Climate, Land, Energy and Water strategies (CLEWs)

Mark Howells (mark.howells@desa.kth.se)

1. Sustainable development and the climate-land use-energy-water nexus

Current development challenges

- Almost 1.1 billion people without access to electricity
- Almost 2.8 billion people without access to modern, clean cooking facilities
- 663 million people lack access to safe drinking water
- 2.6 billion do not have adequate sanitation
- 815 million people without enough food due to extreme poverty
- 2 billion people lack food security
- Mounting concerns over climate change and other pollution related health and environmental hazards

Climate change

Development challenges:

- Mitigation actions
- Adaptation strategies

Environmental concerns:

- Temperatures rise
- Changes in precipitation patterns
- Sea-level rise
- Increase frequency of extreme weather events
- Changes in river flows
- Permafrost thaw

Photo by Martin Jernberg on Unsplash

Photo by Karsten Würth (@inf1783) on Unsplash

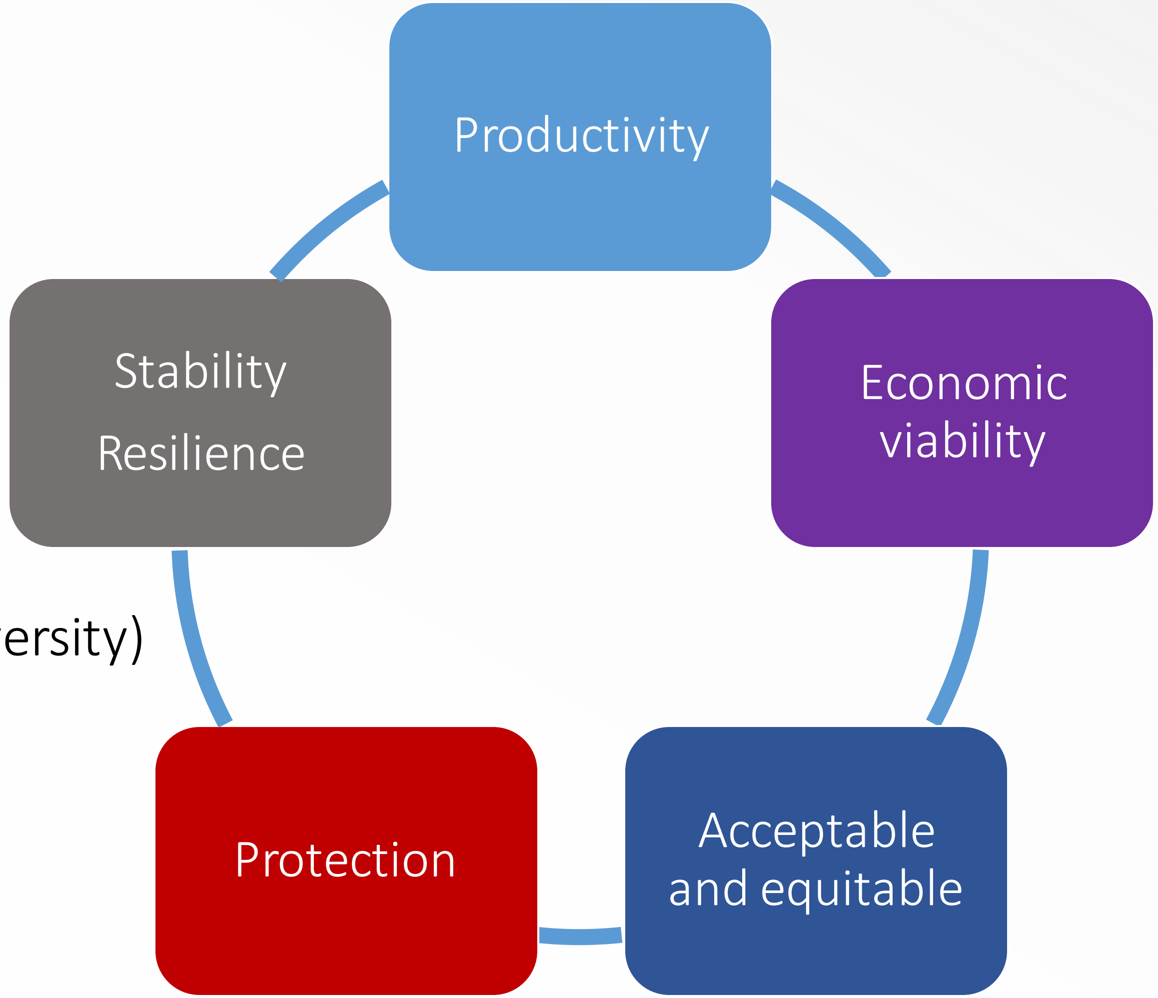
Land use

Development challenges:

- Sustainable agriculture and food supply
- Urbanization
- Adapting to climate change
- Food vs fuel
- Efficient use of water

Environmental concerns:

- Incursion into natural ecosystems (biodiversity)
- GHG emissions (e.g. deforestation)
- Land degradation (from unsustainable agricultural practices)
- Waste



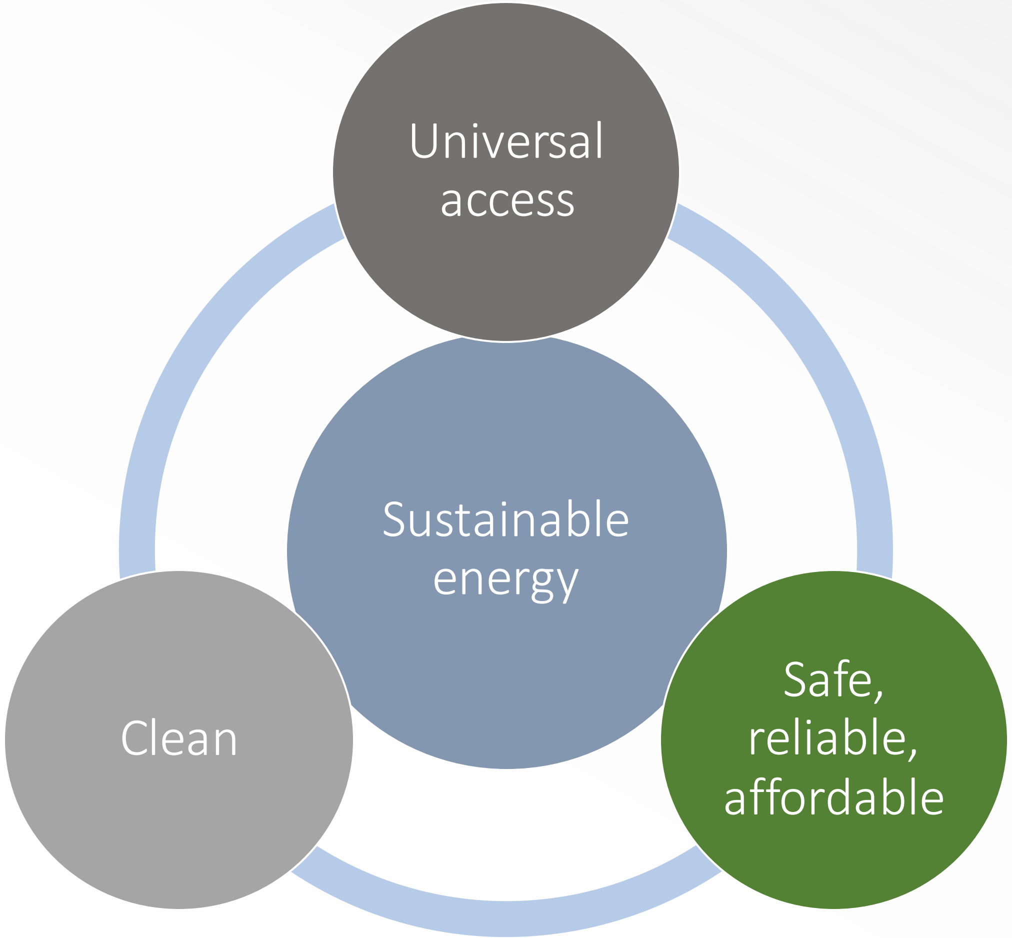
Energy

Development challenges:

- Access to sustainable energy for all
- Support industrial development
- Energy for the needs of the 21st century
- Efficient use of land and water

Environmental concerns:

- Mining (mountain top removal, other)
- Environmental emissions (NOx, SOx, lead, particulates)
- GHG emissions
- Solid waste
- Radioactive waste



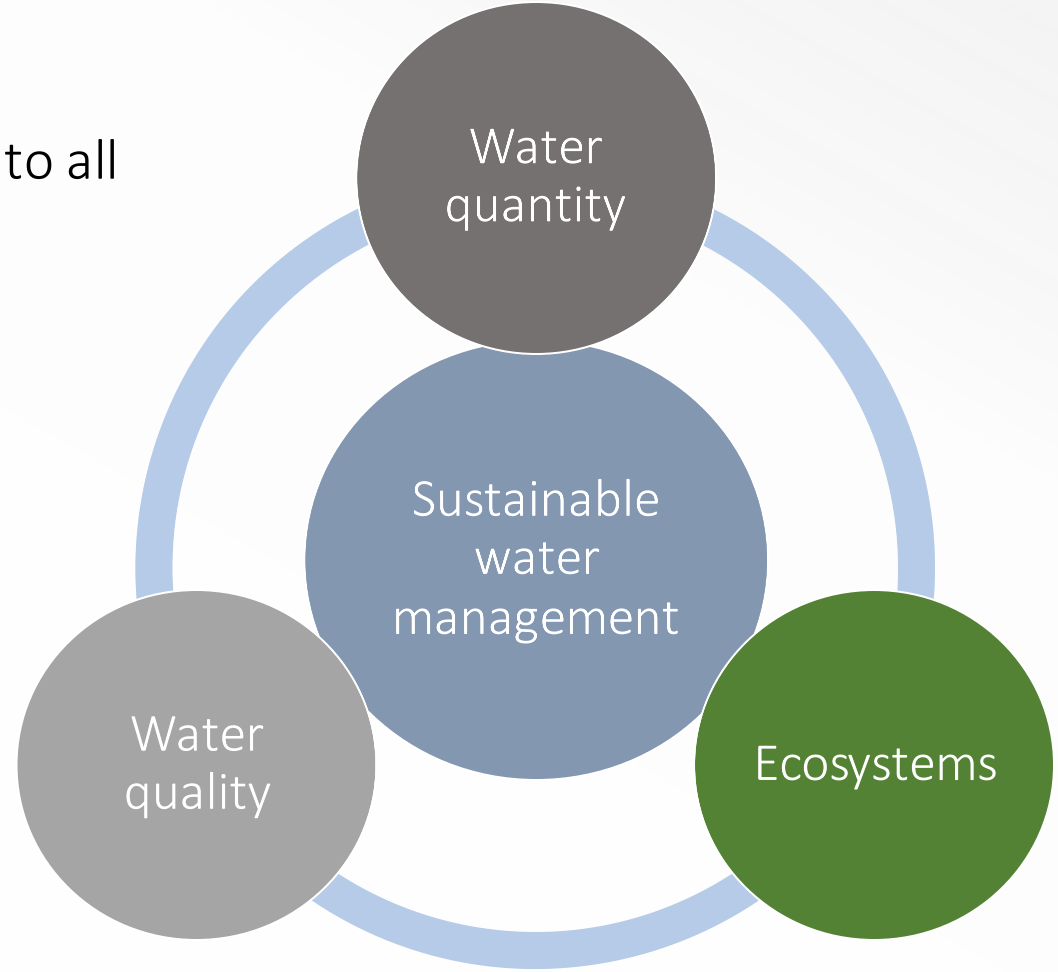
Water

Development challenges:

- Provide safe drinking water and sanitation to all
- Provide sufficient water to feed a growing population
- More efficient use of water resources
- Population growth, economic growth, urbanization
- Protect ground water resources

Environmental concerns:

- Droughts/floods
- Pollution, eutrophication
- Sea level rise



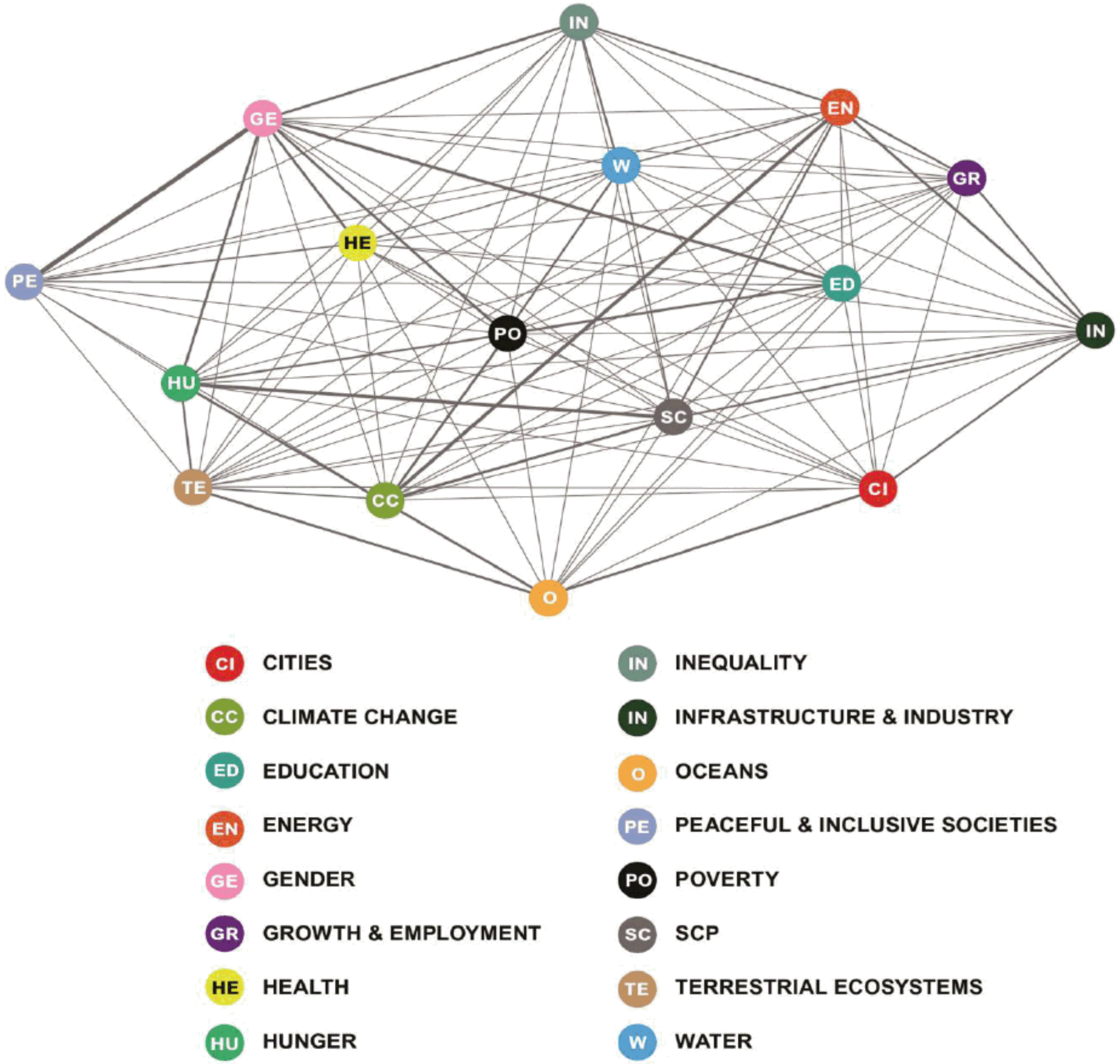
Sustainable development and the climate-land use-energy-water nexus

- Climate, land use, energy and water systems are highly interlinked
- Often referred to by the term **nexus**

Part of broader development challenge as reflected in Agenda 2030 for Sustainable Development

Agenda 2030 for Sustainable Development

- A plan of action for people, planet and prosperity
- Provides a powerful aspiration for improving our world – laying out where we collectively need to go and how to get there
- The SDGs are not 17 separate ambitions, but highly interlinked challenges that require coordinated action



Quick discussion in groups of 2-3 people

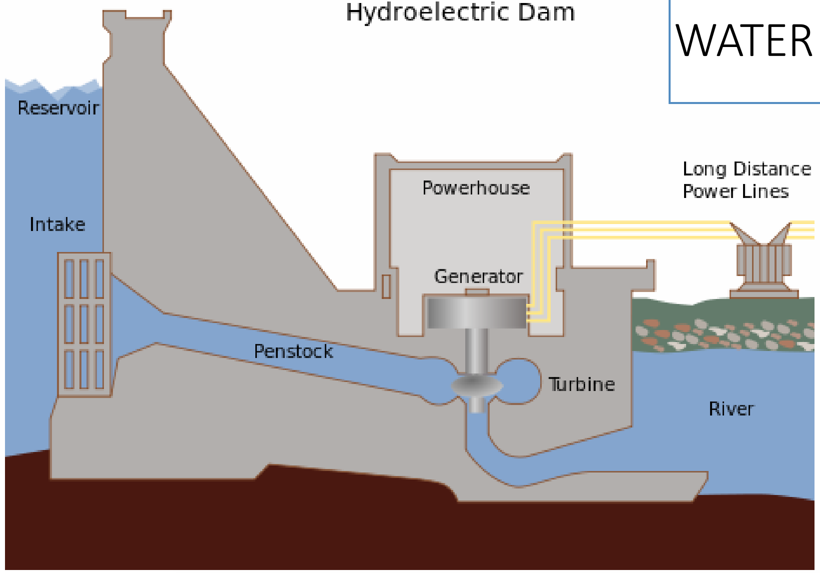
How do these systems (energy, water, land use, climate) interact?

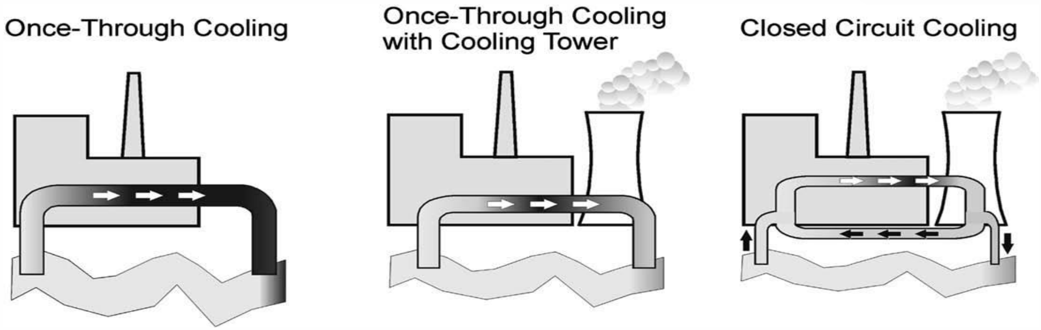
- Where is water needed in the energy system?
- Where is energy needed in land use?

3. Integrated Assessments and the concept of CLEWs

Water to Energy

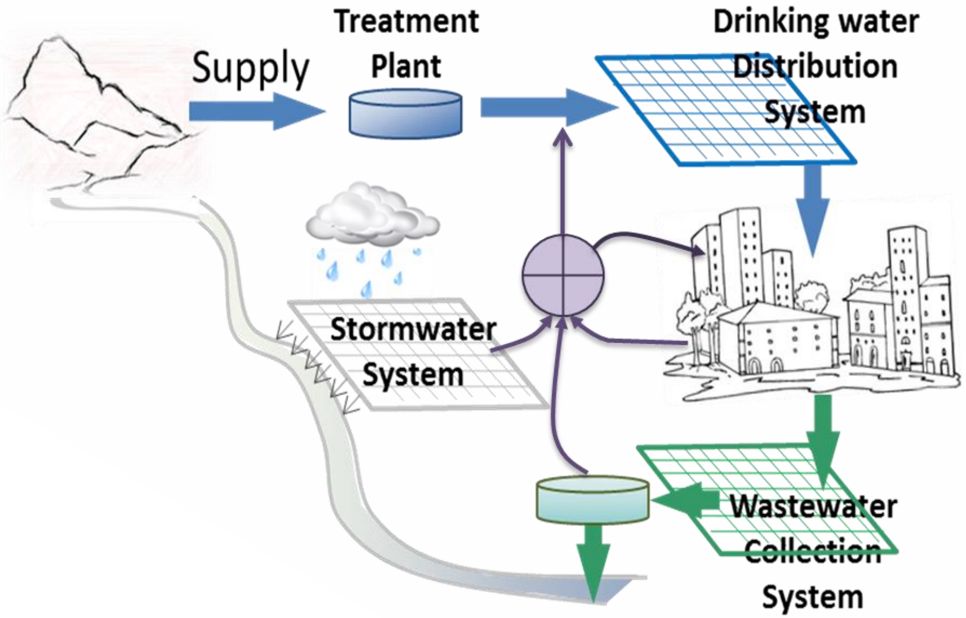
- WATER TO ENERGY
  - Fuel cycle
    - Fossil fuel extraction
    - Fuel processing
    - Biofuel cultivation and processing
  - Energy conversion processes
    - Transport sector
    - Electricity generation
      - hydropower
      - Thermal power
      - Non-hydro renewables





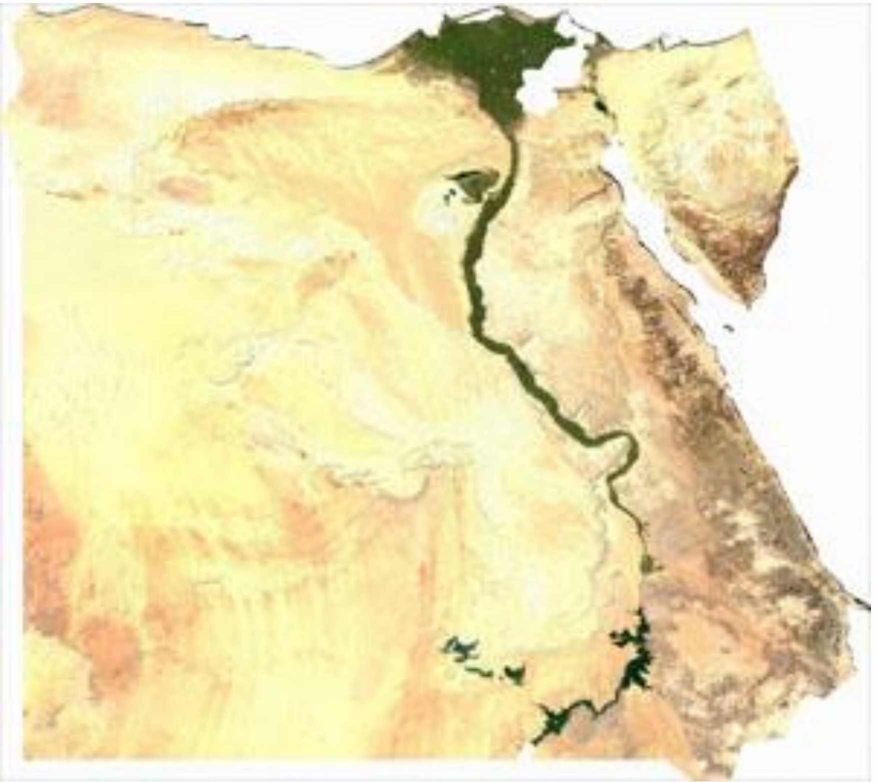
Energy to Water

- 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

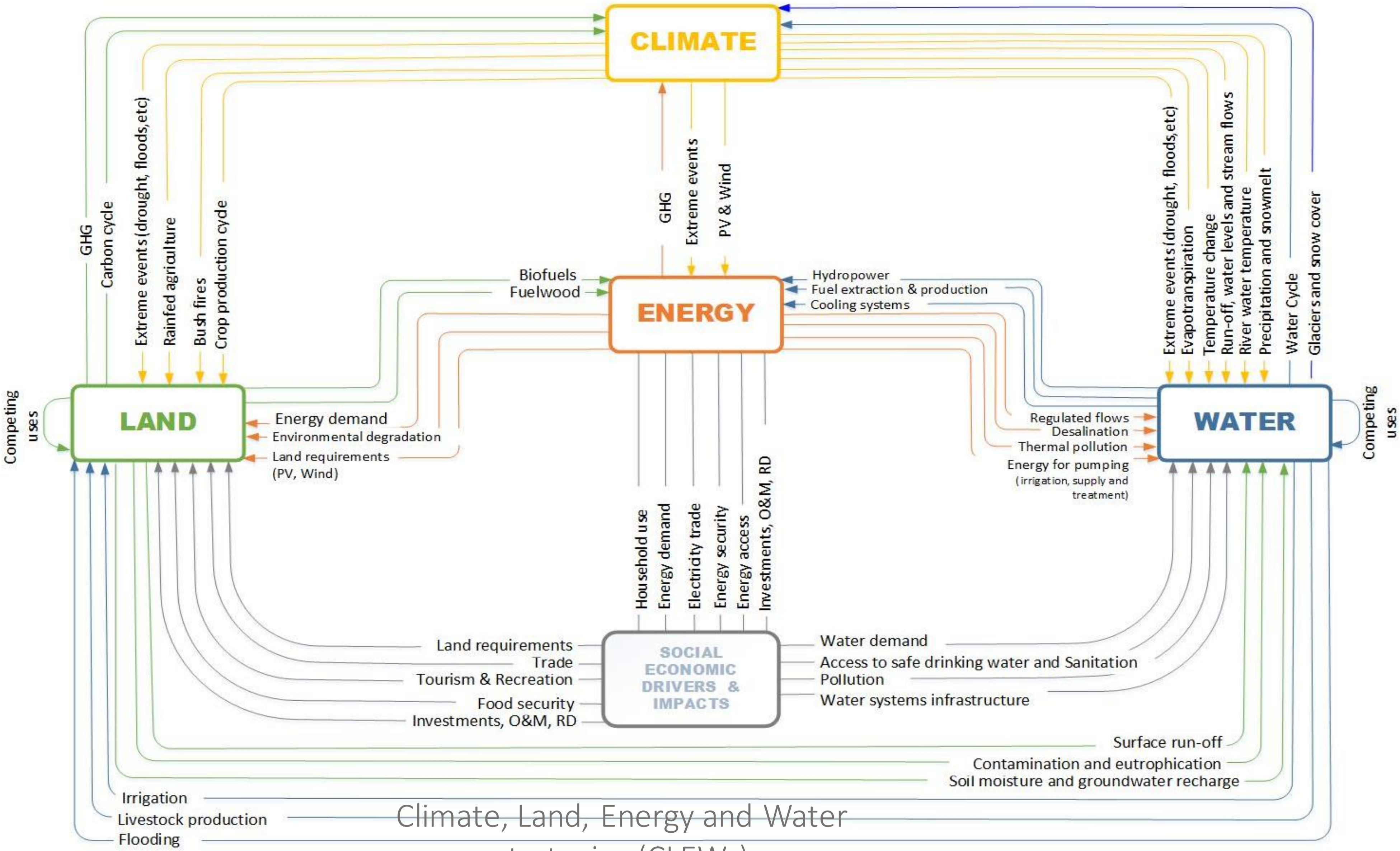


Water to Land

- 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



How do these systems interact?



Assessing the climate, land use, energy and water nexus

Investigation of **how resource systems interact**

The CLEWs framework suggests this can be achieved *quantitatively*:

- with the development of sectoral systems models and integration and iteration between these;
- Using a single model framework (e.g. OSeMOSYS).
- Developing an integrated accounting model

4. Method and Modelling approaches

CLEWs Model type 1: Energy model +

Input

Exogenous water and energy demand

Technology specification

- Water efficiency
- Energy efficiency

Output

Cost optimal allocation of energy and water use technologies

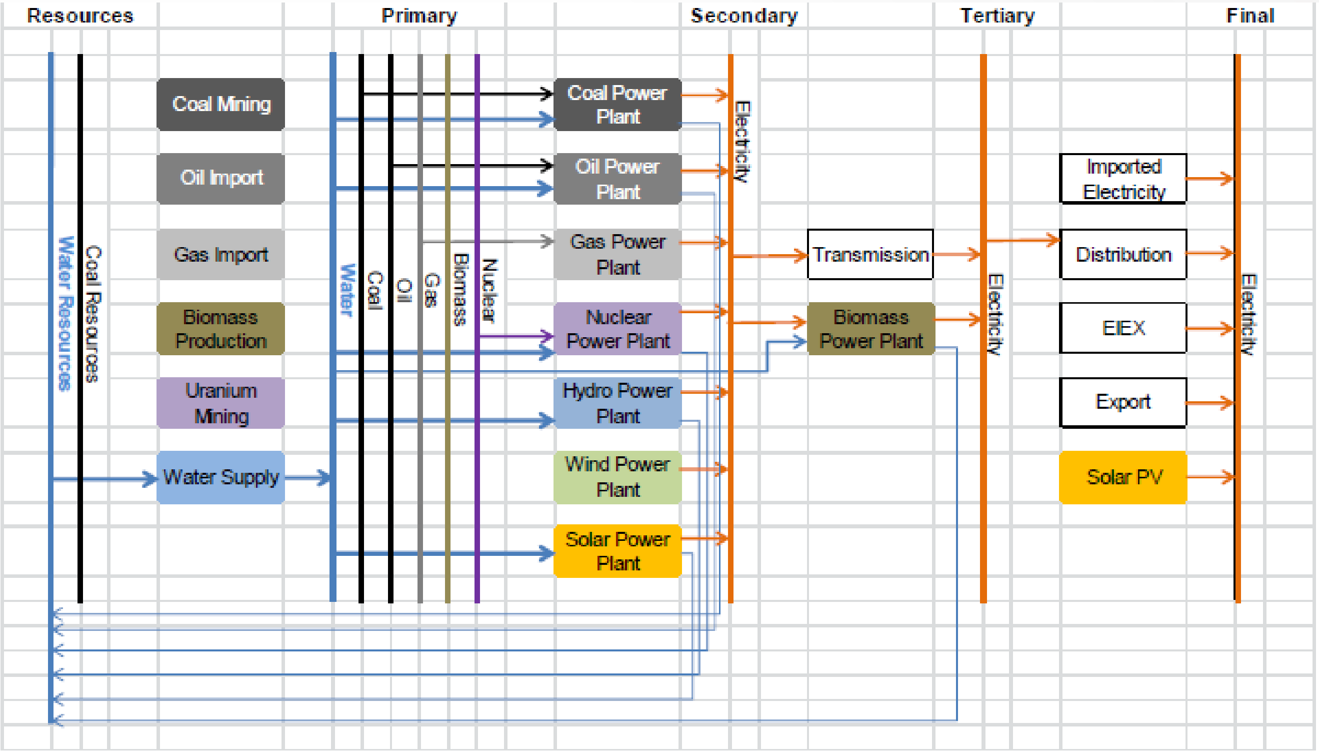


Figure 4: Reference Energy-Water System (REWS) based on the South-African electricity supply system

CLEWs Model type 2: All soft-linked

Input

Exogenous water, food, energy demand

Technology specification

- Water efficiency
- Energy efficiency

Agro-ecological zoning

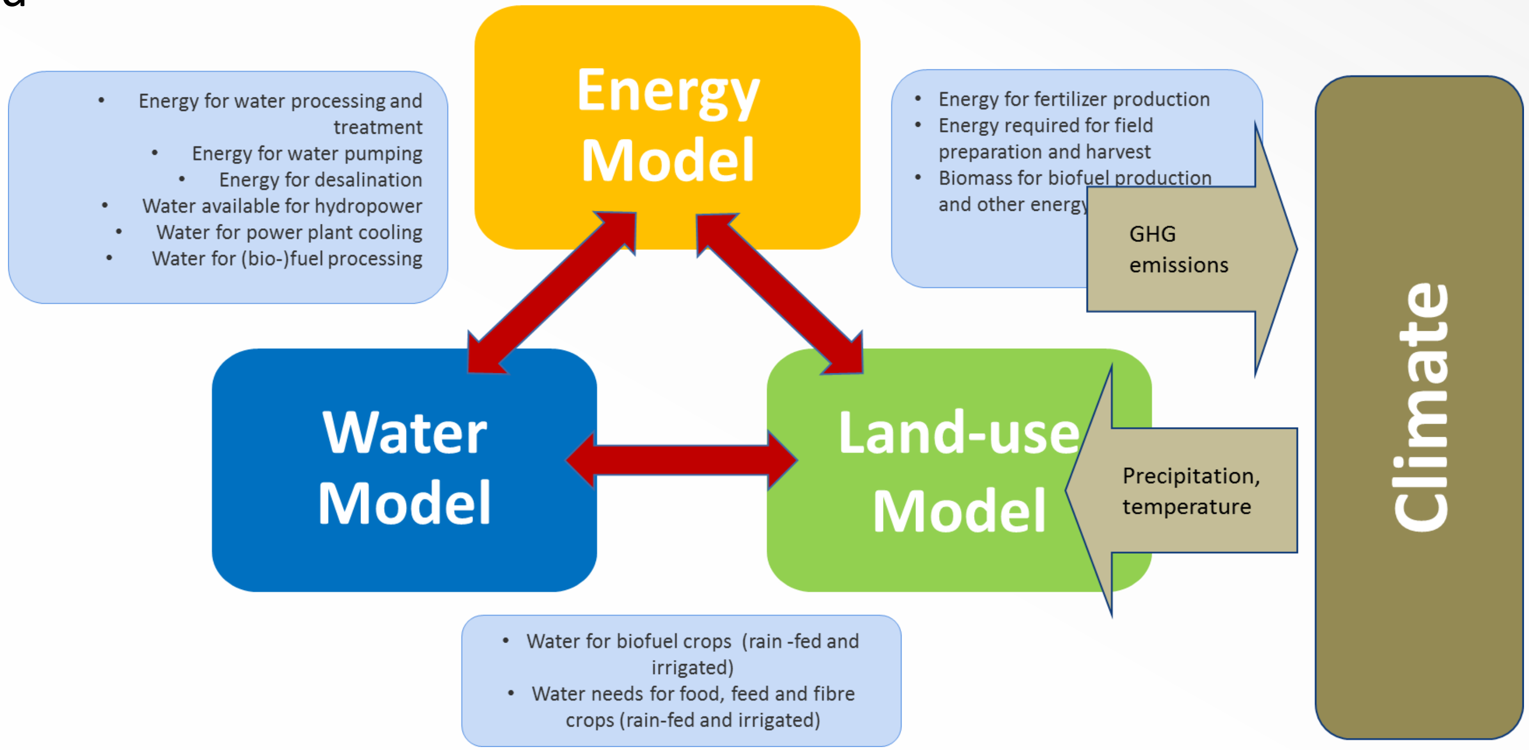
Future weather expectations

Basin info

Output

Consistent scenarios

Water, energy, food balance



CLEWs Model type 3: Full integration

Input

Land limits and yields

Water balance

Technology specification

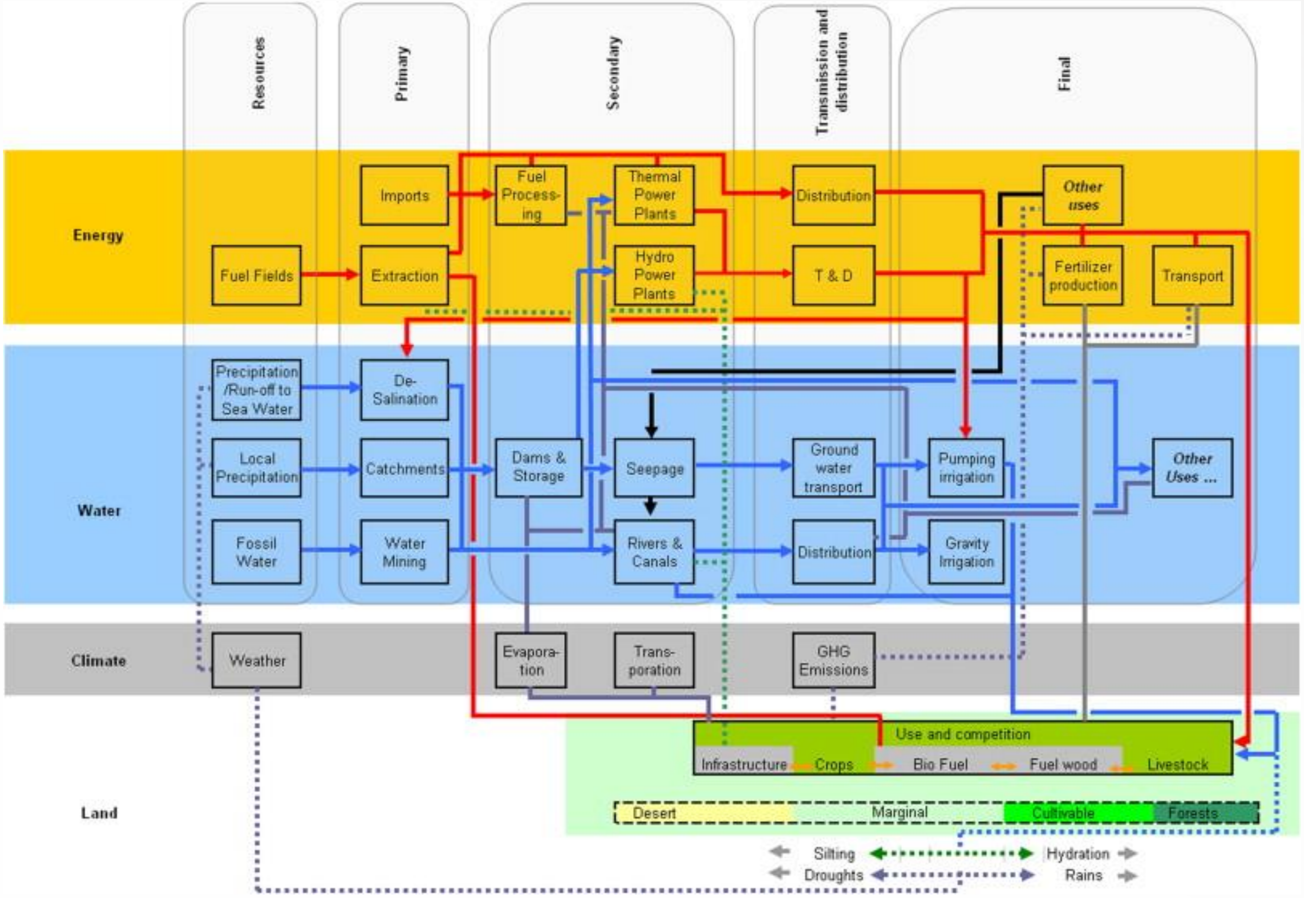
Exogenous water, food, energy demands

Project orientated

Output

Crop; Water; Energy and

CO_2 balance



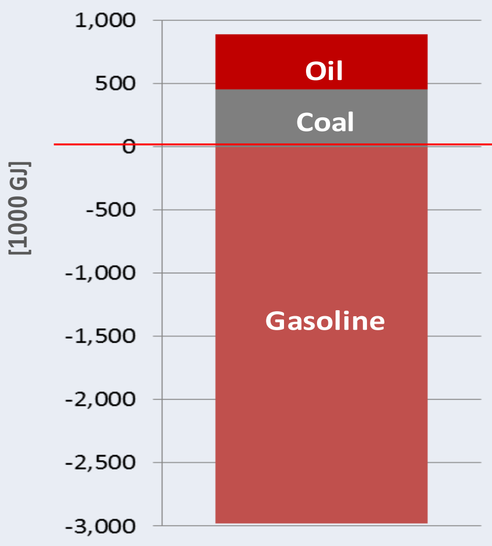
5. Selected Studies

Mauritius

- Main revenue has been tourism and sugar exports
  - Expiration of EU agreement and collapse of revenue from the latter.
- Diversification away from sugar cane to food crops and vegetables
- Sugar cane production and refining – staple industry
- Bagasse from refining – cogeneration of heat and electricity
  - Reduction in sugar production 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

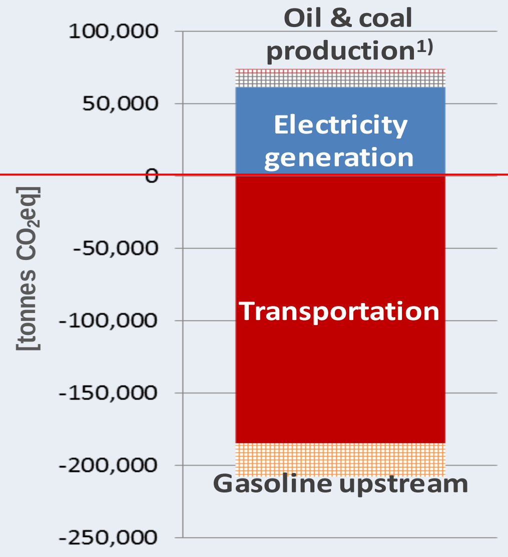
Impact of shifting two major sugar refineries to produce 2nd generation ethanol

Reduced fuel imports



Overall energy import dependence decreases: Gasoline imports are reduced as ethanol replaces gasoline as a motor fuel. Some bagasse is diverted from electricity generation to ethanol production and needs to be substituted by higher imports of coal and distillate oil.

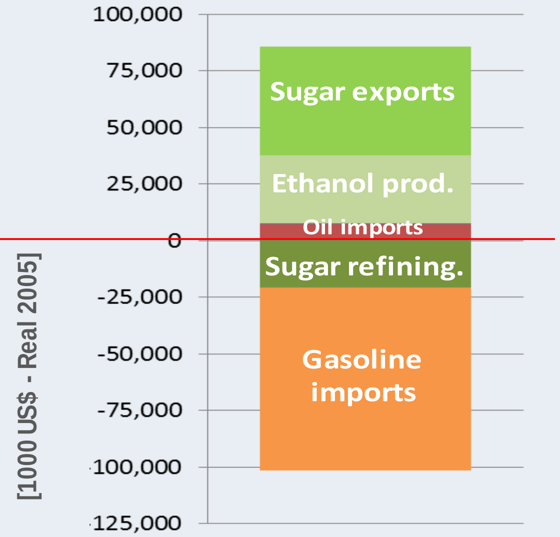
Reduced greenhouse gas emissions



Total greenhouse gas emissions are reduced: Tailpipe and upstream emissions are reduced as gasoline is replaced by ethanol. The increased use of coal and distillate oil (in place of bagasse) for electricity generation results in smaller additional emissions.

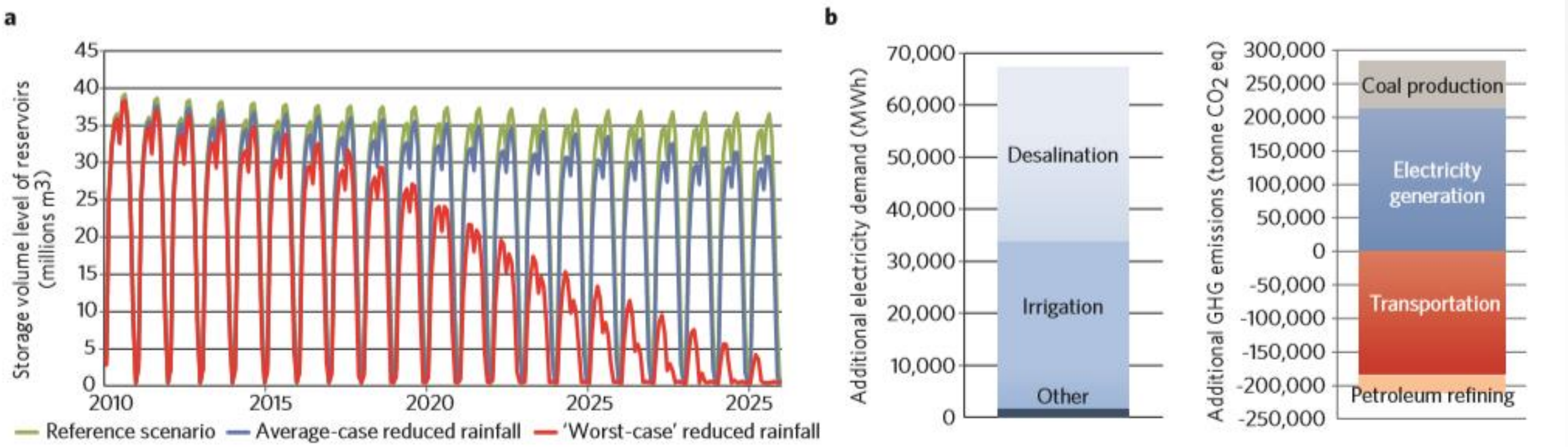
[1)] Indirect emissions

Reduced expenditures



Domestic ethanol production has economic benefits: As some of the sugar is converted to ethanol, the expenditures for sugar refining and gasoline imports are reduced. This outweighs the reduced sugar export earnings and the costs associated with ethanol production and the increases in oil and coal imports.

Impact of climate change in a CLEWs framework



Punjab, India

Punjab has only 1.5% of India's land, but its rice and wheat production accounts for 50% of the grain the government purchases and distributes to feed more than 400 million poor Indians.

- Groundwater is being **withdrawn faster than it can be replenished**
  - **No restriction** on landowners' rights to pump water on their own land.
  - Government-set prices **incentivises planting of water-intensive crops**
  - Electricity is **provided for free** to farmers
- **Water levels drop** and increased pumping is putting additional stress on an already fragile and overtaxed electricity grid.
  - Excessive pumping not only leads to over-exploitation of aquifers it also leads to high electricity demand.
  - **Irrigation accounts for about 15–20% of India's total electricity use**.

Uganda

Aim: to quantify the resilience of large scale hydro expansion using a CLEWS assessment.

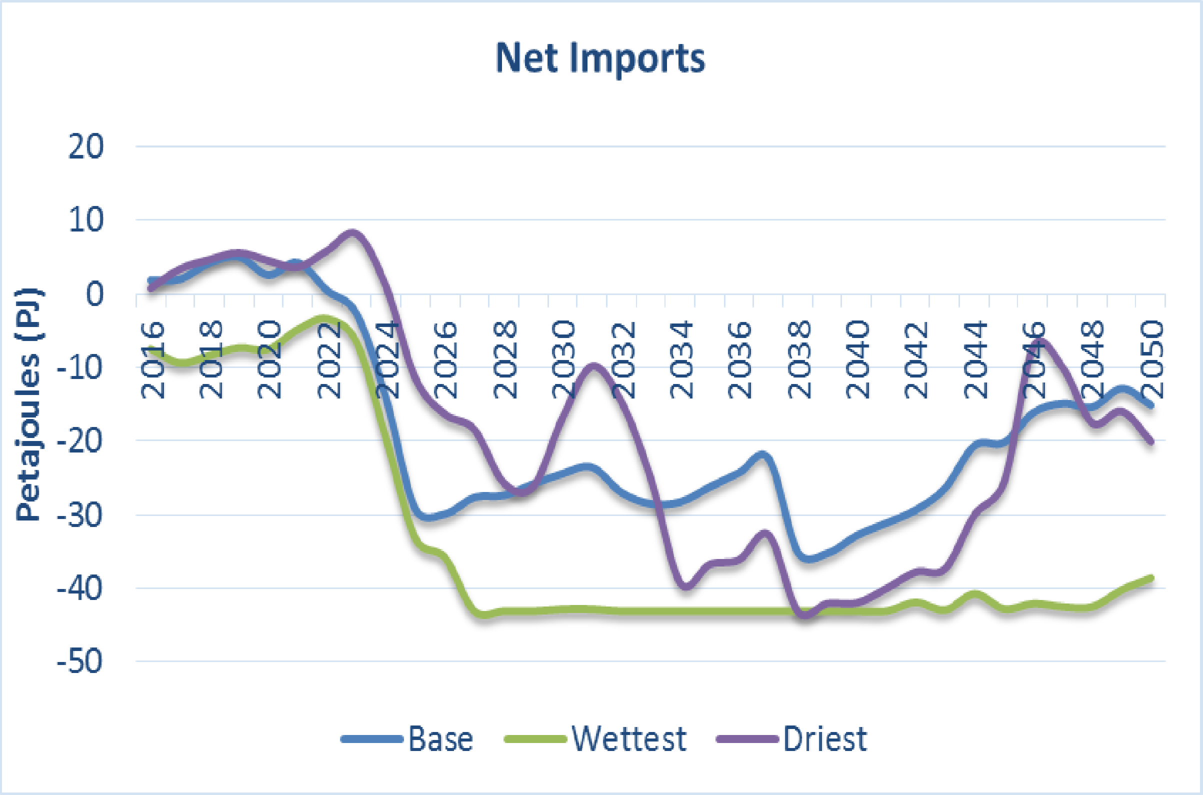
How: by assessing global climate change, regional power expansion and local demands a “CLEWS approach” may provide new insight

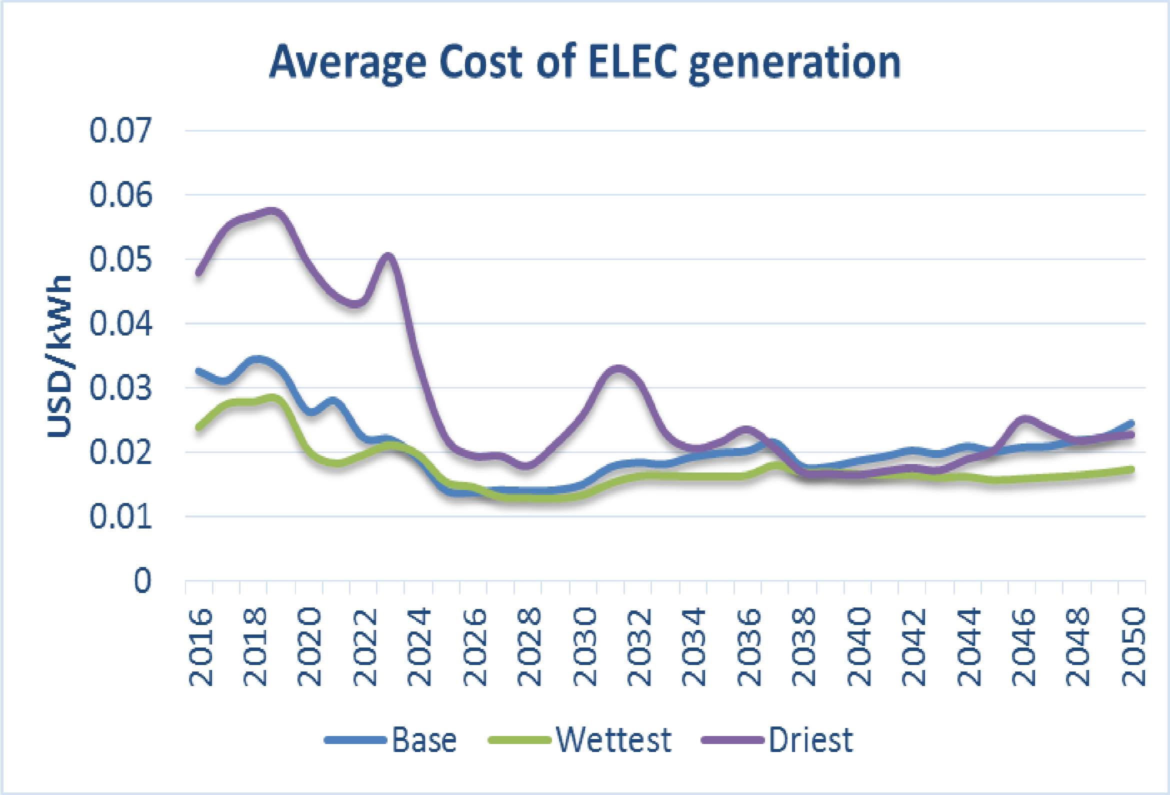
Why: Hydro investments need to be undertaken in the context of local water and regional power needs

- Ethiopia is expanding its hydro system rapidly, potentially stranding Uganda’s expansion and trade potential
- Climate change (with associated water withdrawals) may change production potential
- Local water requirements may grow in the future

Uganda

Resilience of Africa Energy infrastructure to Climate Change : Uganda as part of the East African Power Pool





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Considering the energy, water and food nexus: Towards an integrated modelling approach

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ABSTRACT

The areas of energy, water and food policy have numerous interwoven concerns ranging from ensuring access to services, to environmental impacts to price volatility. These issues manifest in very different ways in each of the three "spheres", but often the impacts are closely related. Identifying these interrelationships *a priori* is of great importance to help target synergies and avoid potential tensions. Systems thinking is required to address such a wide swath of possible topics. This paper briefly describes some of the linkages at a high-level of aggregation – primarily from a developing country perspective – and *via* case studies, to arrive at some promising directions for addressing the nexus. To ...ses the nexus, ...nvironmental ...d jointly the

nature climate change
PERSPECTIVE
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Integrated analysis of climate change, land-use, energy and water strategies

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Land, energy and water are our most precious resources, but the manner and extent to which they are exploited contributes to climate change. Meanwhile, the systems that provide these resources are themselves highly vulnerable to changes in climate. Efficient resource management is therefore of great importance, both for mitigation and for adaptation purposes. We postulate that the lack of integration in resource assessments and policy-making leads to inconsistent strategies and inefficient use of resources. We present CLEWs (climate, land-use, energy and water strategies), a new paradigm for resource assessments that we believe can help to remedy some of these shortcomings.

water
MDPI

Article

A Methodology to Assess the Water Energy Food Ecosystems Nexus in Transboundary River Basins

Lucia de Strasser [1,*], Annukka Lipponen [2,†], Mark Howells [1], Stephen Stec [3] and Christian Bréthaut [4]

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† The views expressed in this article are those of the authors and do not necessarily reflect the views of the United Nations Economic Commission for Europe or its Member States.

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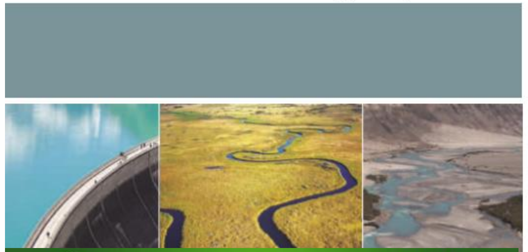
UNECE

Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems nexus



WATER-ENERGY NEXUS

Assessing integrated systems

The various supply chains that deliver the services society needs are often managed in silos. Research now shows the advantages of integrated management.

Mark Howells and H-Holger Rogner

Living in the beautiful cities of Stockholm and Vienna we note, with some irritation, occasional interruptions to their scenic walkways. Striving to provide services, a street might get torn up several times within a few months. First to do sewage repairs, then to lay new high-capacity data cables and finally to increase the capacity of the gas mains — efforts that might cost three times more tax money than if these activities were coordinated. And this is just an example at local level — globally it can be worse. Our societies are simply not organized to undertake integrated planning and action[1]. We spend far more than we need to deliver the services societies demand. Writing in *Environmental Science and Technology*, Bartos and Chester[2] show the missed opportunities from the lack of integrated water-energy management in the state of Arizona, USA.

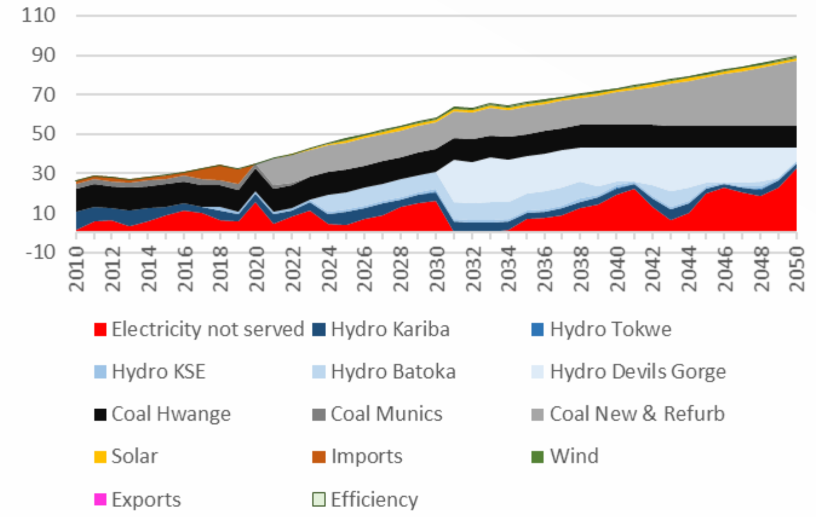
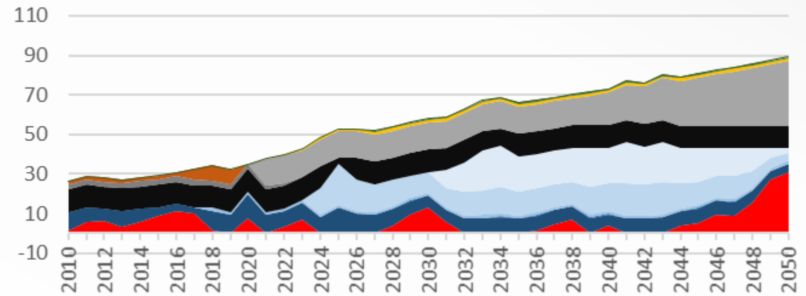
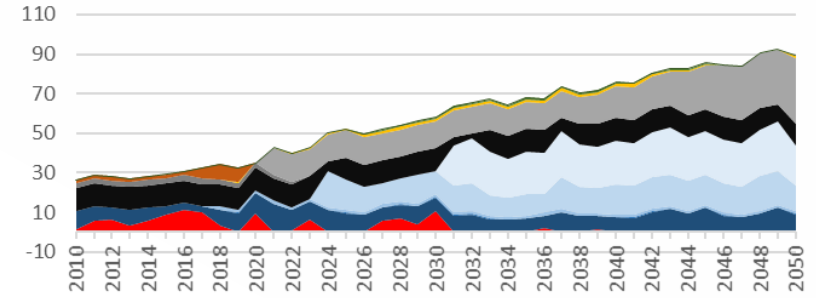
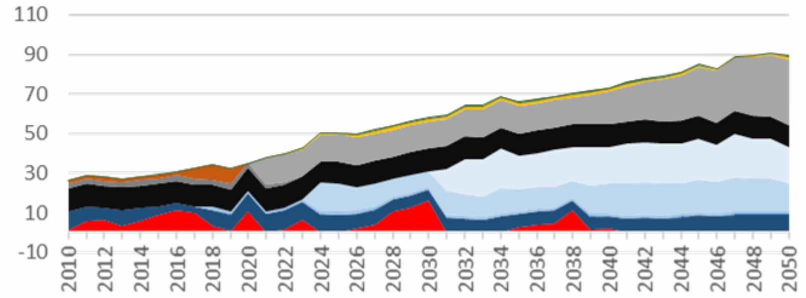
The delivery systems of society's services consist of a chain of activity. They originate from natural resources and ecosystems. These are extracted, processed and transported to provide products and services. Those chains are shaped by economics, technology and policies — notably to ensure secure supplies.

Society's 'delivery chains' have traditionally been managed individually. Initially, interactions between many chains were largely inconsequential — their supplies were abundant and our demand was small. For practical reasons, separate management also allows for delineated responsibility and focused planning. Hence, at all governmental levels, we find authorities for energy, water, agriculture and so on, each tasked with their own sectoral mandates. Such mandates often do not include any assessments of the impacts of action in one sector on others. A notable exception is the European Commission's Strategic Environmental Assessments. These assessments are required for certain types of public plans and programmes (for example, on land use, transport, waste and water management, energy and agriculture)[3].

nature climate change

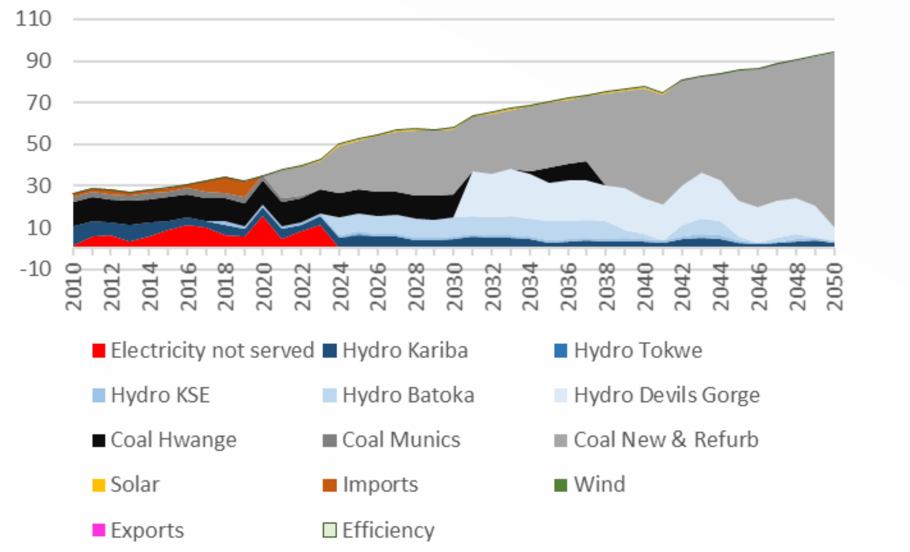
Climate change impacts without adaptation

Zimbabwe

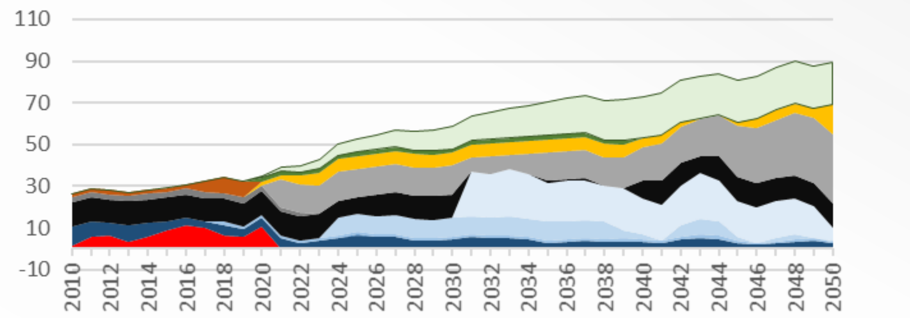
Climate V3 GJ of electricity generated	Climate V4
	 Note the unserved electricity in red comes with very high economic cost and damage.
Climate V5	**Climate V6**
	

Benefits of adaptation: coal and RET options

Climate V3: Coal based resilience: PJ generated

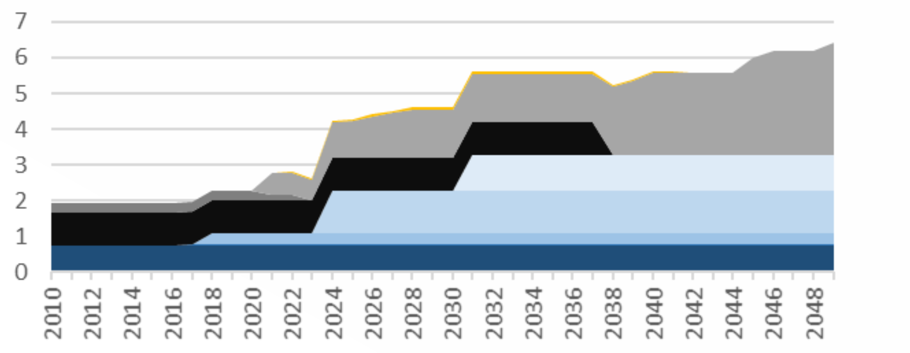


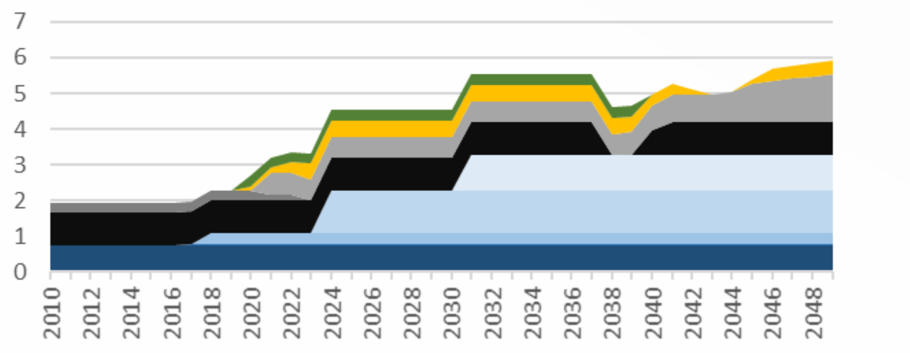
Aggressive energy efficiency and RET resilience



In both cases unserved electricity is removed with important impacts. In the 'clean' case aggressive energy efficiency with associated non-tirvial institutional advances is needed. This comes with large investment and emissions reduction.

GW Generation capacity

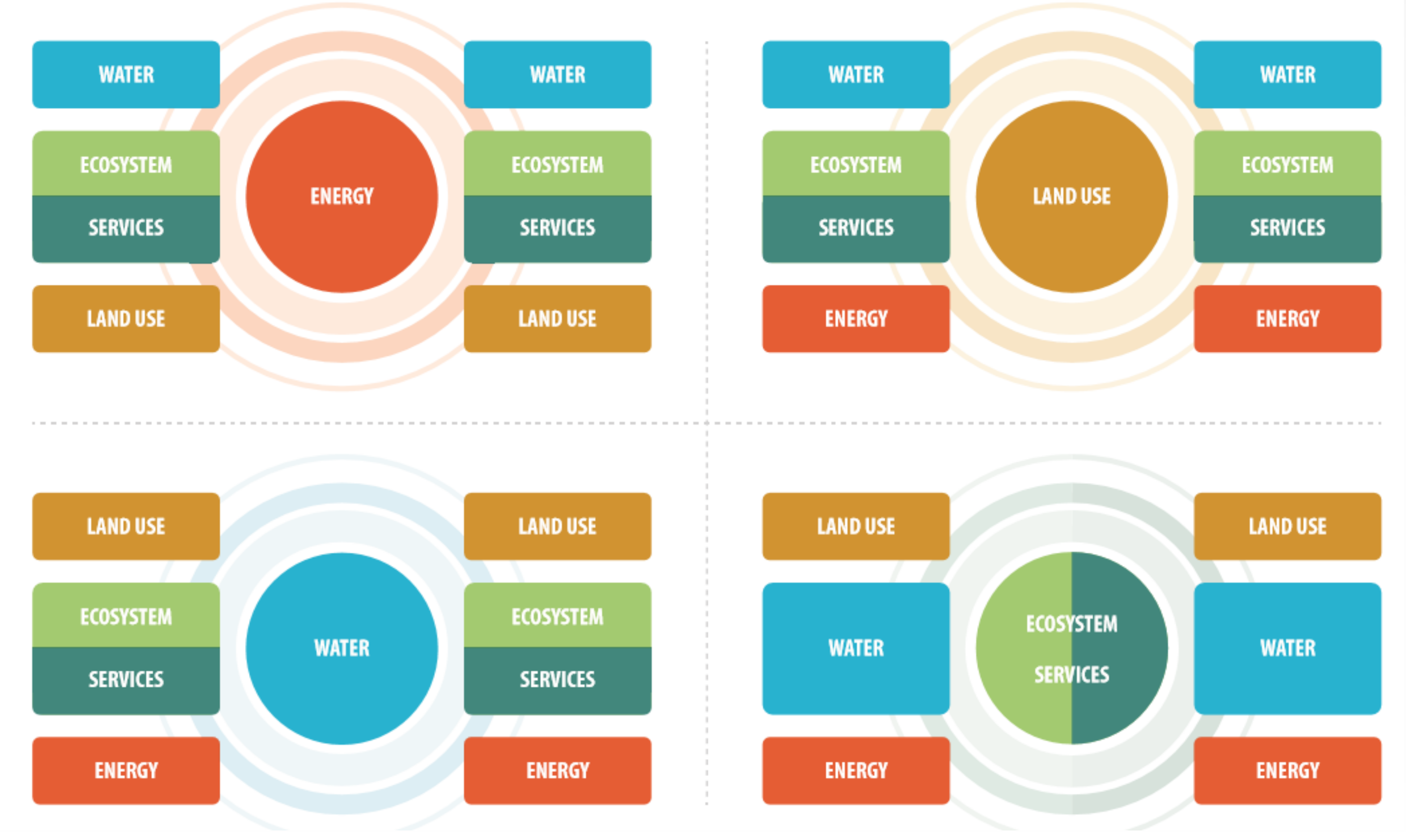




Zimbabwe

www.optimus.community

Capacity building and communication ….



7. Key take-home messages

A summary of key points

- Assessments are by necessity case specific and scale specific
- CLEWs is an approach, not a tool. But it is based on:
  - Quantitative modelling of …
  - … integrated resource systems
  - With adequate tools and methods that can capture the identified nexus challenges
- The focus of CLEWs assessments lies on:
  - Analysing physical resource system interactions –supply chains and operational interactions
  - Providing policy support and analysing alternative development pathways/choices

Ongoing CLEWs projects

- SIM4NEXUS , EU Horizon 2020 project with 24 European partners
- Niger River Basin CLEWs, Formas funded project on integrated assessments across scales (from city to transboundary basin)
- UNECE Transboundary nexus assessments (NWSAS, Drina 2)
- FAO - Marocco and Jordan (national)
- First CLEWs summer school in 2017 in Trieste, Italy (together wtih ICTP, UNDESA, Cambrigde, UNDP)
- Country level capacity-building focused CLEWs projects in Nicaragua and Uganda, with UNDESA

And…

- …earlier in 2017, KTH dESA supervised 6 groups of KTH students analysing CLEW interlinkages in 5 African countries in SIDA sponsored minor field study (MFS) program)

Ongoing CLEWs projects

- Joint Summer School on Sustainable Development: integrated modelling tools for Climate, Land use, Energy, Water (CLEW) Strategies
  - Upcoming event: **June 2018**, in Trieste (Italy)
  - Organized together wtih ICTP, UNDESA, Cambridge, UNDP

For more information, and to apply for participating in the upcoming Summer School, please visit the following page:

http://indico.ictp.it/event/8315/

Questions?

Useful links and papers

- Introduction to CLEWs and the Mauritius Case study: http://www.nature.com/nclimate/journal/v3/n7/full/nclimate1789.html
- Global CLEWs featured in: https://sustainabledevelopment.un.org/globalsdreport/2014
- Transboundary CLEWs, and CLEWs methodology (in collaboration with UNECE, 2015): https://www.unece.org/index.php?id=41427
- Urban CLEWs approach for New York City: https://www.sciencedirect.com/science/article/pii/S2210670716305947?via%3Dihub
- An inventory of the *nexus*: https://www.sim4nexus.eu/userfiles/Deliverables/D1.1%20Final%20submitted%20v03.pdf
- UN's SDG Acceleration toolkit: https://undg.org/sdg_toolkit/climate-land-food-energy-water-strategies-clews-framework/
- UN DESA Modelling Tools for Sustainable Development: https://un-desa-modelling.github.io/