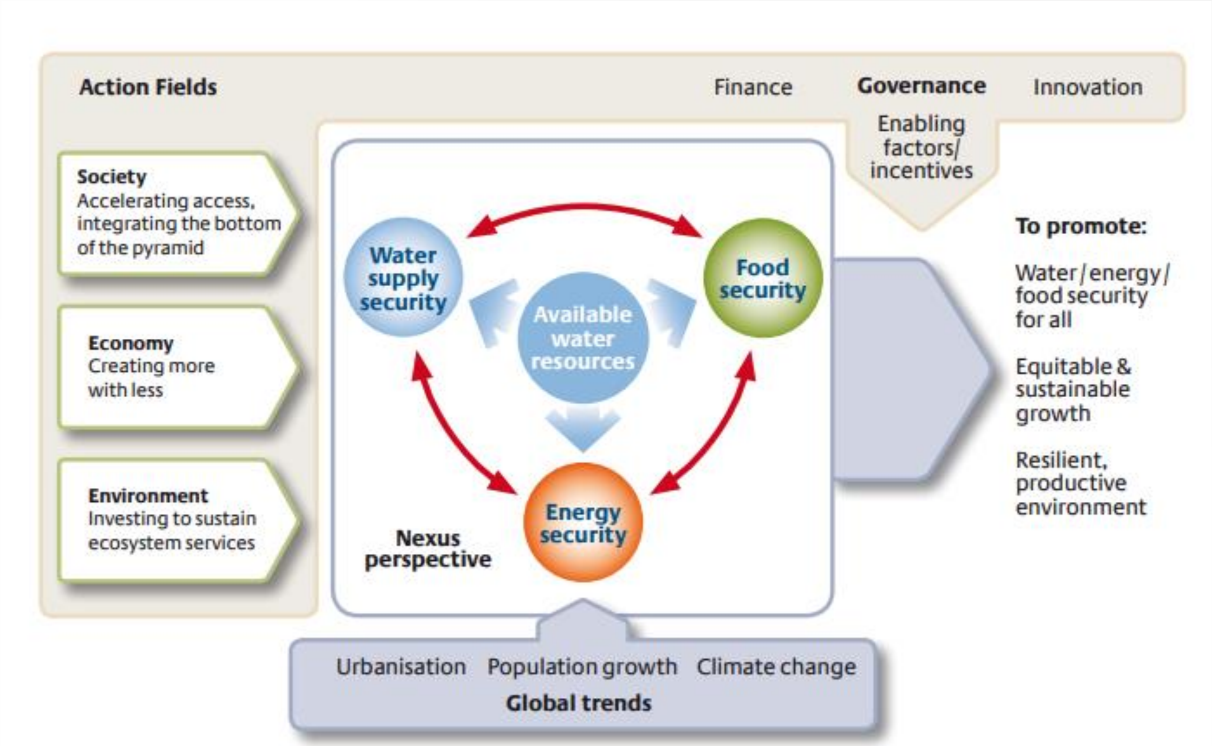
nexus approach

A systematic process of inquiry that accounts for water, land, energy, food and climate interactions (and/or other systems), in both quantitative and qualitative terms, with the aim of better understanding their dynamic relationships and inform planning and decision making in these domains.

Nexus approach - Frameworks

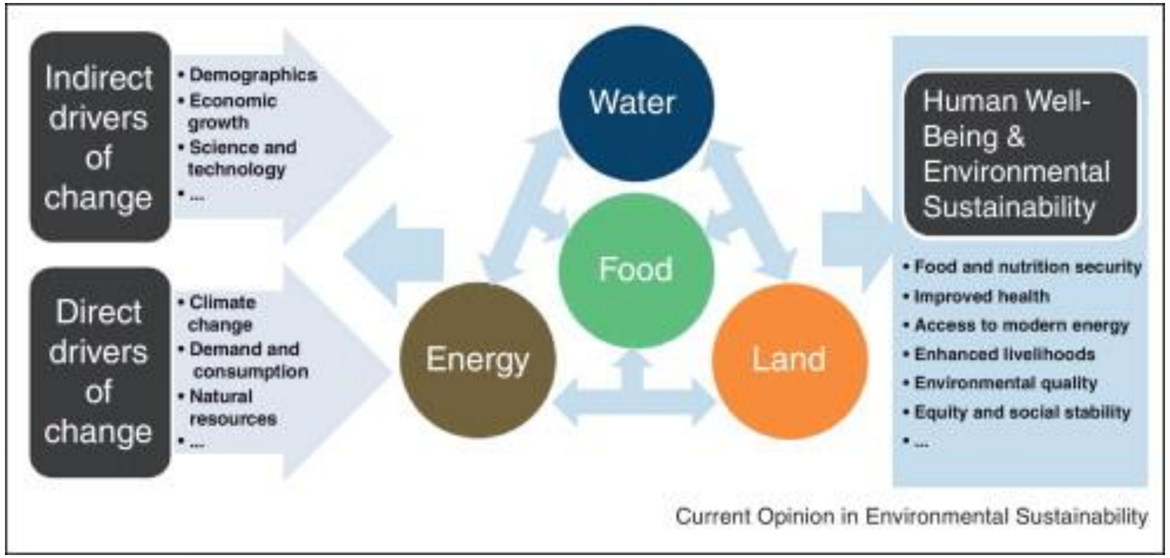


CLEWs (IAEA, 2009)

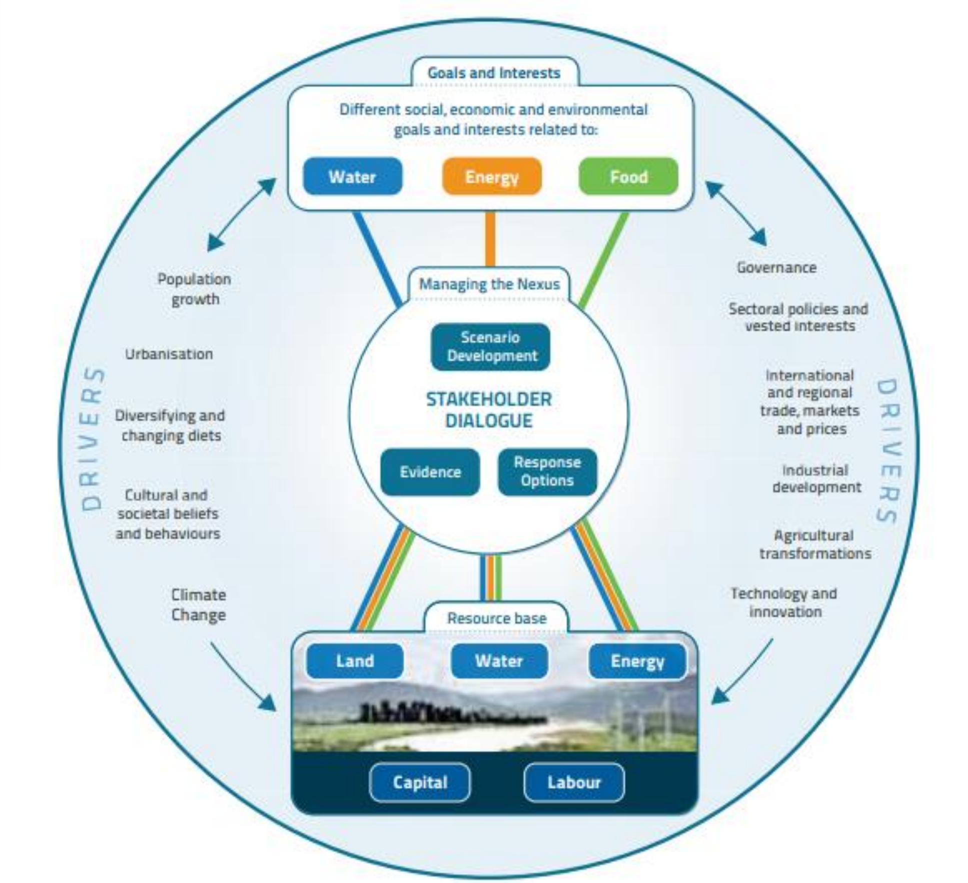


Water-energy-food security nexus (Hoff, 2011)

Nexus approach - frameworks

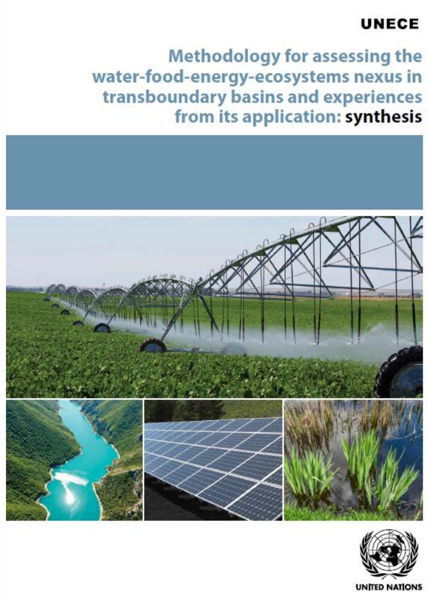


WELF nexus (Ringler et al, 2013)



WEF nexus approach (FAO, 2014)

Nexus approach - frameworks

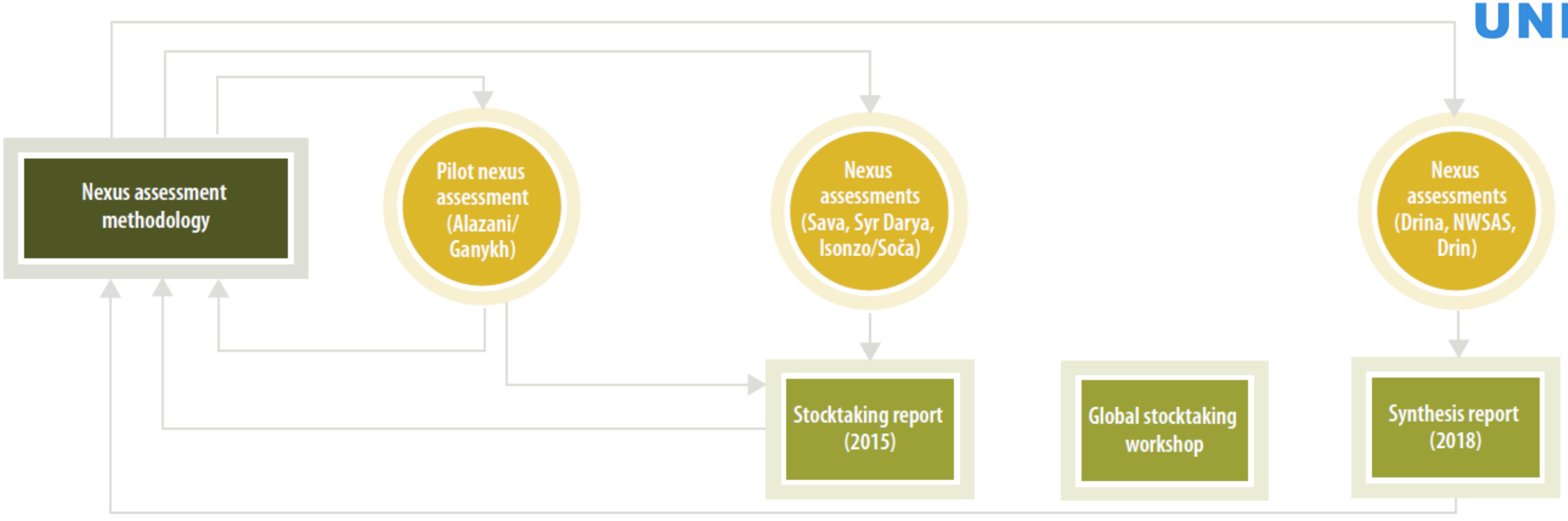


UNECE, M. Roidt and L. De Strasser, *Methodology for assessing the water-food-energy-ecosystems nexus in transboundary basins and experiences from its application*, 2018

Programme of Work 2013-2015 under the UNECE Water Convention, adopted by the Parties

FIGURE 6

Phases of development of the TBNA methodology



Nexus approach - frameworks

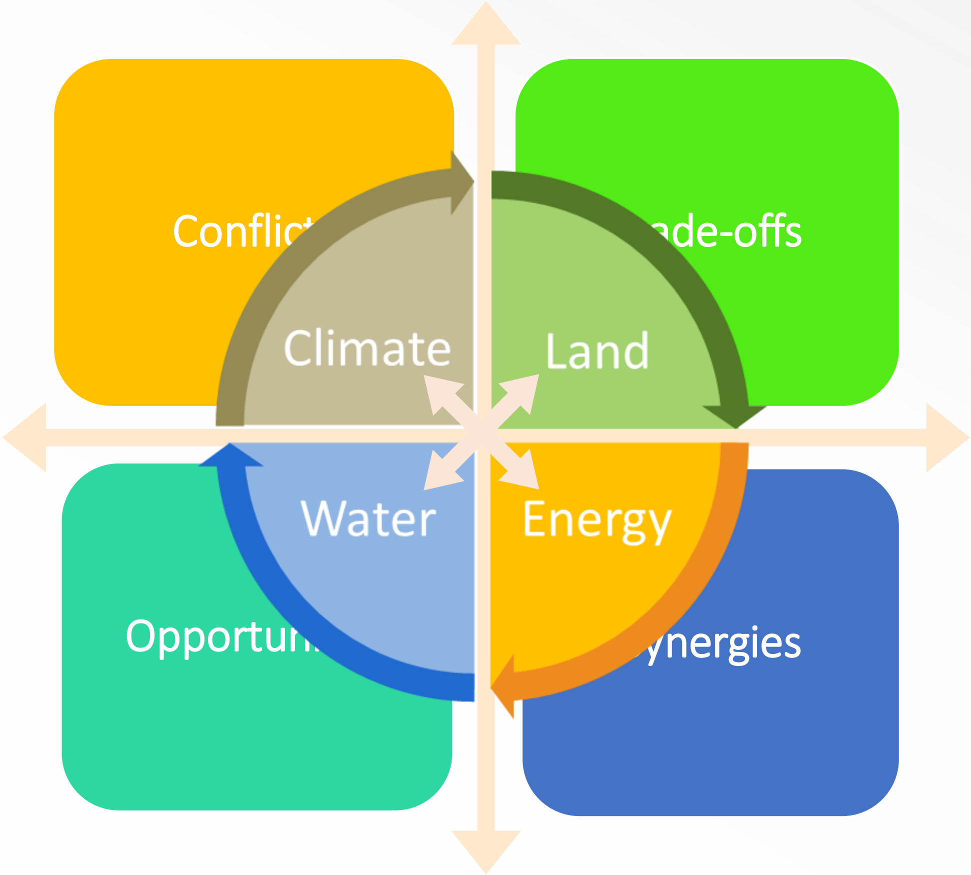
STEP		LOCATION	SECTORS
1	Identification of basin conditions, the socio economics	Desk study	General. Information normally used to underpin sectoral planning. Key elements include general socio-economic goals.
2	Identification of key sectors and stakeholders	Desk study	General. Requires expert judgment understanding of local context, governance.
3	Analysis of the key sectors	Desk study/ 1st Workshop	Individual sector experts and plans. Key elements include identifying resource flows and institutional mapping.
4	Identification of intersectoral issues	1st Workshop	Sectoral group discussion on interlinkages (input needs, impacts and trade-offs), and discussion on sectoral plans
5	Nexus dialogue and future developments	1st Workshop	Agreeing on a prioritization of main interlinkages. How the interlinkages are expected to change (development trends, key uncertainties and drivers)
6	Identification of opportunities for improvement	1st & 2nd Workshop/Desk study	Identification of solutions with multiple impacts between sectors, scales and boundaries

The CLEWs framework

What is the CLEWs framework?

CLEWs stands for: **C**limate-**L**and-**E**nergy-**W**ater systems

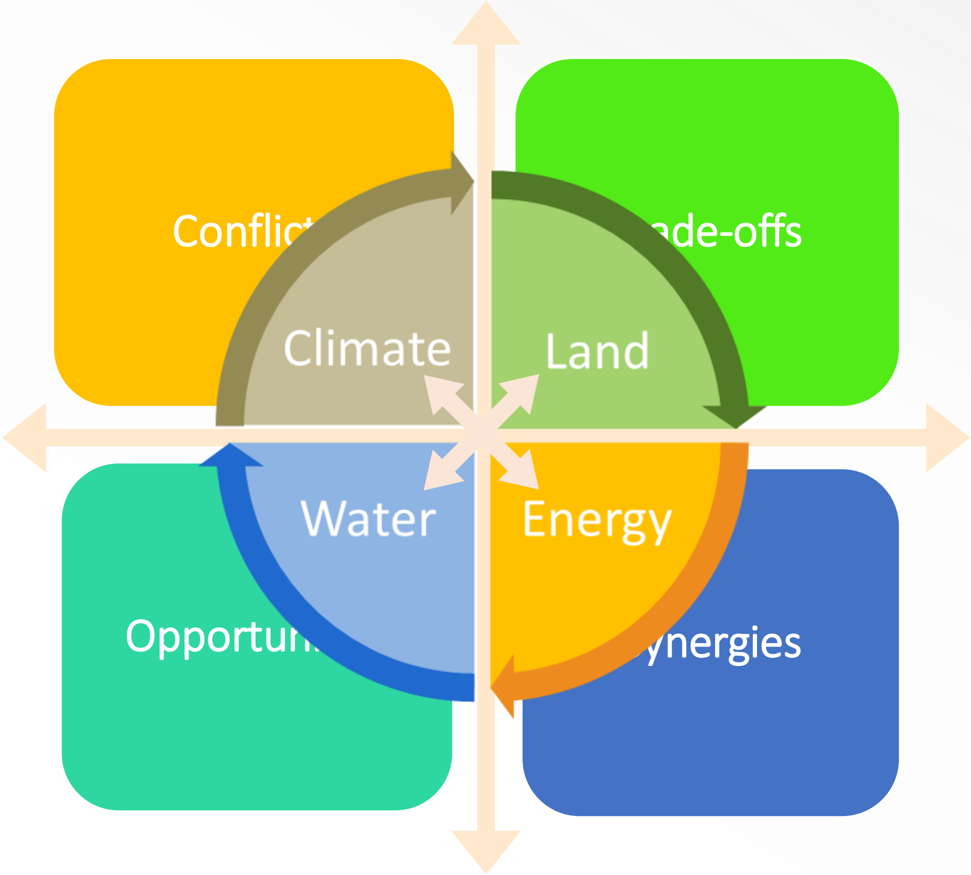
Integrated analysis of resource systems' interactions and quantitative assessment of critical linkages using modelling tools.



What is the CLEWs framework?

Enables evaluation of the general robustness of a particular strategy or policy

- Provide policy support and analysing alternative development pathways/choices
- Investigate implications of technology deployment and sector-specific solutions (irrigation, electricity generation, afforestation)



CLEWs models

- Techno-economic representations of real-world systems
- Designed to assess the role of technology change and technology choice
- Enable scenario-based analysis to evaluate risks and uncertainties
- Intended for long-term analysis of sustainable development issues (e.g., one or more decades)
- Highly customizable/flexible with respect to system boundaries, geographical coverage, level of detail, and economic characteristics

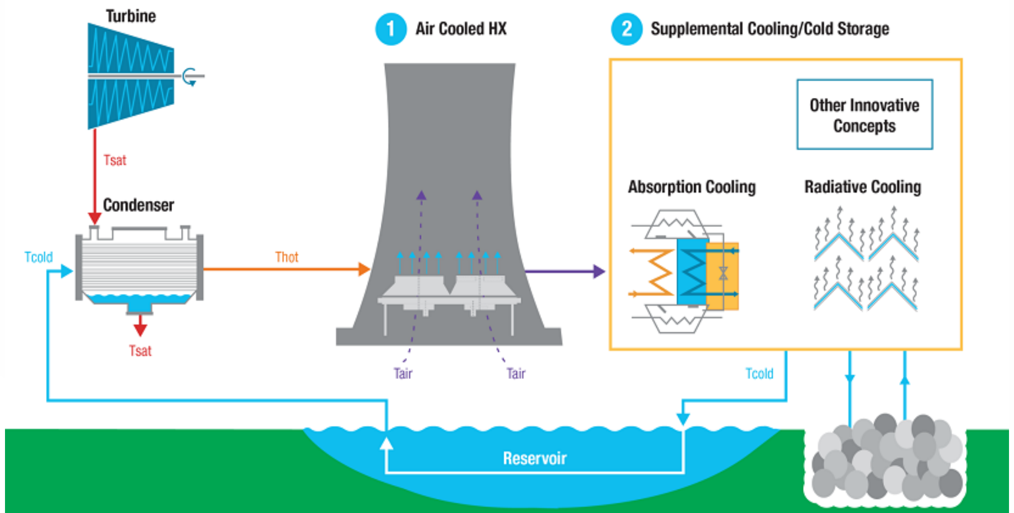
CLEWs models

Caveats to consider when applying the CLEWs methodology

- CLEWs models are not crystal balls
- CLEWs models have idealized representation
- Some policies and measures cannot be represented directly in CLEWs model

Water to Energy

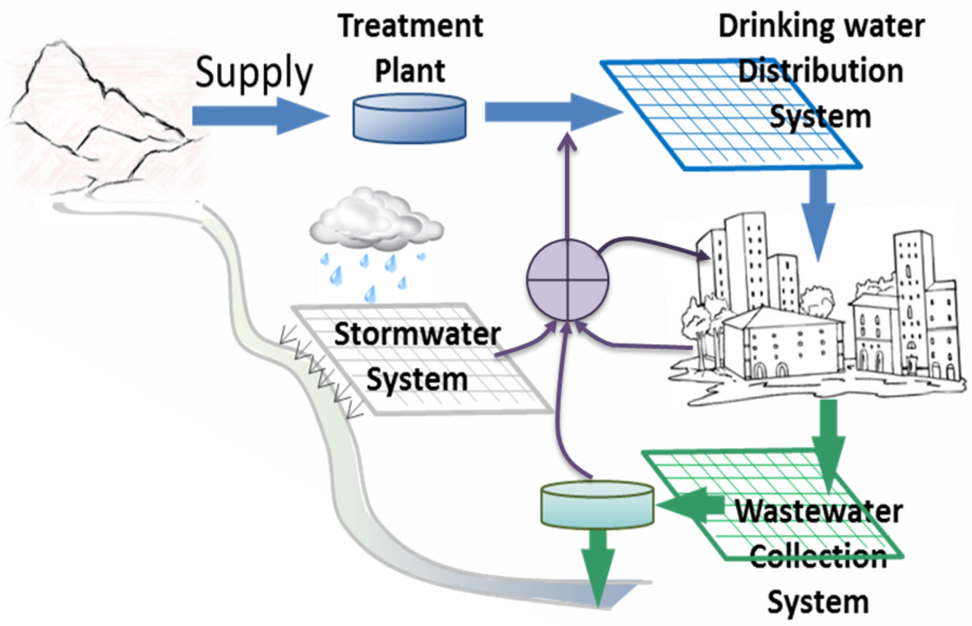
- Fuel cycle
  - Fossil fuel extraction
  - Fuel processing
  - Biofuel cultivation and processing
- Energy conversion processes
  - Transport sector
  - Electricity generation
    - Hydropower
    - Thermal power
    - Non-hydro renewables



Source: https://arpa-e.energy.gov/?q=news-item/arpa-e-arid-program-advances-technologies-reduce-water-usage-power-plants

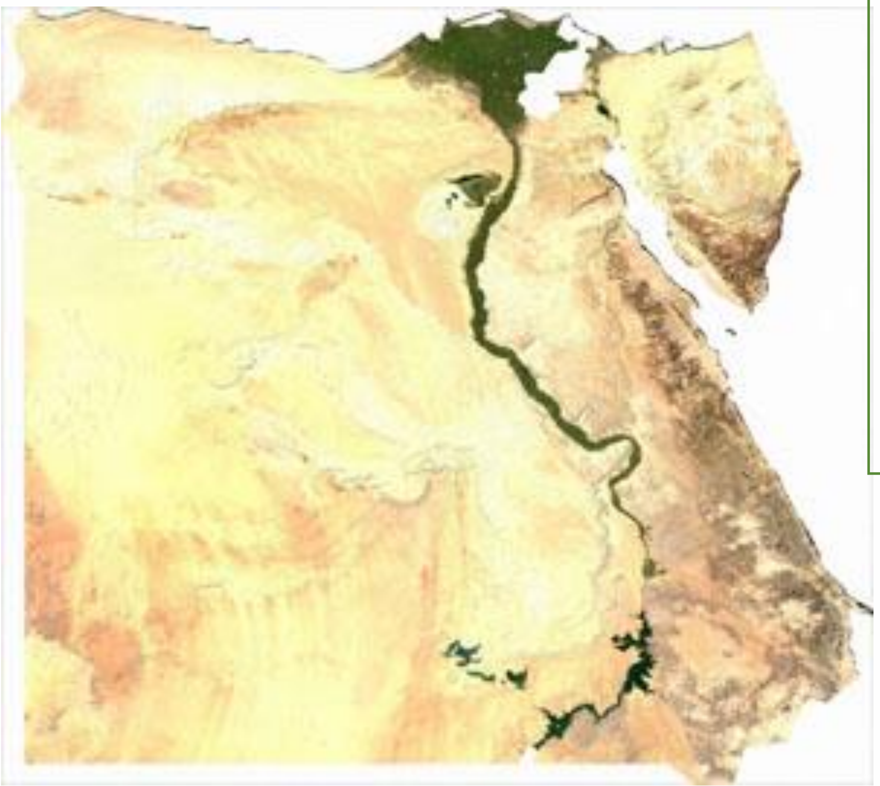
Energy to Water

- Operation of water systems
  - pumping (extraction and distribution
  - water purification
  - wastewater treatment
  - non-conventional production of potable water
  - pump storage power plants
- Use of water
  - Water heating
  - Energy use and end use (e.g. washing machines)
- Energy for agriculture
  - Irrigation systems



Water to Land

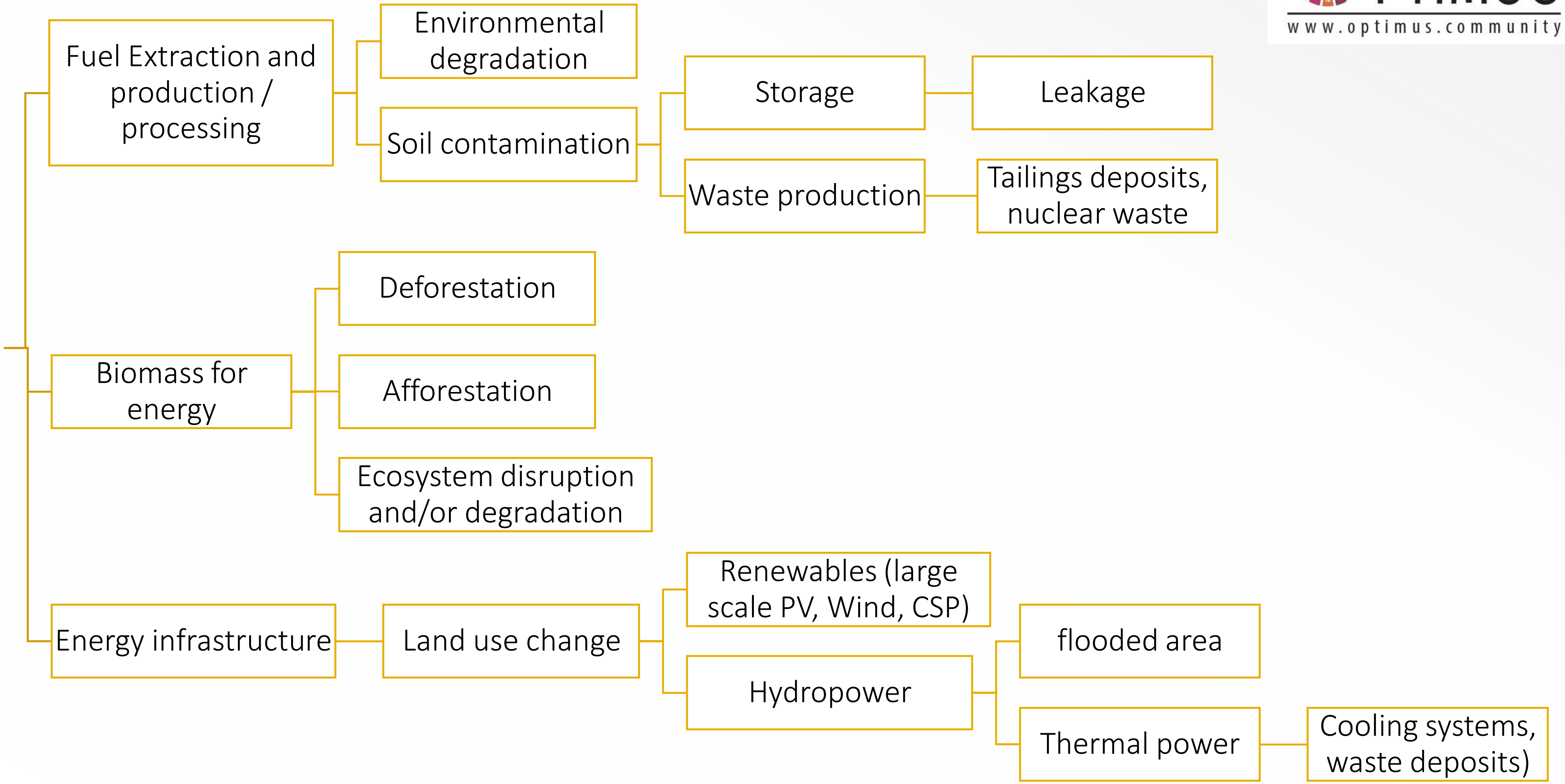
- URBAN AREAS & PLANNING
  - Population distribution and location of water resources
- AGRICULTURE
  - Crop suitability and yields
  - Livestock
- Natural cover
  - Forests
  - Wetlands
  - Inland water



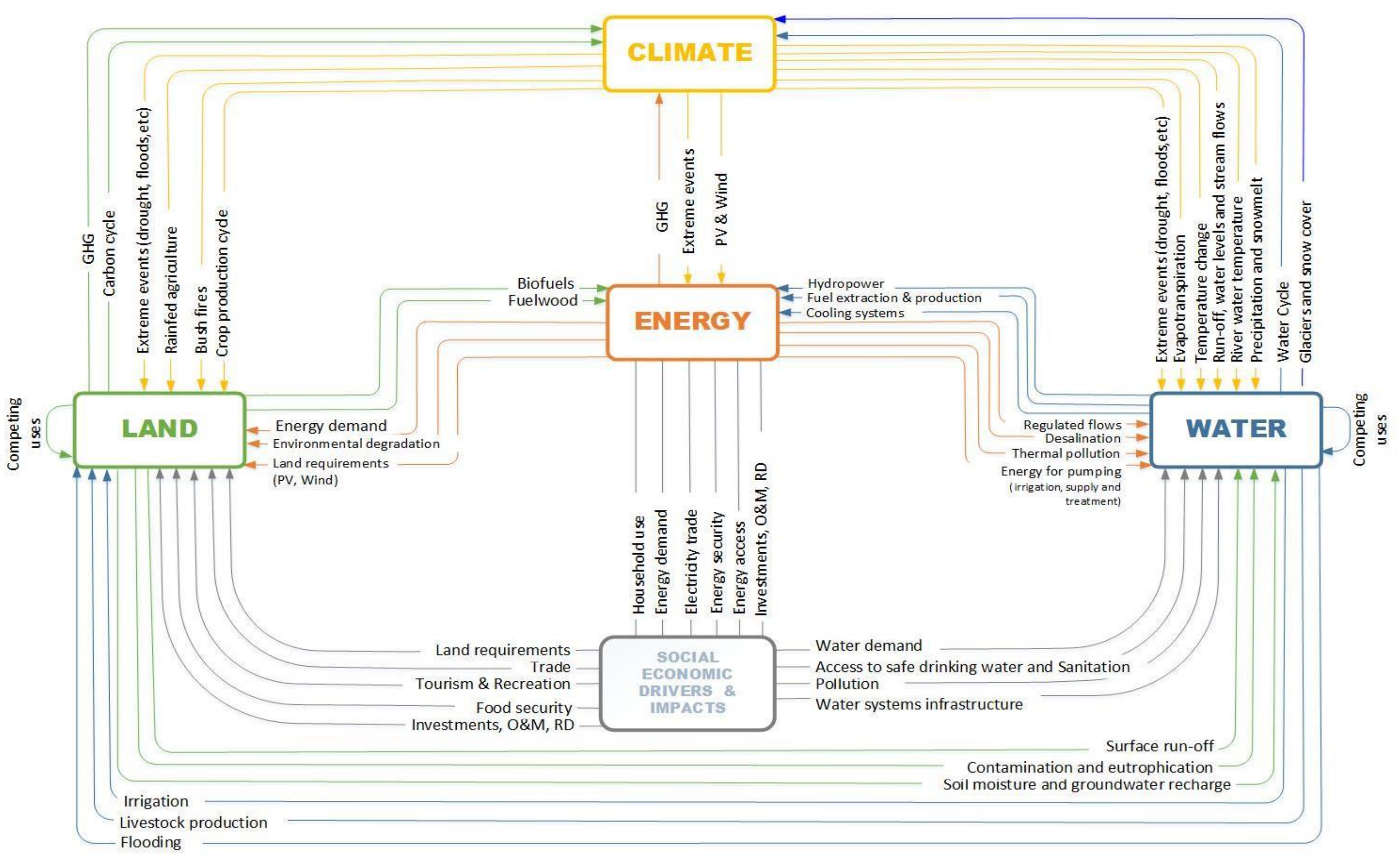
Land to Energy

- Fuel Extraction and production / processing
  - Mining
  - Oil fields, tar sands, shale gas
  - Storage
- Biomass for energy
  - Agroforestry residues
  - Biofuel production
- Energy infrastructure
  - Electricity transmission network
  - Power plants
    - Renewables (large scale PV, Wind, CSP)
    - Hydropower (flooded area)
    - Thermal power
      - Cooling systems, waste deposits)

Energy to Land



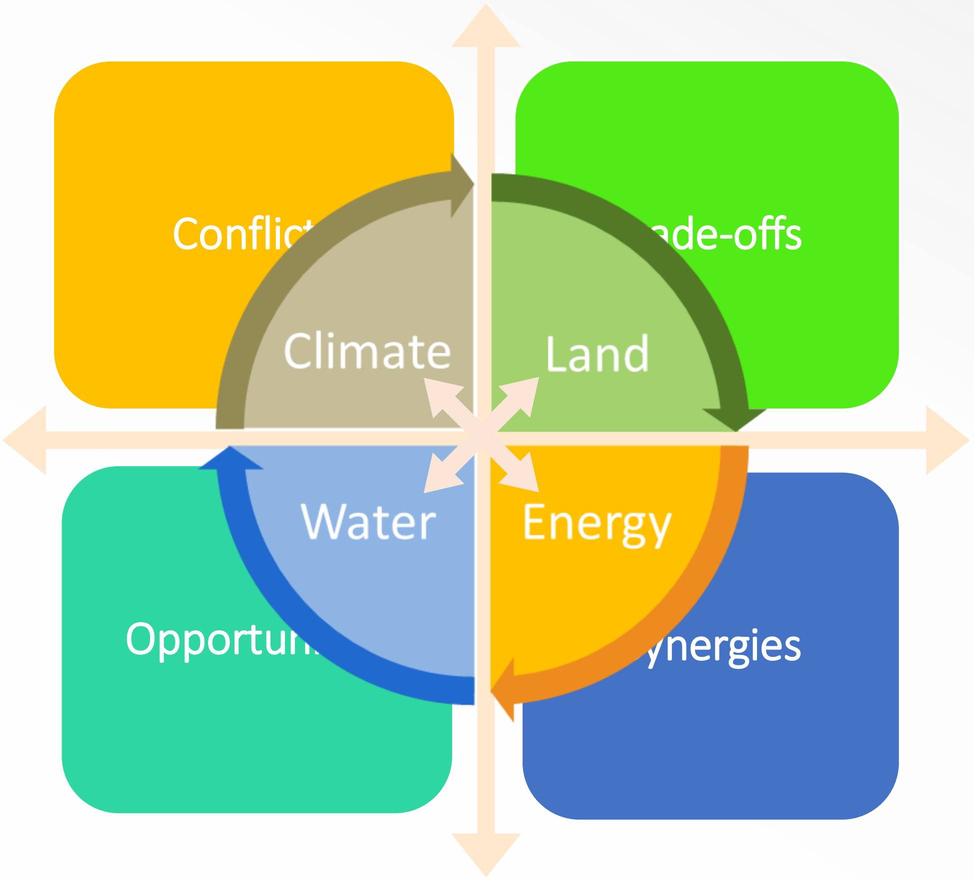
Mapping systems' interactions: the whole picture



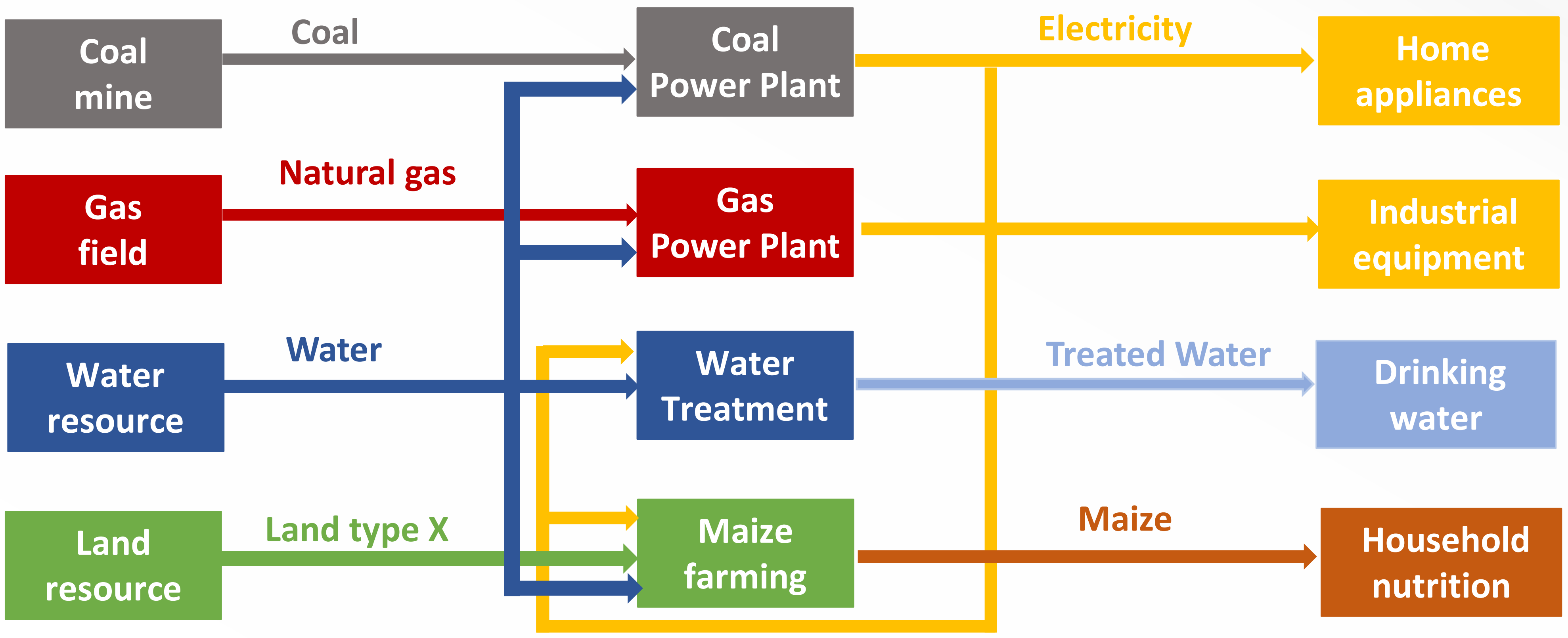
CLEWs: modelling

The CLEWs framework suggests the linkages can be quantified

- developing an integrated accounting model (resources use factors, adding CLEWs elements to sectoral models);
- with the development of sectoral systems models and integration and iteration between these;
- using a single model framework



CLEWs: modelling



Examples of CLEWs Modelling Tools

OSeMOSYS

Water
Evaluation
And
Planning

WEAP

GAEZ
Global Agro-Ecological Zones

QGIS

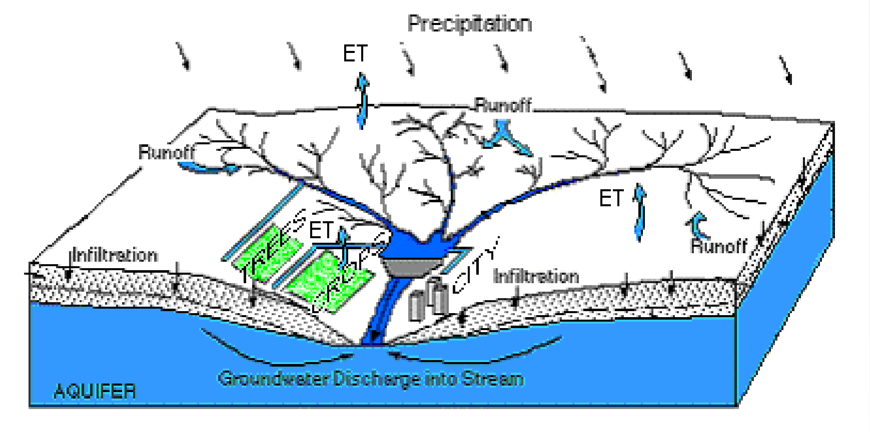
LEAP

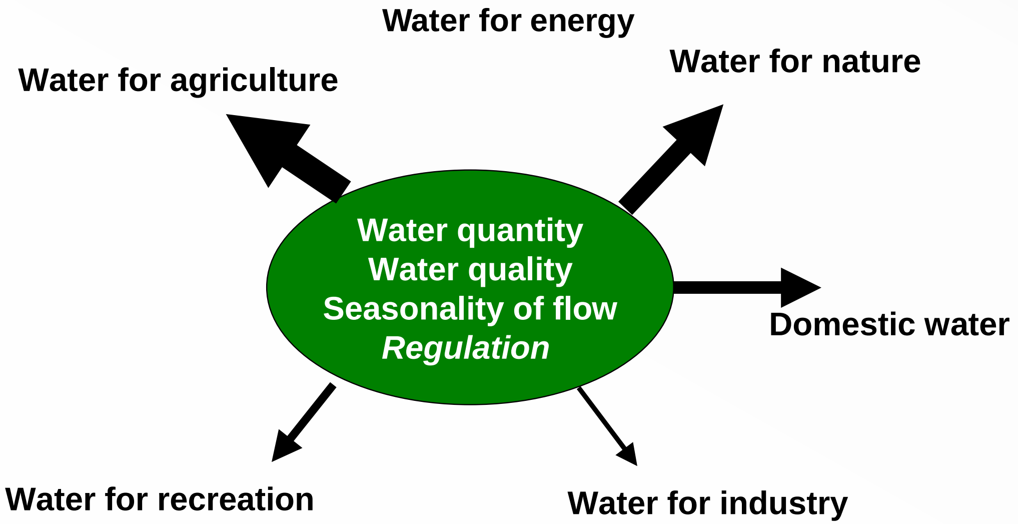
python™

Water Management modelling

Critical Questions

- How should water be allocated to various uses in time of shortage?
- How should infrastructure in the system (e.g., dams, diversion works) be operated to achieve maximum benefit?
- What is the demand for irrigated water and what are the associated energy requirements?

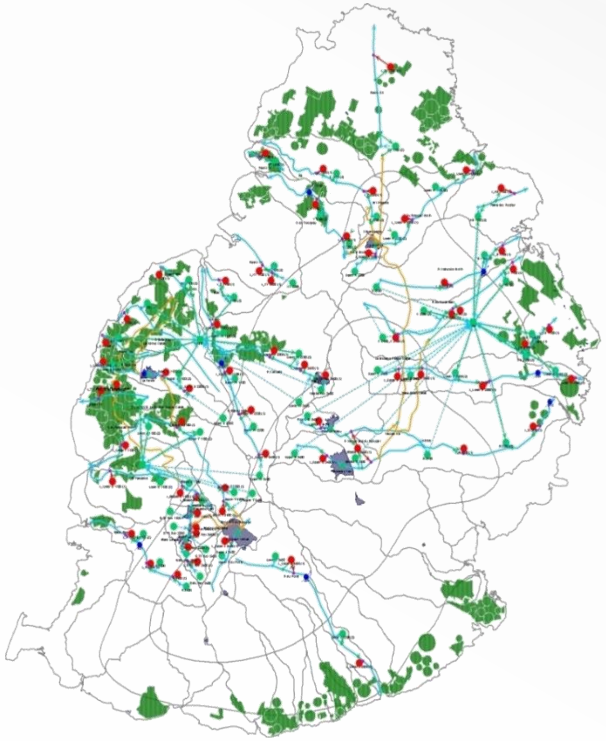




Water Management modelling

Required model inputs include:

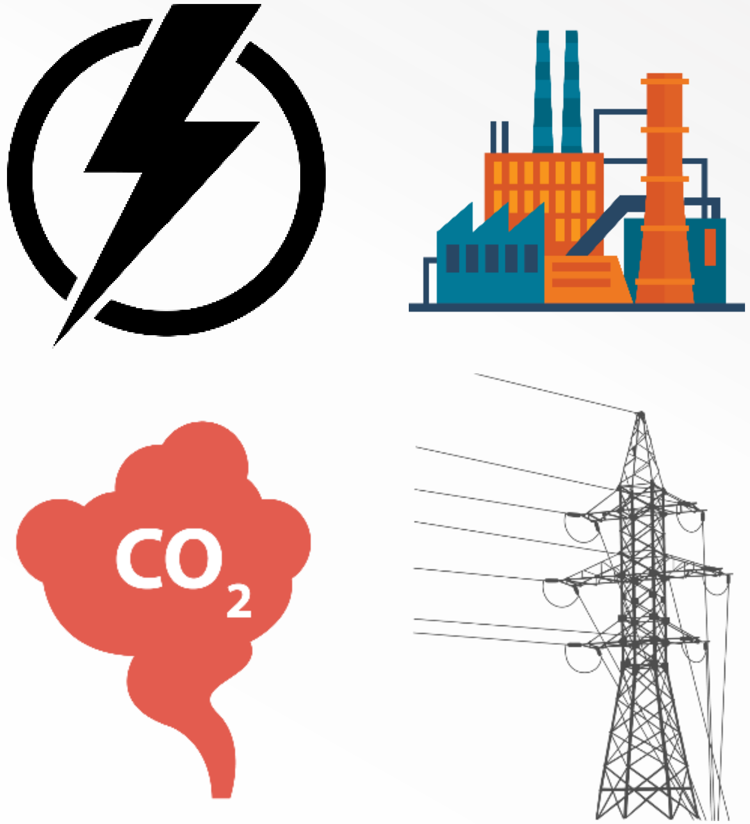
- Definition of all Catchment areas
- Real Climatic Data : Rainfall, min & max temperature, humidity, ...
- All main rivers & reservoirs plus stream flow data and reservoirs levels
- Modelling of existing canals / distribution systems
- Using GIS: land cover classes to calculate evapotranspiration
- Water Demand data (urban and agricultural) according to national statistics and population density
- Operational rules of hydro power plants



Energy system modelling

Critical questions

- What investments are needed in generation and network infrastructure to meet electricity demand and when?
- What technologies achieve the least-cost and most reliable energy mix?
- What are the associated impacts on land-use? E.g. from growing biofuels or from large-scale solar PV parks
- What are the associated water requirements for a specific energy mix? E.g. water for cooling, hydropower
- What pollutants are emitted and at what level?



Energy system modelling

- Can be used to assess the impact of predetermined pathways for development; accounting models (LEAP, MAED)
  - Represent decisions of actors within the system; simulation models
  - Potential for replacing existing technologies with low-carbon, more efficient or cost effective alternatives.
- Can be used to optimize a specific system; cost-optimization modelling (OSeMOSYS, MESSAGE, MARKAL, PLEXOS, ARTELYS CRYSTAL…)
  - Technology learning rates, resource availability, technical limitations, environmental criteria, costs etc. directly affect the optimal system design
  - Seeks the least-cost configuration of the energy system (investments and supply)

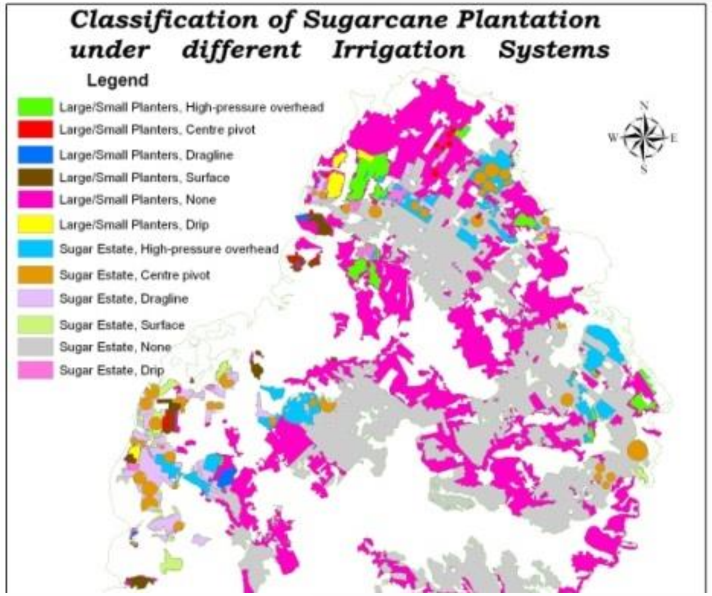
Agro-ecological modelling

Critical questions

- What is the potential yield of a range of crops in each region?
- What are the water requirements for each crop?
- How do different climate scenarios affect crop yield?
- What are the energy requirements to ensure a certain yield?

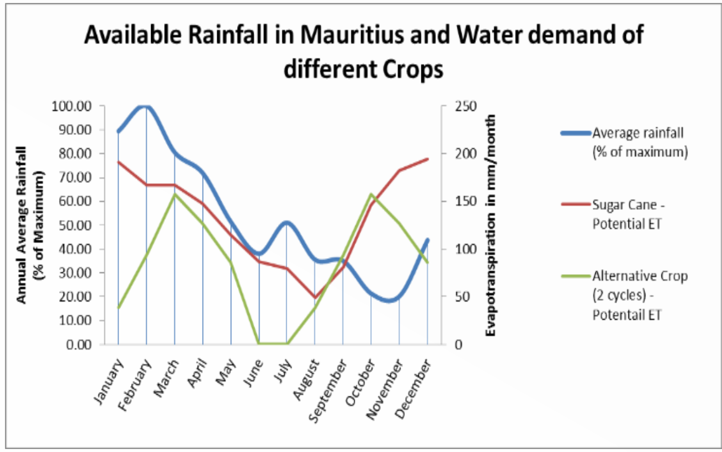
Input:

- Climatic Data
- Detailed soil map and data
- GIS data for landcover
- Irrigated areas



Output:

- Optimal crops, potential water use, and potential yield, …



How to set up a CLEW case study?

SYSTEMS PROFILING

- Current state and historical trends
- Main stress points
- Sectoral policies, plans, strategies

PRE-NEXUS ASSESSMENT

- Interlinkages between sectors
- Pressure points between sectors (‘nexus issues’)

MODEL DEVELOPMENT

- Development of independent models with integration possibilities
- Scenario development
- Soft-linking of models inputs and/or outputs

How to set up a CLEW case study?

ANALYSIS

- Analysis of results
- Revise inputs / assumptions
- Conduct additional model runs

INFORM POLICY MAKING

- Report on the quantification of the impacts of sectoral interactions
- Suggestion of strategies and pathways towards sustainability

Selected CLEWS Studies

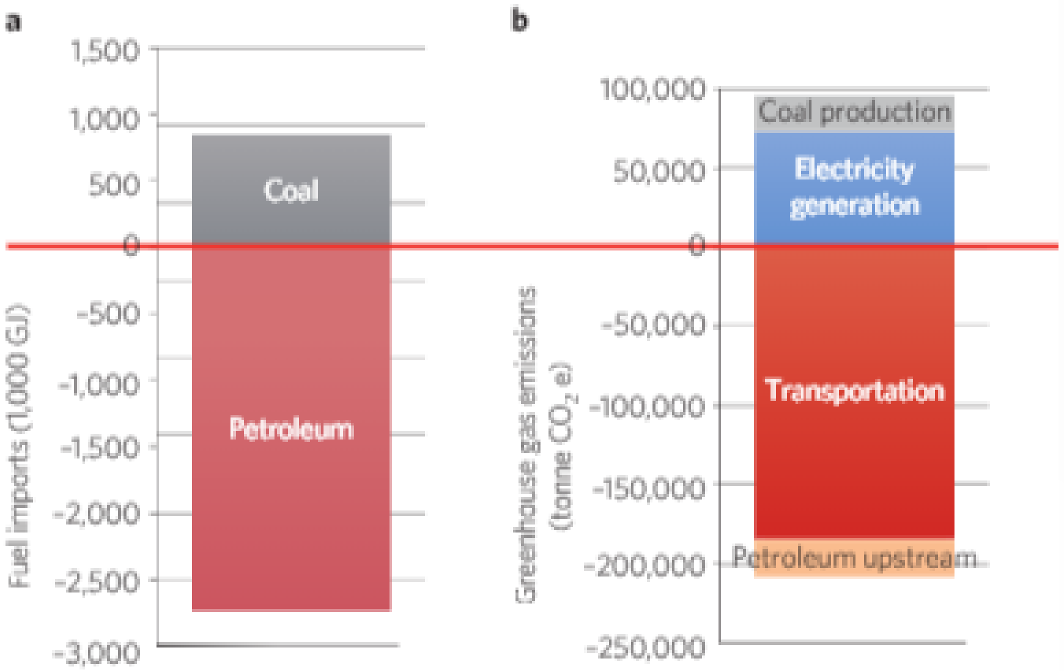
Mauritius – National CLEWs

- Main revenue has been tourism and sugar exports
  - Expiration of EU agreement and collapse of revenue from the latter.
- Diversification from sugar cane to food crops and vegetables
- Bagasse from refining – cogeneration of heat and electricity
  - Reduction in sugar prod. led to lower electricity generation from bagasse
- Consequent increase in fuel imports – coincided with increase in international fuel prices
- Irrigation requirements higher for food crops-vegetables than for sugar cane
  - Increased water demand

Mauritius – National CLEWs

Fuel imports
(in 1,000 GJ)

GHG emissions
(tonnes CO2 eq)



The impact of transforming two sugar-processing plants to produce second-generation ethanol in Mauritius (projections for 2030).

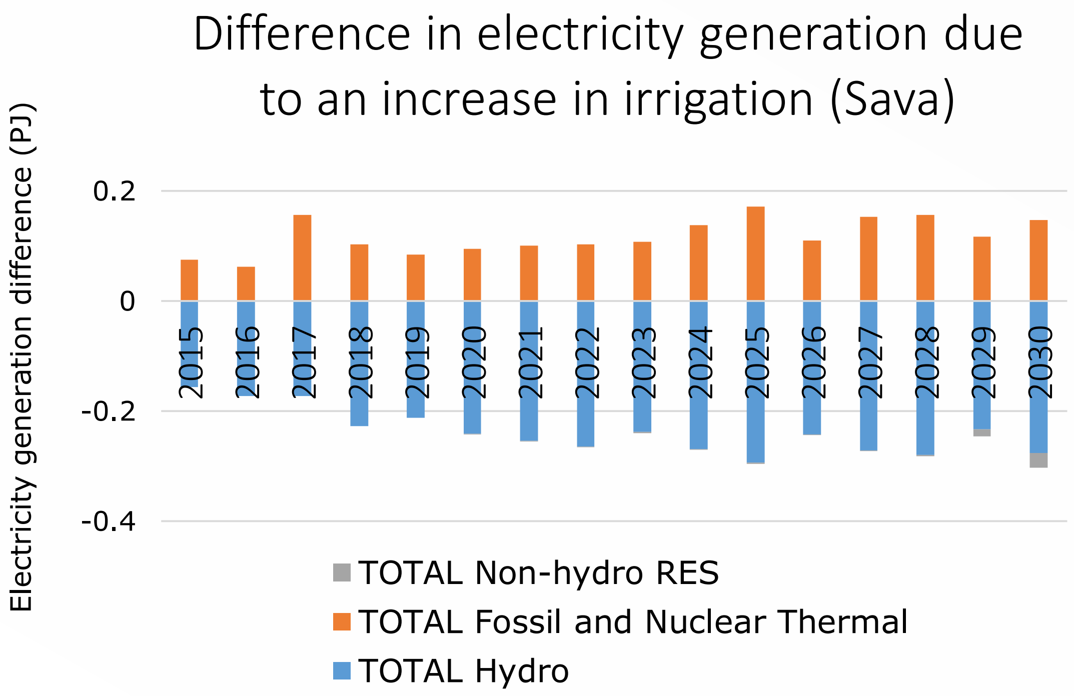
Sava and Drina River Basins

Aim: to assess water, energy and agriculture at a sub-regional level in a transboundary river basin context.

Main issues:

- Dependency between the basin water resources and the energy sector;
- Hydropower expansion vs climate change and competing irrigation demand;
- Water consumption in agriculture and for cooling systems;
- Relation between CO_2 emissions and water resources use in electricity generation.

Sava and Drina River Basins



Link: [Sava River Basin Nexus Assessment]

Link: [Drina River Basin Nexus Assessment]

Thank you!

Questions?

Changelog and Attribution

Date	Author	Reviewer	Reviser
2021-07-06	Sridharan, V., Ramos, E.P., Engström, R., Alfstad, T.	Gardumi, F.	Gardumi, F.

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