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2372-23

Joint ICTP-IAEA Workshop on Sustainable Energy Development: Pathways and Strategies after Rio+20

1 - 5 October 2012

Finding CLEWs
Exploring Sustainable Energy Developments: Looking at Climate-Land-Energy-Water Interactions methodology and components

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Finding CLEWs

Exploring Sustainable Energy Developments:
Looking at Climate-Land-Energy-Water Interactions

methodology and components

Joint ICTP-IAEA Workshop on Sustainable Energy Development:
Pathways and Strategies after Rio20

01-05 October, 2012, Trieste, Italy

Overview

Intro
CLEWs explained
Tools
Summary

1. Introduction: Why integrated CLEWs are important?
2. The CLEW methodology
3. Overview about Modelling tools
4. Integration of Tools and Summary

What is this about?

- **C**limate
- **L**and-use
- **E**nergy
- **W**ater
- **S**trategies

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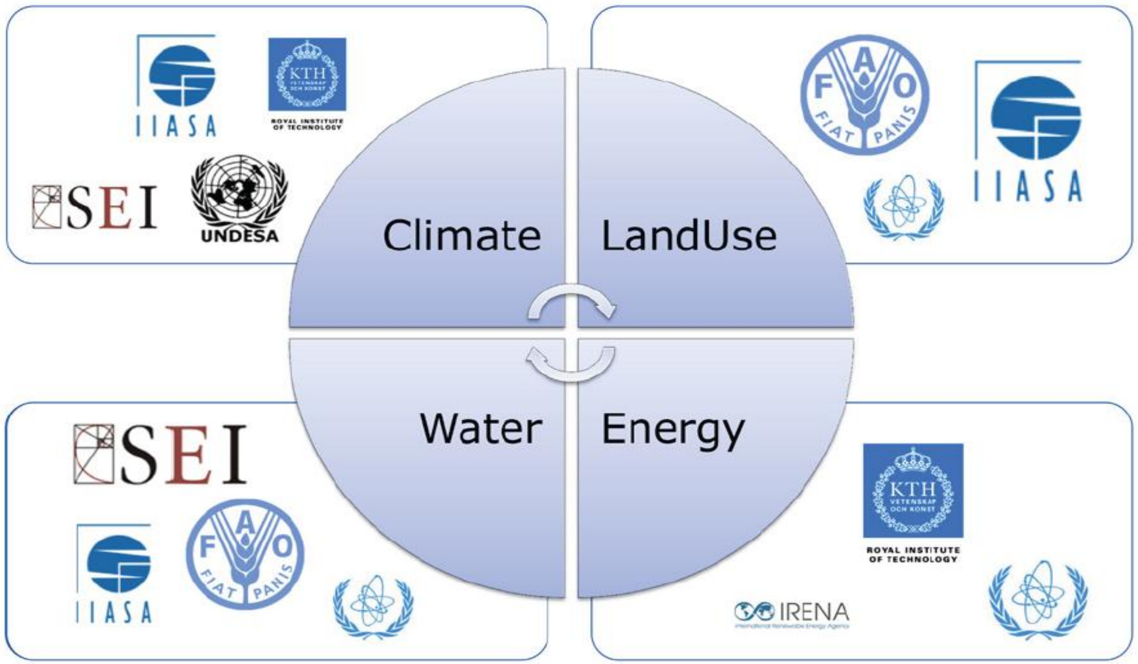
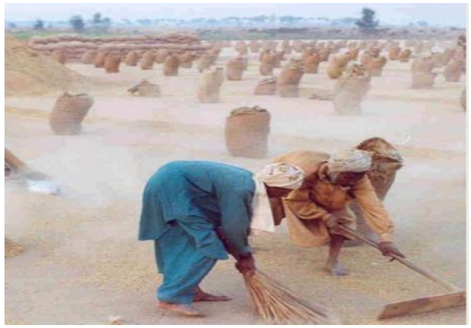
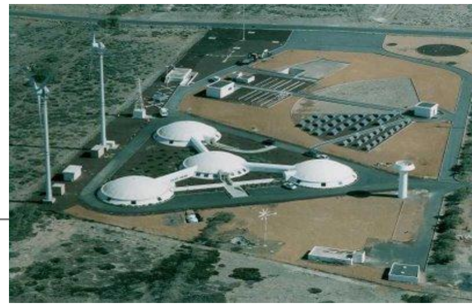
Why finding CLEWs is important

We need to find sustainable development CLEWS: Climate, Land, Energy and Water strategies. This is an acronym given to a set of methodologies that are being developed at a number of leading institutions. Some specific goals are to address questions such as:

- How we can meet common development needs (food, water, energy) in a sustainable manner?
- What technologies and configurations of technologies are best going to help?
- What policies are going to make this feasible and economically viable – and thereby help reduce future conflicts?
- And what happens if we do nothing ?







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Climate, Land-use, Energy and Water (CLEW) – some well known facts …

Intro

CLEWs explained

Tools

Summary

- The world's food, water and energy resources are already under stress
- Renewed concerns over food security and increased commercial pressure on land
- Water scarcity is estimated to affect one in three people globally
- Energy prices are high and volatile
- Energy supply has to increase by an estimated one-third by 2030
- Mounting concerns over climate change

CLEW resources are inter-linked

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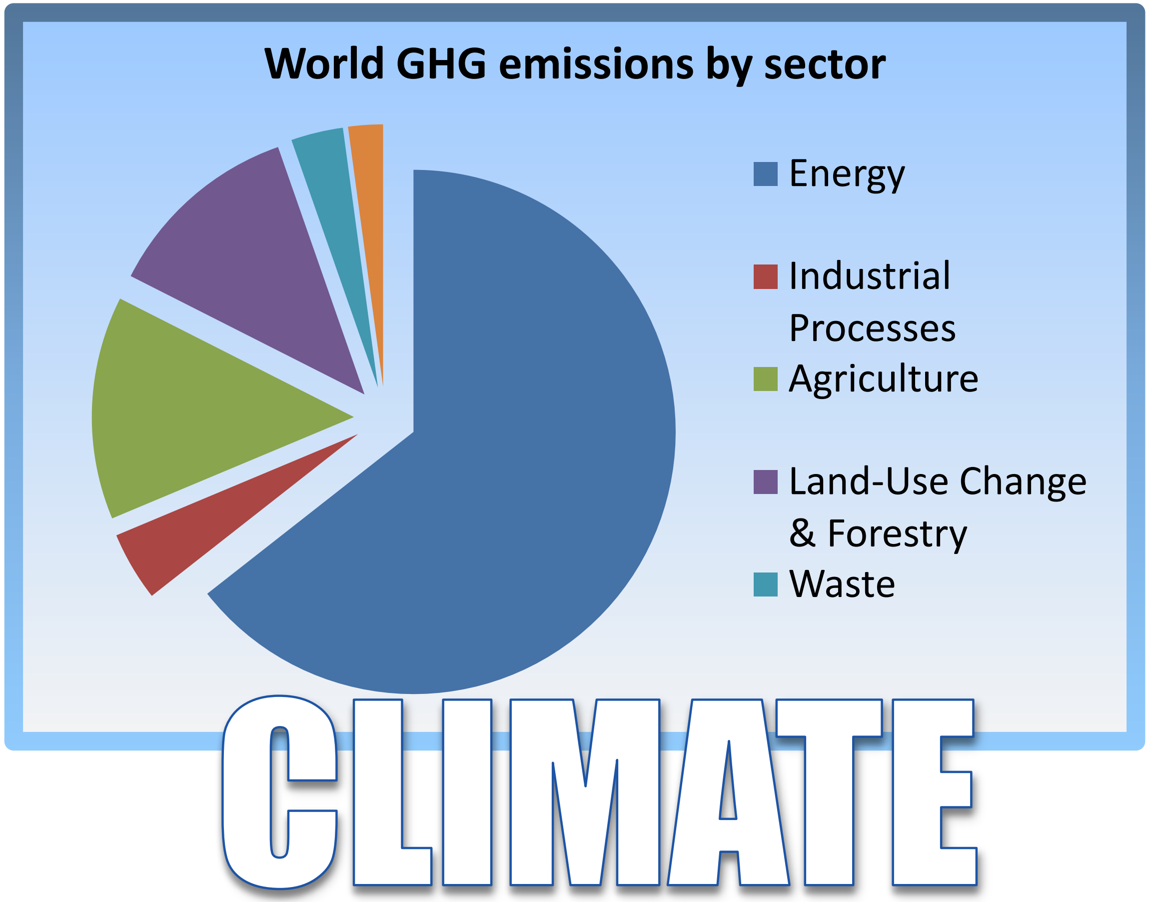
- The energy system and agriculture and forestry sectors account for the majority of anthropogenic GHG emissions



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CLEW resources are inter-linked

- A growing share of cropland is dedicated to producing energy

- On average 11% of coarse grains, 11% of oil seeds and 21% of sugar cane was used for biofuel production over the 2008-2010 period.

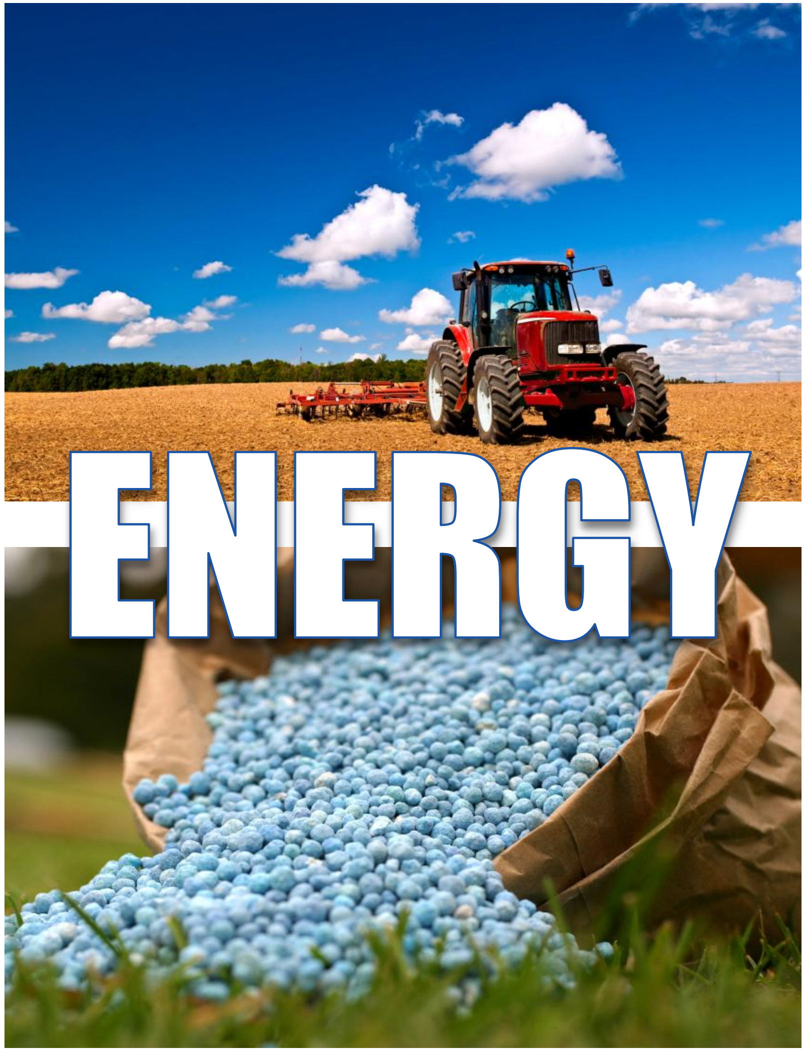
CLEW resources are inter-linked

- Energy is required to produce, treat and transport water
- The supply and treatment of water accounts for approximately 7% of electricity demand world-wide

CLEW resources are inter-linked

- Energy is required to power agricultural machinery for field preparation, crop harvesting, drying and processing. Direct energy use accounts for roughly 2.1% of global final energy demand

- Energy is required to produce fertilizers, pesticides and other agricultural inputs. Indirect energy use in agriculture is about 1.2% of global final energy demand



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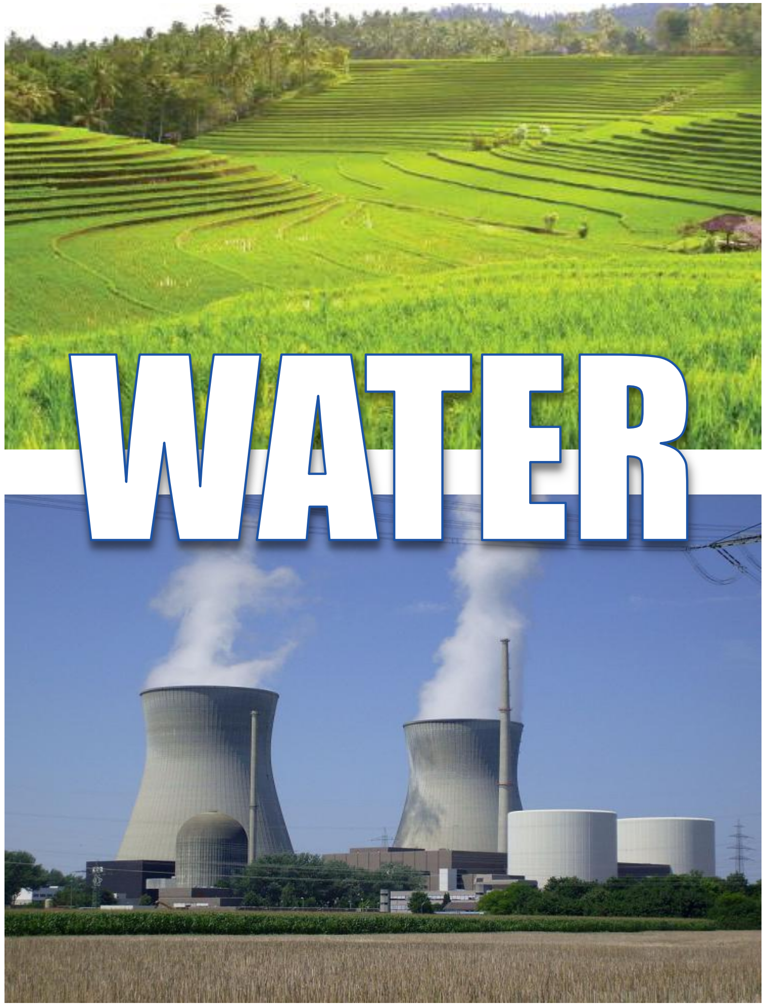
CLEW resources are inter-linked

- About 70% of freshwater withdrawals worldwide are for agriculture

- Approximately 20% of freshwater withdrawals are for cooling thermal processes in the power and manufacturing sectors



The CLEW challenge for coming decades

- Need for more "**crop per drop**" and more crop per hectare
- Produce **more energy** for a larger and more affluent population in a more sustainable manner.
- Adopt sustainable practices for supply of **more freshwater** and disposal of wastewater.
- Integrate the possible Effects of **Climate Change** into our planning.

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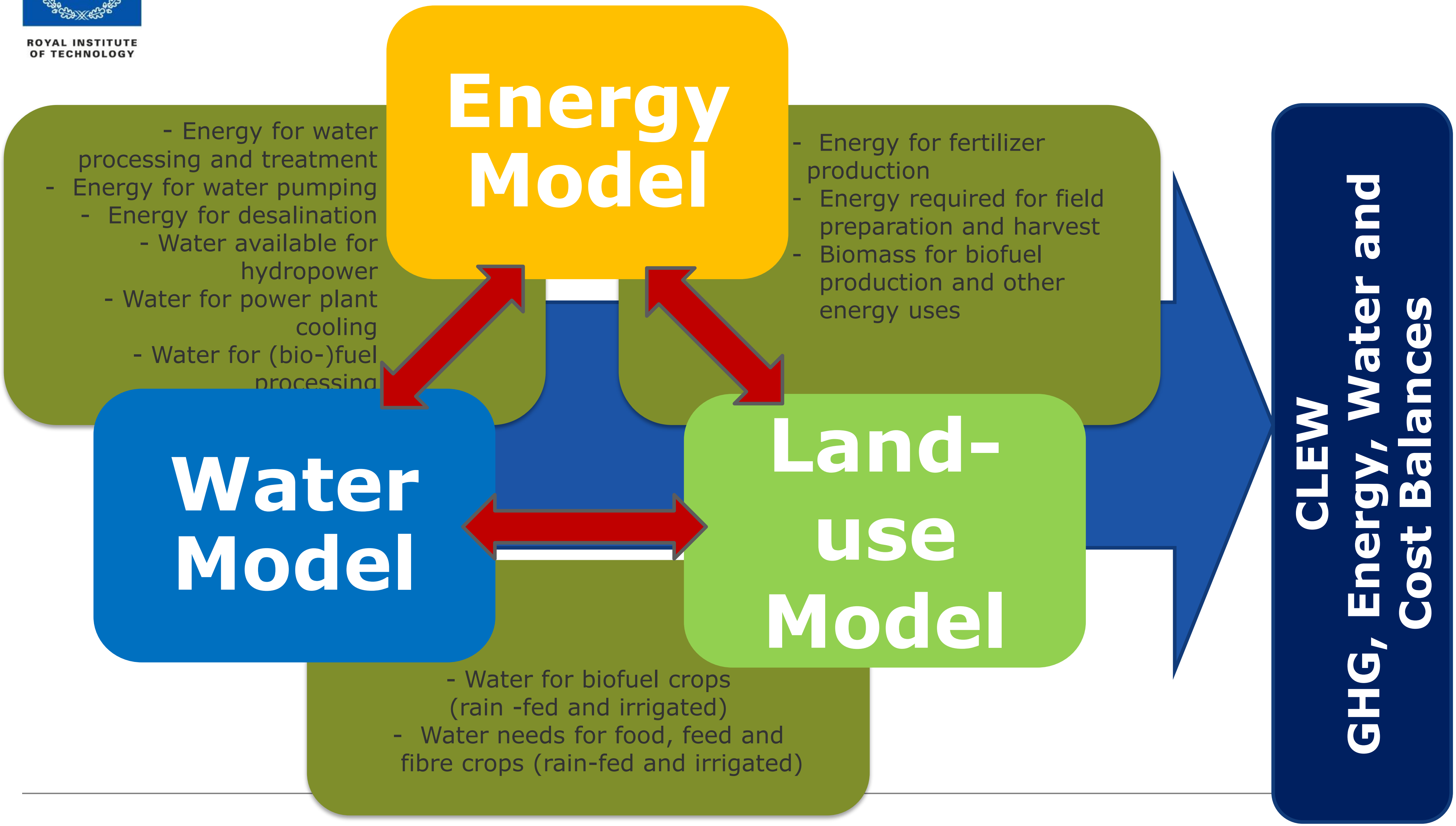
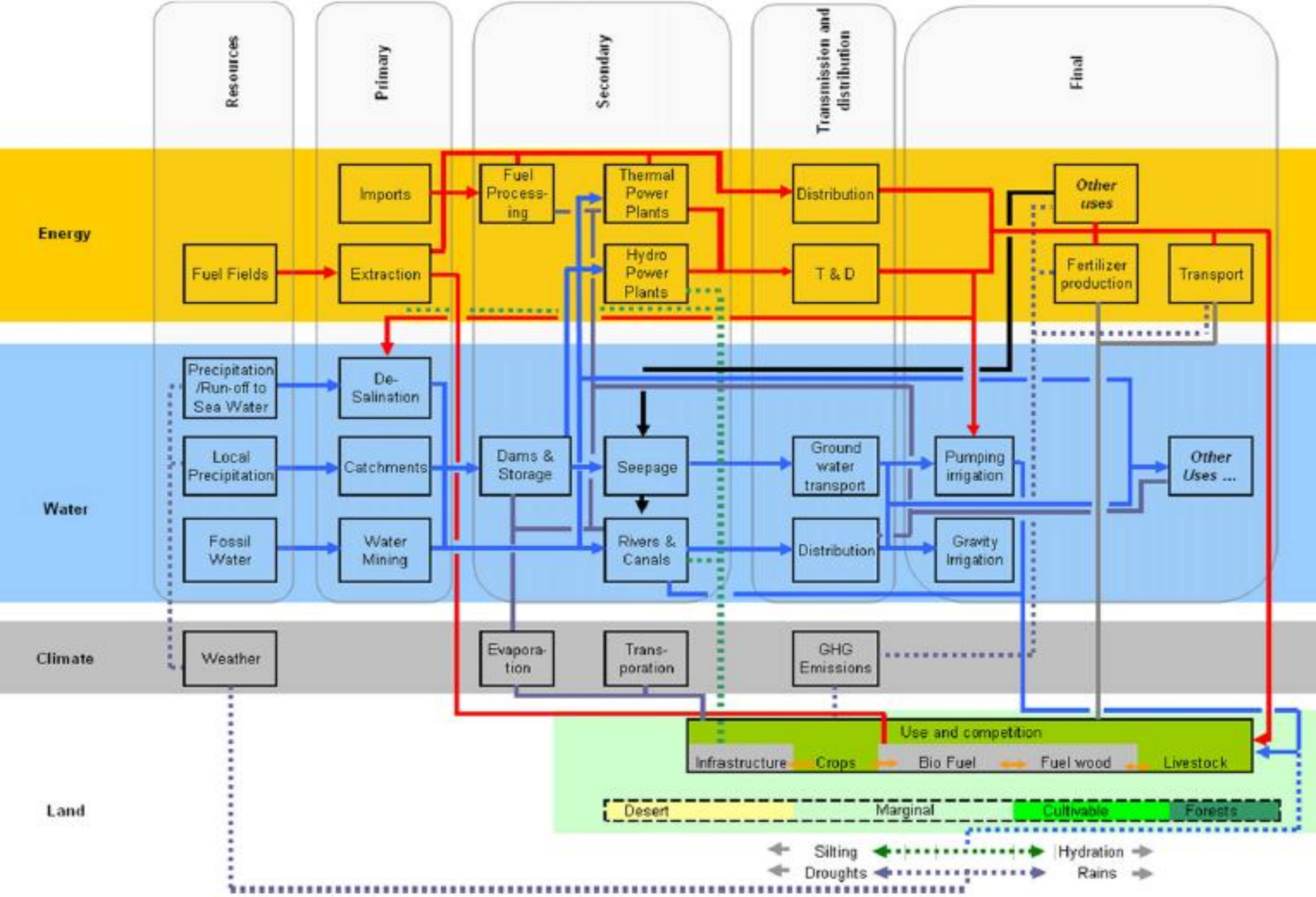
A key weakness today …

Policy formulation and assessments are often done in isolation by separate and disconnected institutional entities – this might lead to:

- Lack of incentives and institutional structures required for effective action
- Risk that incoherent policies are promoted
- High probability that inefficient resource use will ensue.

The CLEW Framework





Resources
Primary
Secondary
Transmission and distribution
Final
Energy
Water
Climate
Land
Imports
Fuel Process-ing
Thermal Power Plants
Distribution
Other uses
Fuel Fields
Extraction
Hydro Power Plants
T & D
Fertilizer production
Transport
Precipitation /Run-off to Sea Water
De-Salination
Local Precipitation
Catchments
Dams & Storage
Seepage
Ground water transport
Pumping irrigation
Other Uses ...
Fossil Water
Water Mining
Rivers & Canals
Distribution
Gravity Irrigation
Weather
Evapora-tion
Trans-poration
GHG Emissions
Use and competition
Infrastructure
Crops
Bio Fuel
Fuel wood
Livestock
Desert
Marginal
Cultivable
Forests
Silting
Hydration
Droughts
Rains

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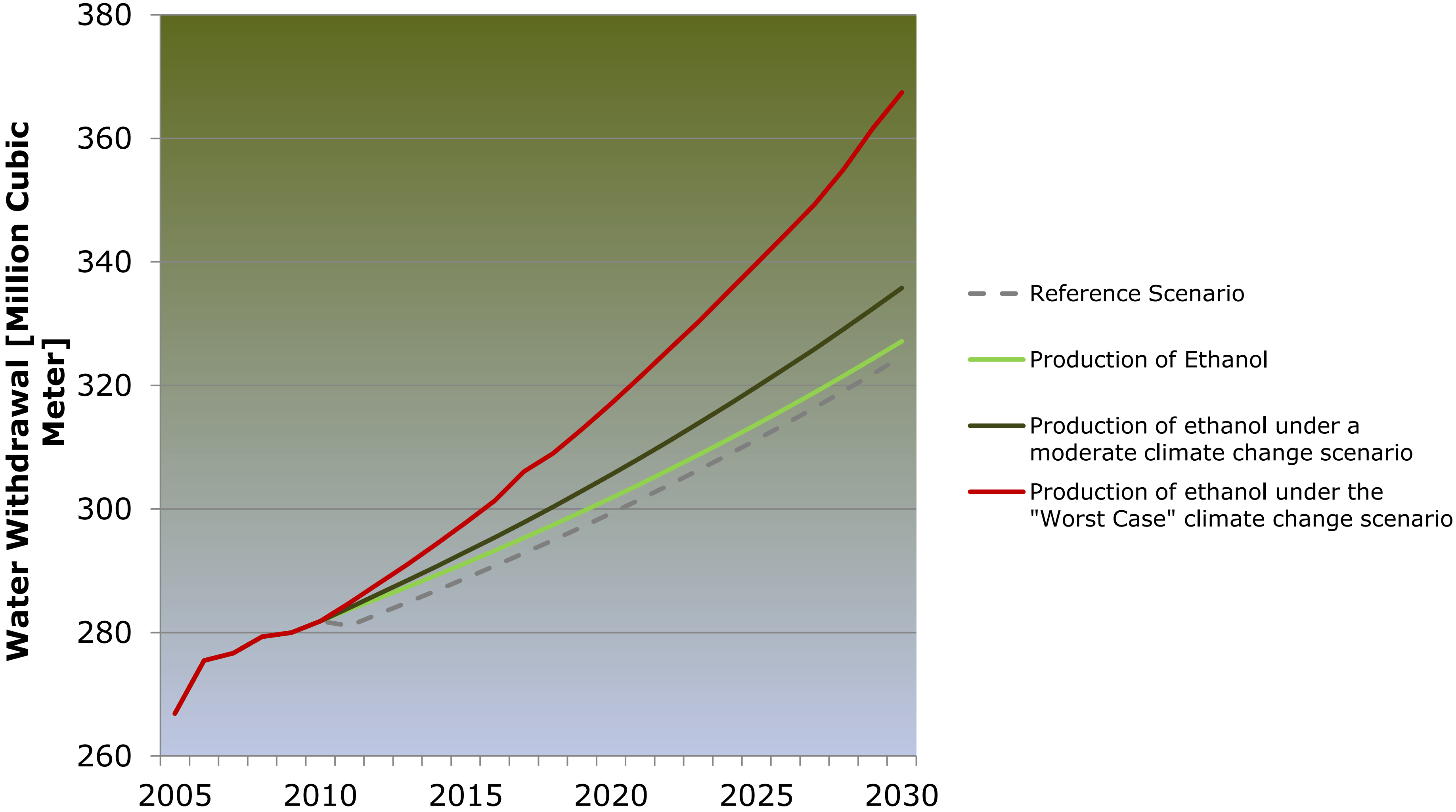
Scenario based analysis



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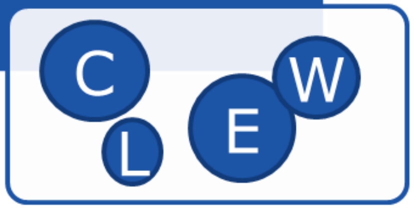
The CLEWS Framework

- Simple idea: the land, energy and water resource systems are highly integrated and any assessment of these resources should ideally treat them as such
- Collaborative effort across disciplines needed
- Allows for integrated assessment of the water-food-energy nexus.
- Enables evaluation of the general robustness of a particular strategy or policy with respect to risks of climate change.

The Aim of CLEW

Quantifying Indicators



Solve Problem

(e.g. energy shortage, water shortage, food shortage)

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Conclusions and way forward

- Major improvements to efficiency in natural resources use is required
- The CLEW framework provide a foundation for assessing resource use in an integrated manner that allows trade-offs and co-benefits to be explored
- Governments must take the lead and promote public-private-civil alliances to address the CLEW challenges.

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CLEW TOOLS

Overview about Modelling Tools and their Potential for Integration

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Water
Evaluation
And
Planning

WEAP

OSeMOSYS

LEAP

AEZ - The Land-Use Model

Modelling Tools used …

	Energy	Water	Land Use
Model	MESSAGE(IAEA,IIASA) LEAP(SEI) OSeMOSYS(KTH)	WEAP(SEI) plus several others	AEZ(IIASA)
„Scale of Operation"	From small island systems to large country analysis	Local water systems based on geographical data	Small scale to country analysis (flexible grid cells sizes)
Input	• Demand (current / future, load curves), • Existing + planned Power plants, • Imports and exports, and resource availability, • GHG emission factors	• Climatic data, • Land cover data, • Soil data and water avail., • Water consumption, • Desalination and hydropower	• Climatic data (plus projections), • Land cover data, • Soil data,
Output & Results	• Future optimal energy mix under different conditions, • Future GHG emissions • Costs	• Water availability under different scenarios (CC and/or w. demand change) for ALL points in a modelled system	• Crop Map (most suitable crops per area) • Crop Calendar • Future water demand • Fertilizer demand

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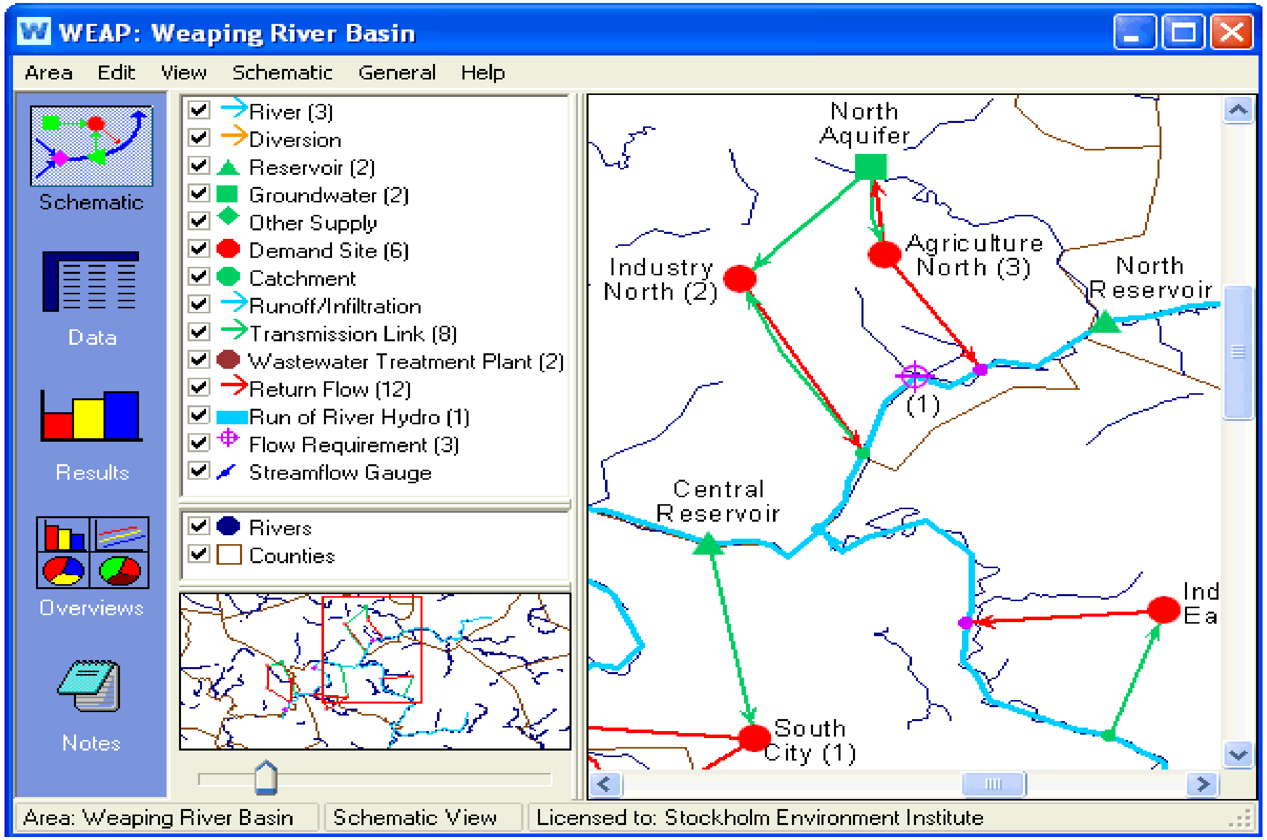
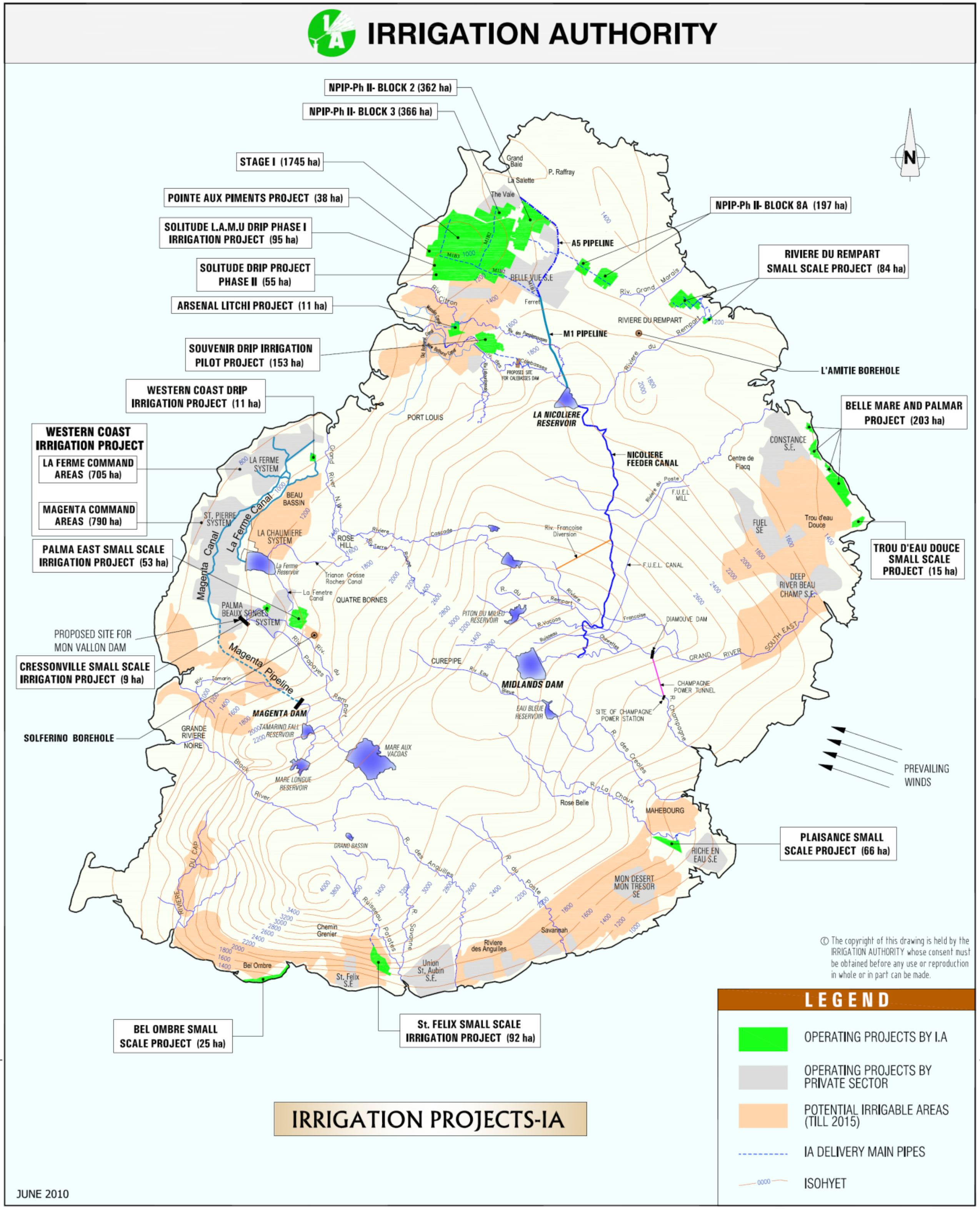
Water Evaluation And Planning

WEAP



Software available from
Stockholm Environmental Institute (SEI)

www.weap21.org


IRRIGATION AUTHORITY
NPIP-Ph II- BLOCK 2 (362 ha)
NPIP-Ph II- BLOCK 3 (366 ha)
STAGE I (1745 ha)
POINTE AUX PIMENTS PROJECT (38 ha)
SOLITUDE L.A.M.U DRIP PHASE I IRRIGATION PROJECT (95 ha)
SOLITUDE DRIP PROJECT PHASE II (55 ha)
ARSENAL LITCHI PROJECT (11 ha)
SOUVENIR DRIP IRRIGATION PILOT PROJECT (153 ha)
WESTERN COAST DRIP IRRIGATION PROJECT (11 ha)
WESTERN COAST IRRIGATION PROJECT
LA FERME COMMAND AREAS (705 ha)
MAGENTA COMMAND AREAS (790 ha)
PALMA EAST SMALL SCALE IRRIGATION PROJECT (53 ha)
PROPOSED SITE FOR MON VALLON DAM
CRESSONVILLE SMALL SCALE IRRIGATION PROJECT (9 ha)
SOLFERINO BOREHOLE
NPIP-Ph II- BLOCK 8A (197 ha)
A5 PIPELINE
RIVIERE DU REMPART SMALL SCALE PROJECT (84 ha)
M1 PIPELINE
L'AMITIE BOREHOLE
LA NICOLIERE RESERVOIR
NICOLIERE FEEDER CANAL
BELLE MARE AND PALMAR PROJECT (203 ha)
TROU D'EAU DOUCE SMALL SCALE PROJECT (15 ha)
PORT LOUIS
La Ferme Canal
Magenta Canal
Magenta Pipeline
MAGENTA DAM
MIDLANDS DAM
QUATRE BORNES
CUREPIPE
MARE AUX VACOAS
PREVAILING WINDS
MAHEBOURG
PLAISANCE SMALL SCALE PROJECT (66 ha)
BEL OMBRE SMALL SCALE PROJECT (25 ha)
St. FELIX SMALL SCALE IRRIGATION PROJECT (92 ha)
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LEGEND
OPERATING PROJECTS BY I.A
OPERATING PROJECTS BY PRIVATE SECTOR
POTENTIAL IRRIGABLE AREAS (TILL 2015)
IA DELIVERY MAIN PIPES
ISOHYET
IRRIGATION PROJECTS-IA
JUNE 2010

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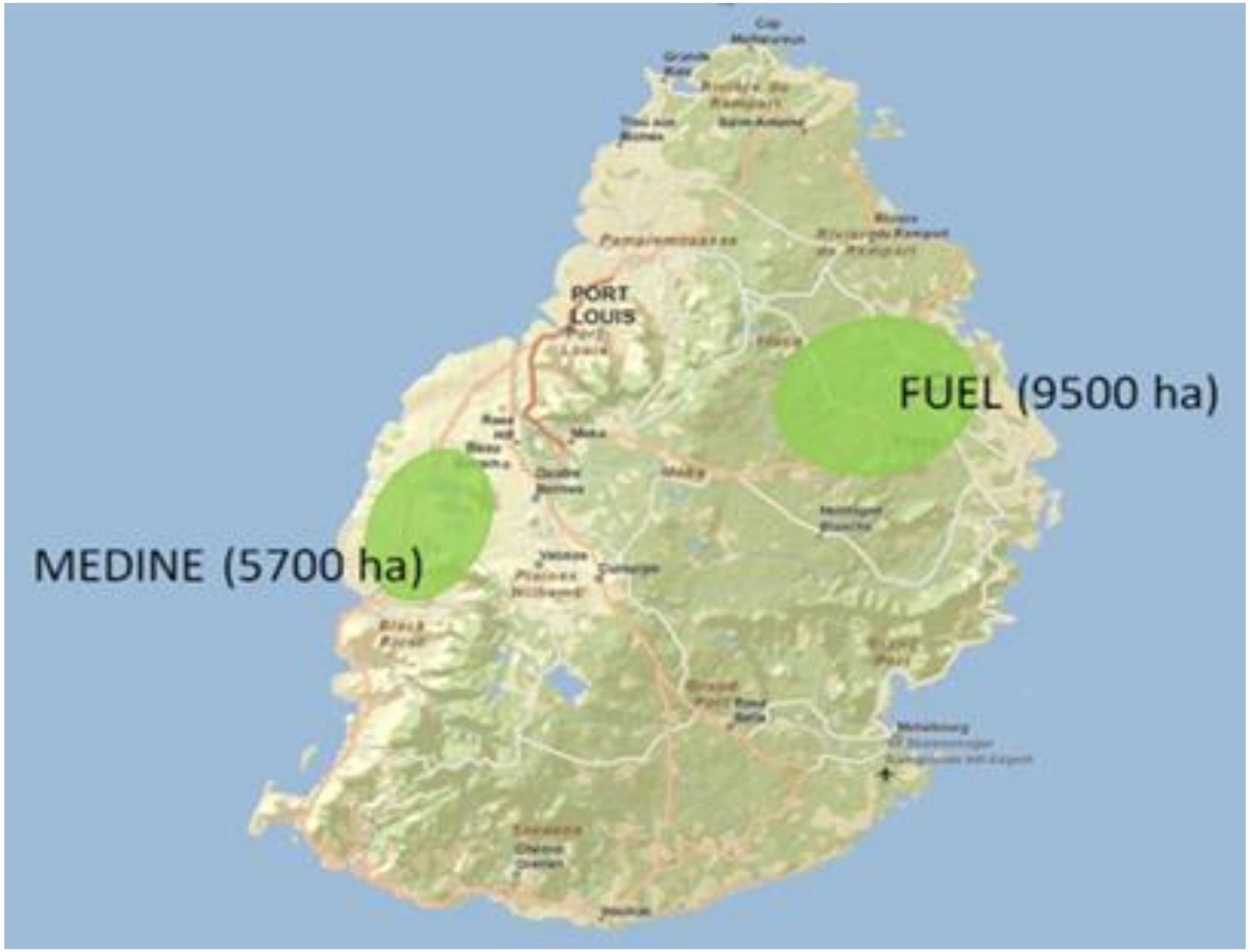
Water Evaluation And Planning

WEAP



Water
Evaluation
And
Planning

WEAP

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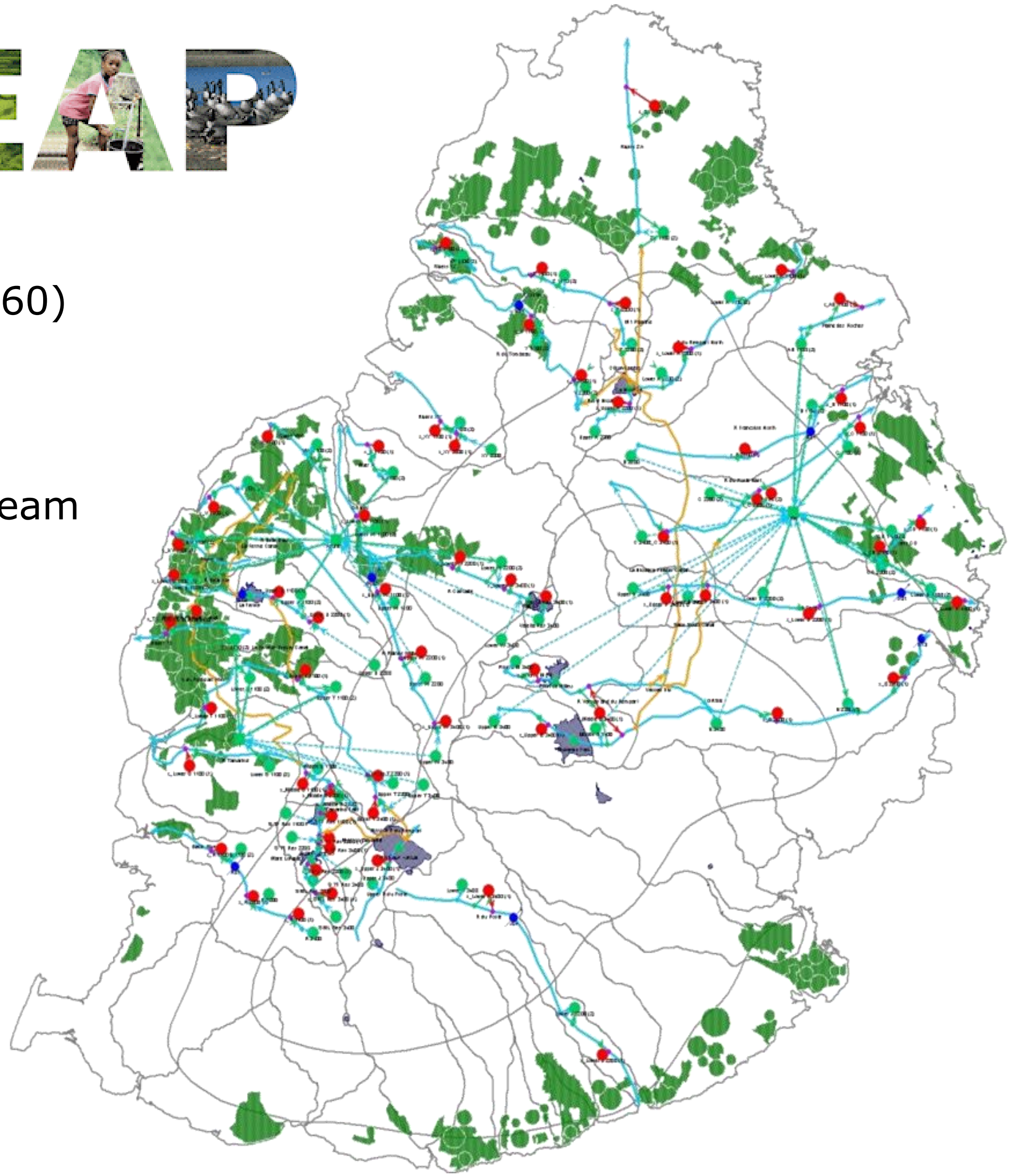
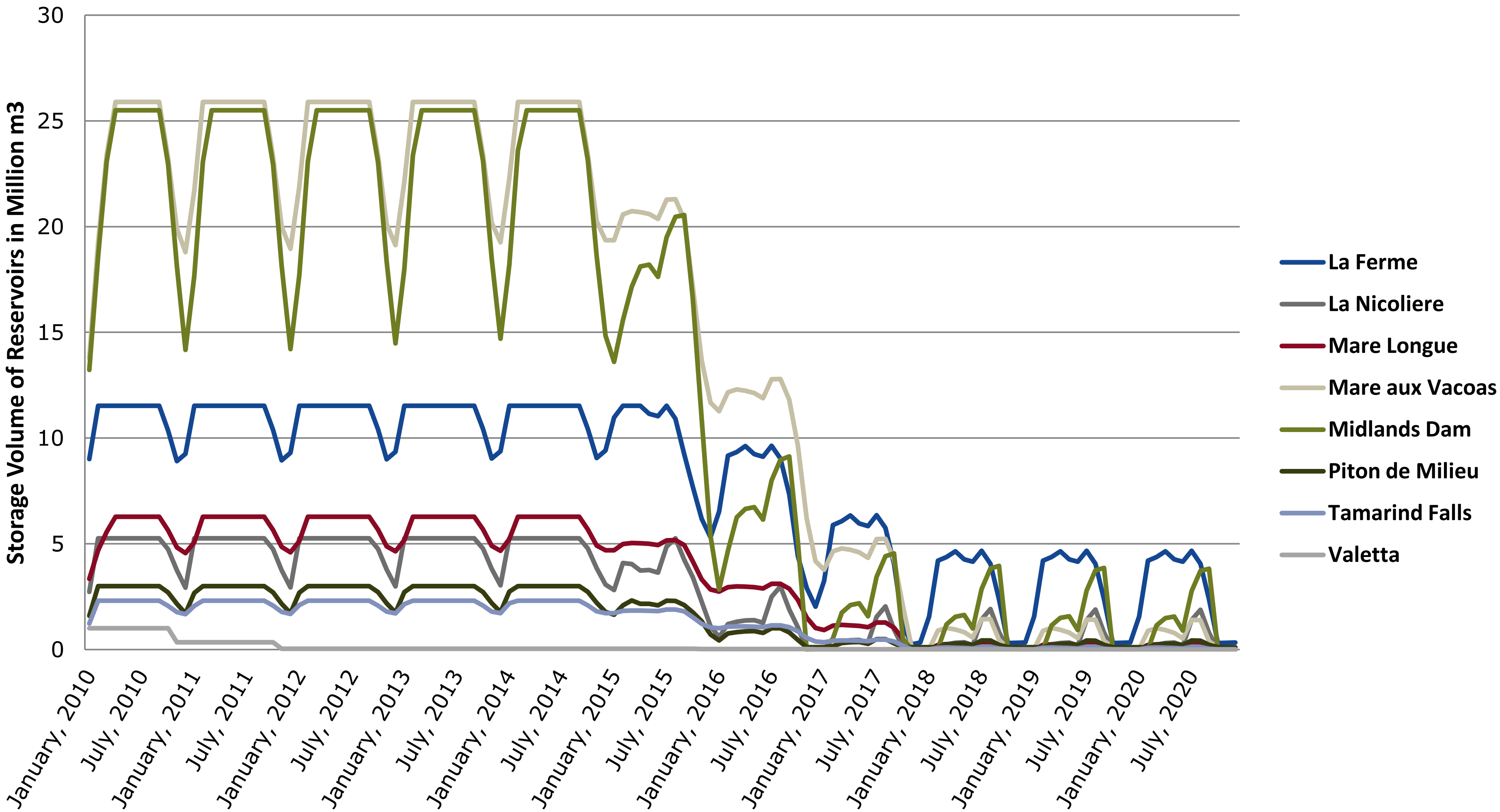
Summary

- Definition of all Catchement areas (60)
- Real Climatic Data (1996 – 2005):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

Result: Water availabilty for each point in the system



Results – Scenario B (40% rainfall reduction): Reservoir levels



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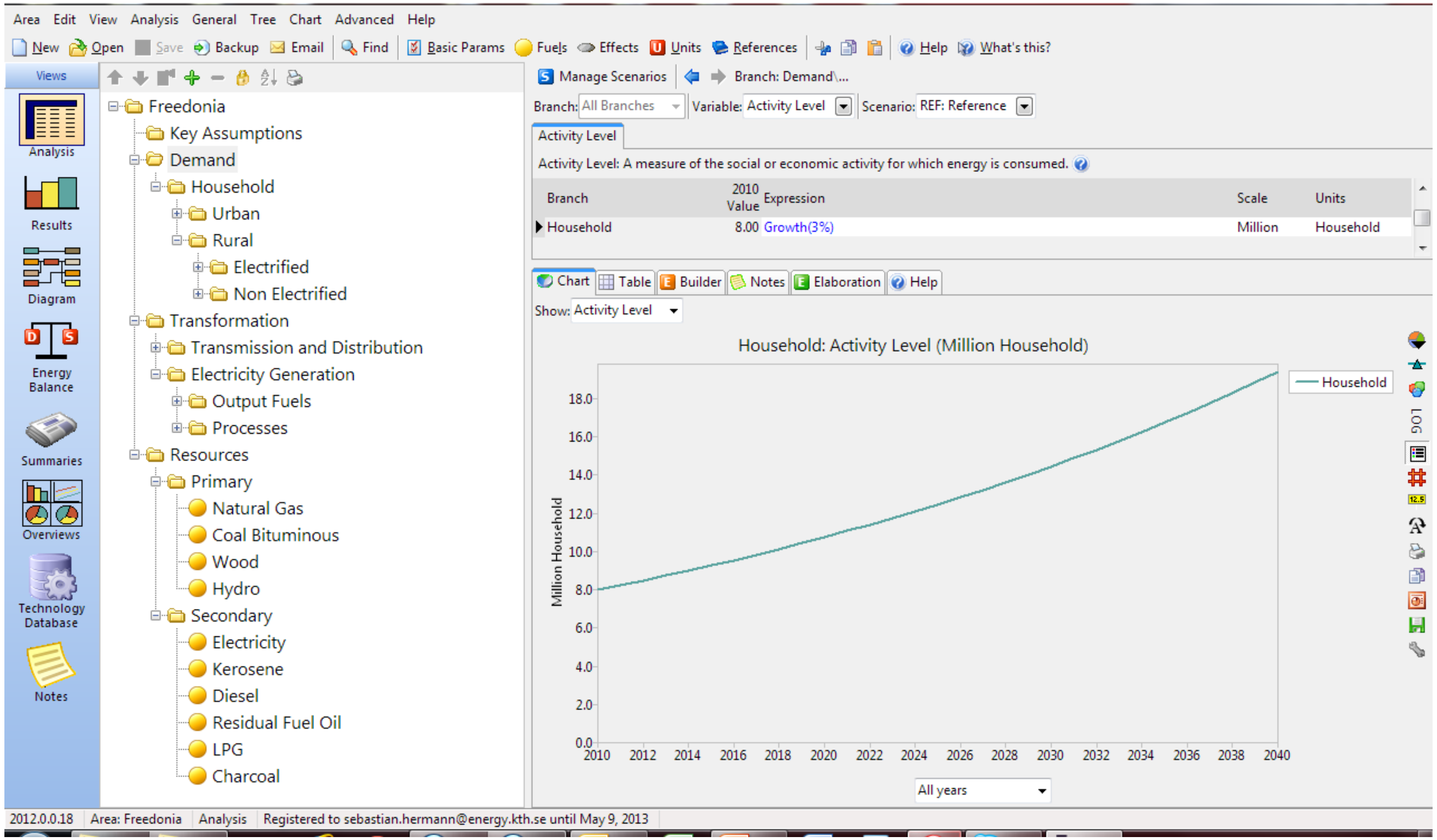
LEAP

www.energycommunity.org



Software available from Stockholm Environmental Institute (SEI)

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Input Data

- Supply:
  - All existing and planned power plants (capacities and plant factors)
  - Hydropower Plants and monthly production
  - Potential renewable energy targets
  - Energy production from bagasse
  - Oil and Coal imports
  - In the Scenarios: 1st & 2nd generation from biomass plus bioethanol production
- Demand:
  - from national statistics and official projections, assumptions for pumping water and desalination
  - Demand for ethanol production from sugar cane (1st and 2nd gen.)
  - Energy needs for fertilzer production

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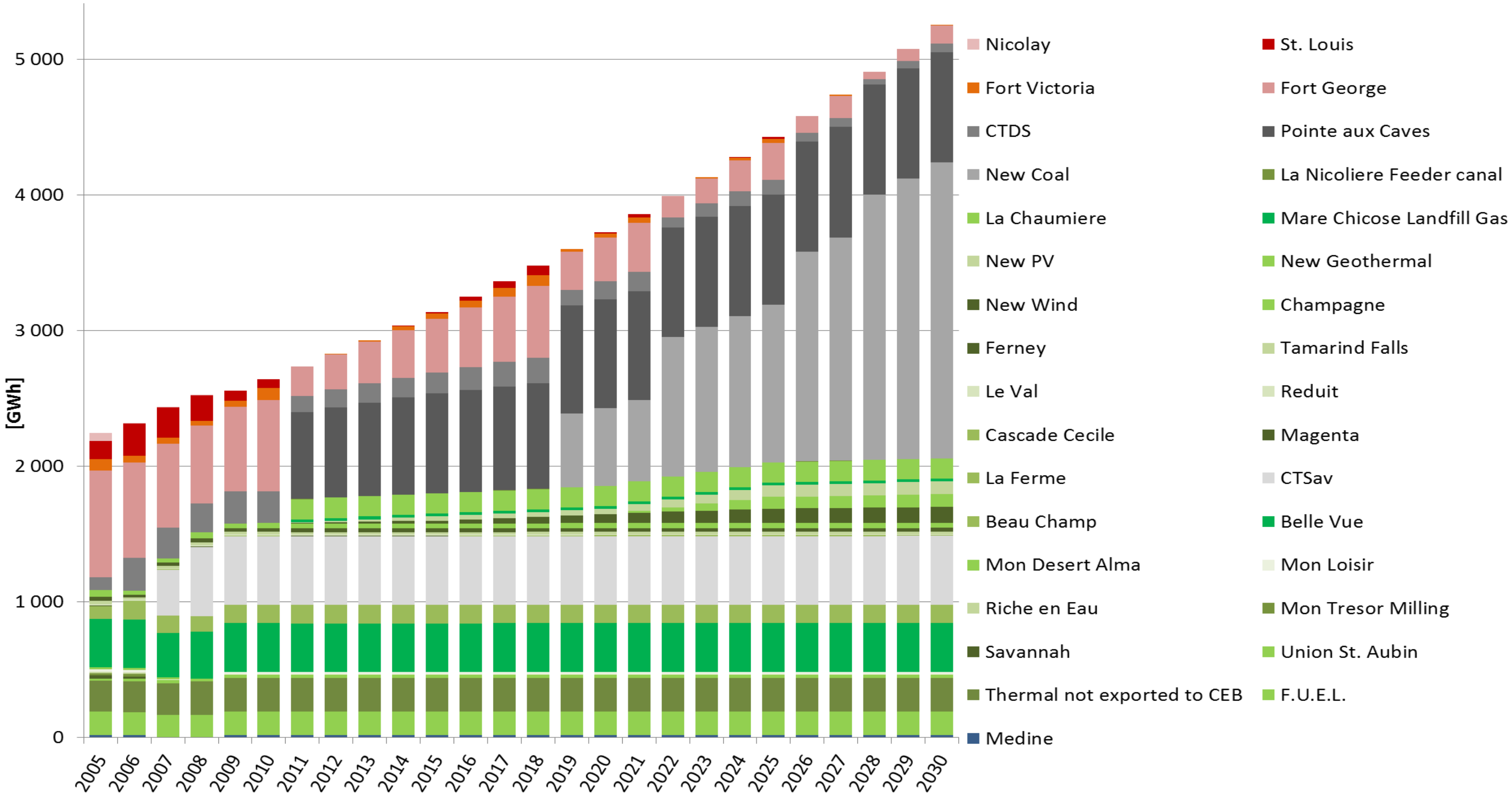
LEAP



WEAP

- **Water Evaluation And Planning System.**
- Integrated watershed hydrology and water planning.
- www.weap21.org

LEAP

- **Long range Energy Alternatives Planning System.**
- Integrated Energy Planning and GHG Mitigation Assessment.
- www.energycommunity.org

Both Tools:

- General purpose model building, data management and scenario analysis tools.
- Environmental engineering perspective on long-term resource allocation problems.
- Integrated analysis across demand and supply.
- Transparent, flexible and user-friendly with low initial data requirements.
- Common code and modeling language.
- Similar user interfaces and terminologies.
- Closely coordinated Application Programming Interfaces.
- Widely used in Governments, Universities, Consulting Companies, Utilities and NGOs: 100s of users worldwide.
- Available at no charge to non-profit, academic and governmental institutions based in developing countries.

Linking Water and Energy Issues

Groundwater depletion
Water quality
Unmet ecological flows
Costs

Insufficient water for hydro and cooling, even with increased groundwater pumping.

Still insufficient water--further enhance supply with desalination.

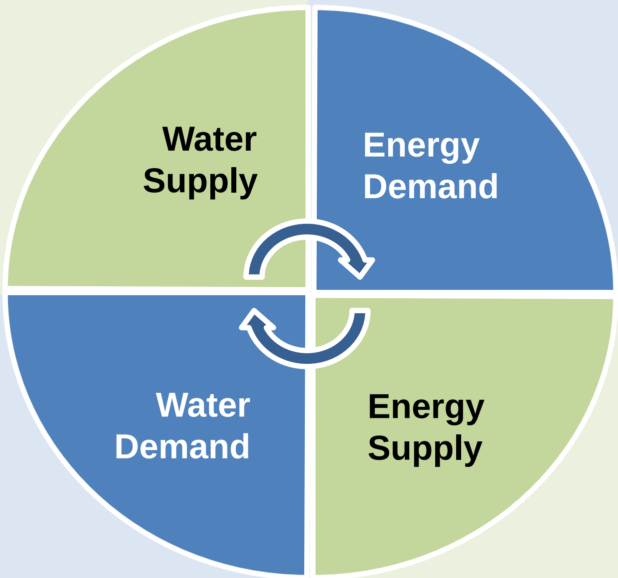
WEAP

Water requirements for hydropower & thermal cooling

Water conservation

Limited hydropower & cooling water, increased energy requirements for pumping.

Increased energy requirements for desalination.



Hydropower energy & cooling water requirements

Reduced water demands

Electricity demand

Energy efficiency

LEAP

Hydropower & fossil generation

Wind & solar, less water-intensive cooling

Fuel Use
GHGs
Local air pollution
Costs

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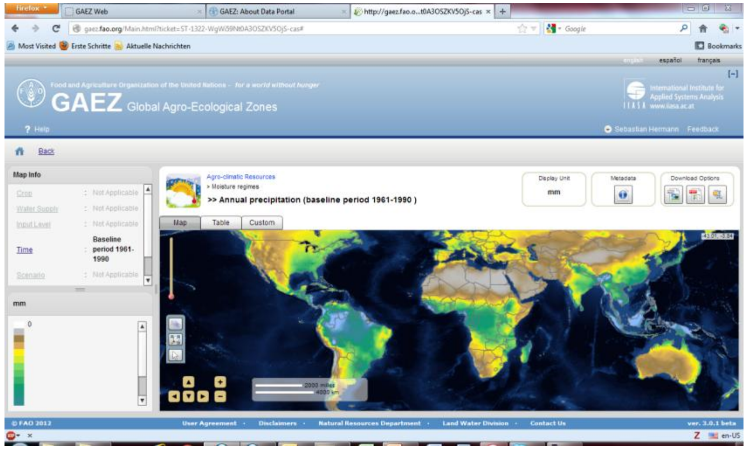
GAEZ
Global Agro-Ecological Zones

Online tool provided by IIASA and FAO.

Available at:

- http://gaez.fao.org/Main.html# (FAO)
- http://www.gaez.iiasa.ac.at/w/ (IIASA)



AEZ - The Land-Use Model ...

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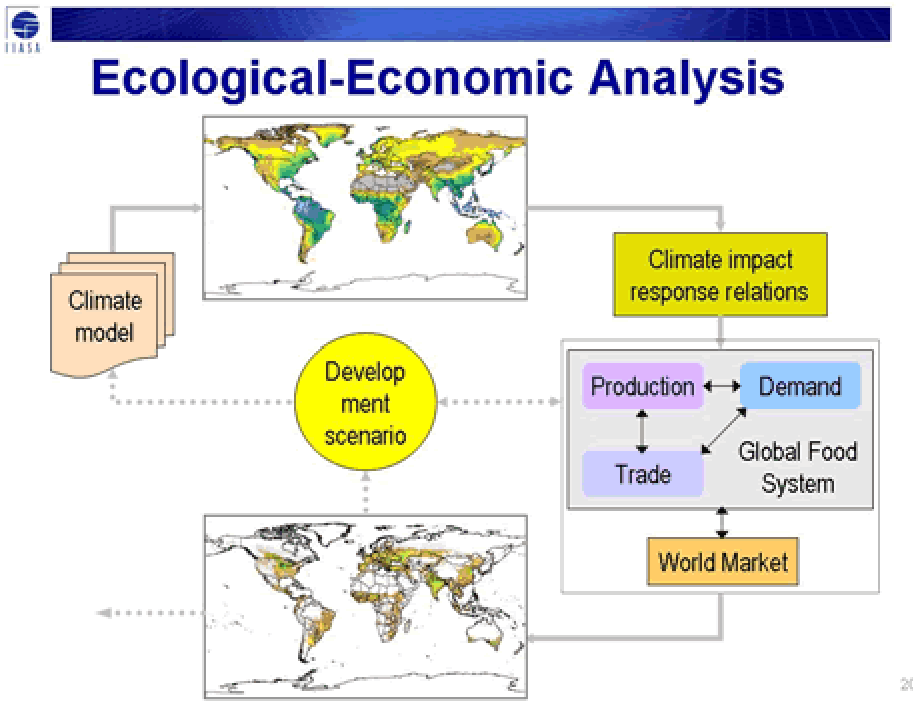
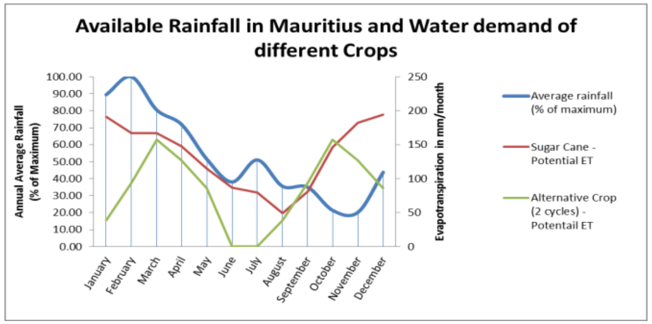
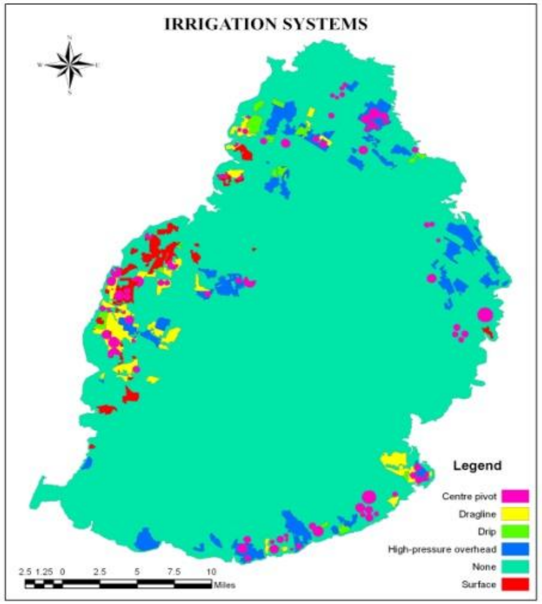
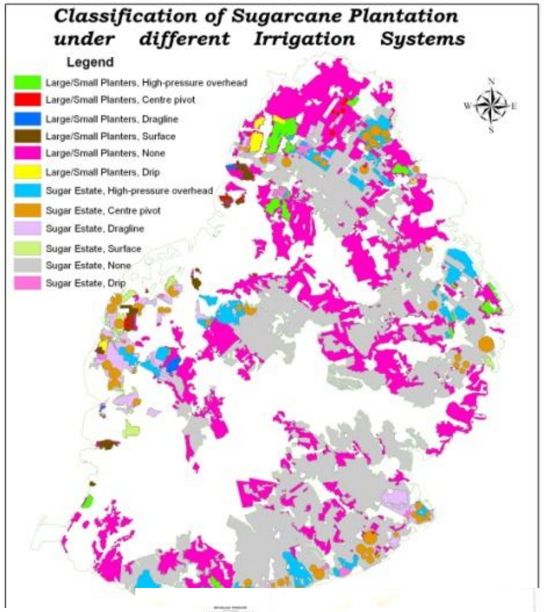
- Input:
  - Climatic Data
  - Detailed soil map and data from soil profils
  - Slopes and marginal land
  - GIS data for landcover
  - Irrigated areas
- Output:
  - Grid map of Mauritius show optimal crops, potential water use, and potential yield, plus crop calendar

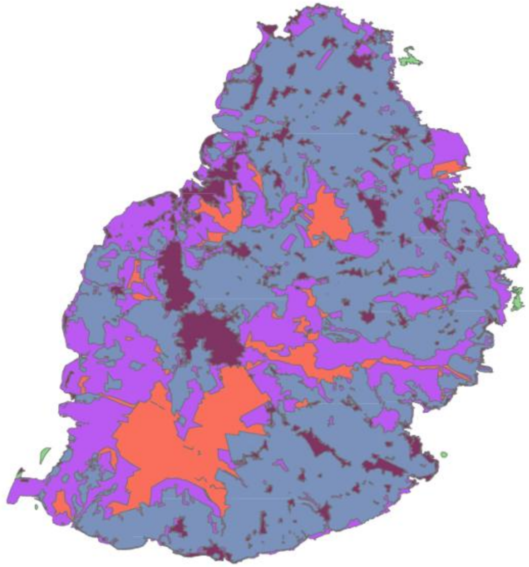


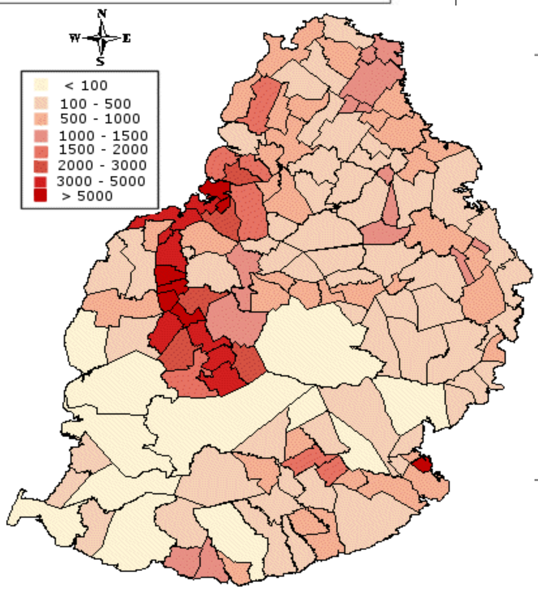


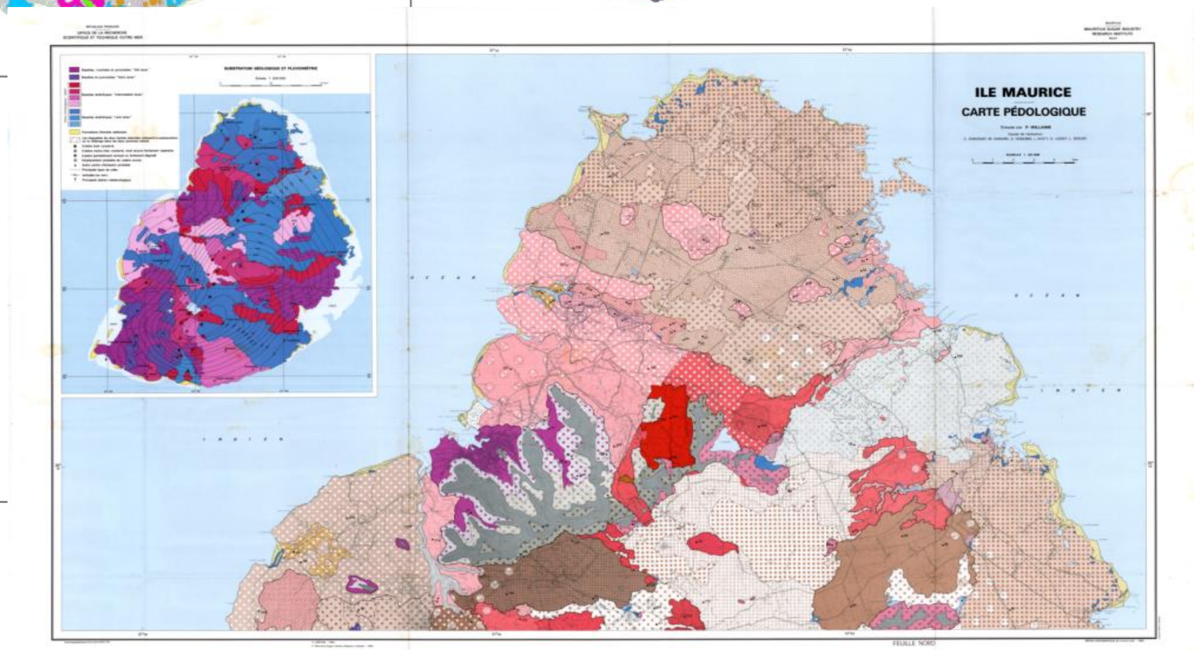
Input Maps used for AEZ ...











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Integration of Tools and Common Problems and Difficulties

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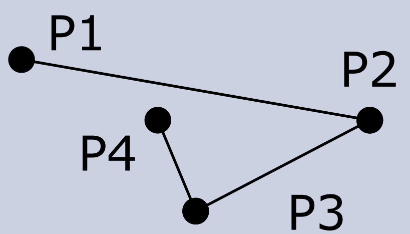
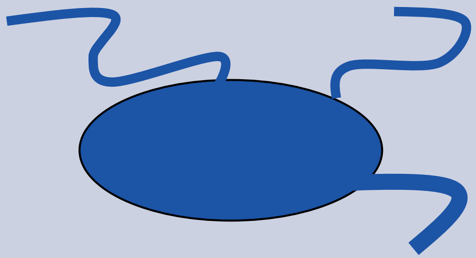
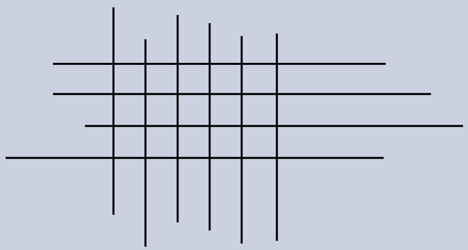
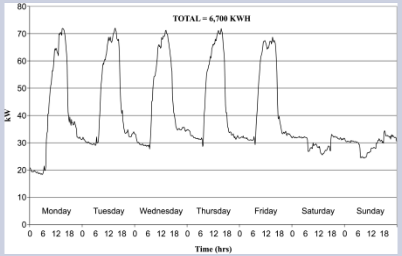
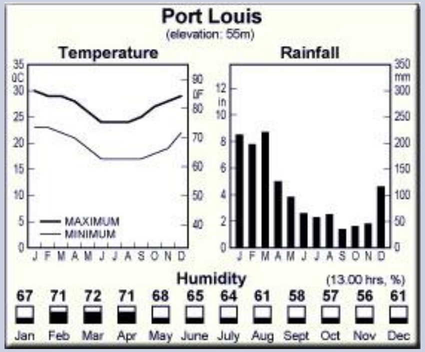
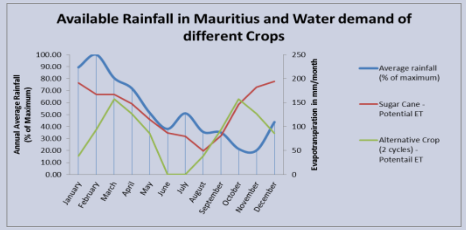
- Geographical / Spatial Distribution
- Time resolution
- Policy decisions / national priorities / socioeconomic constrains

Integration of Tools and Common Problems and Difficulties

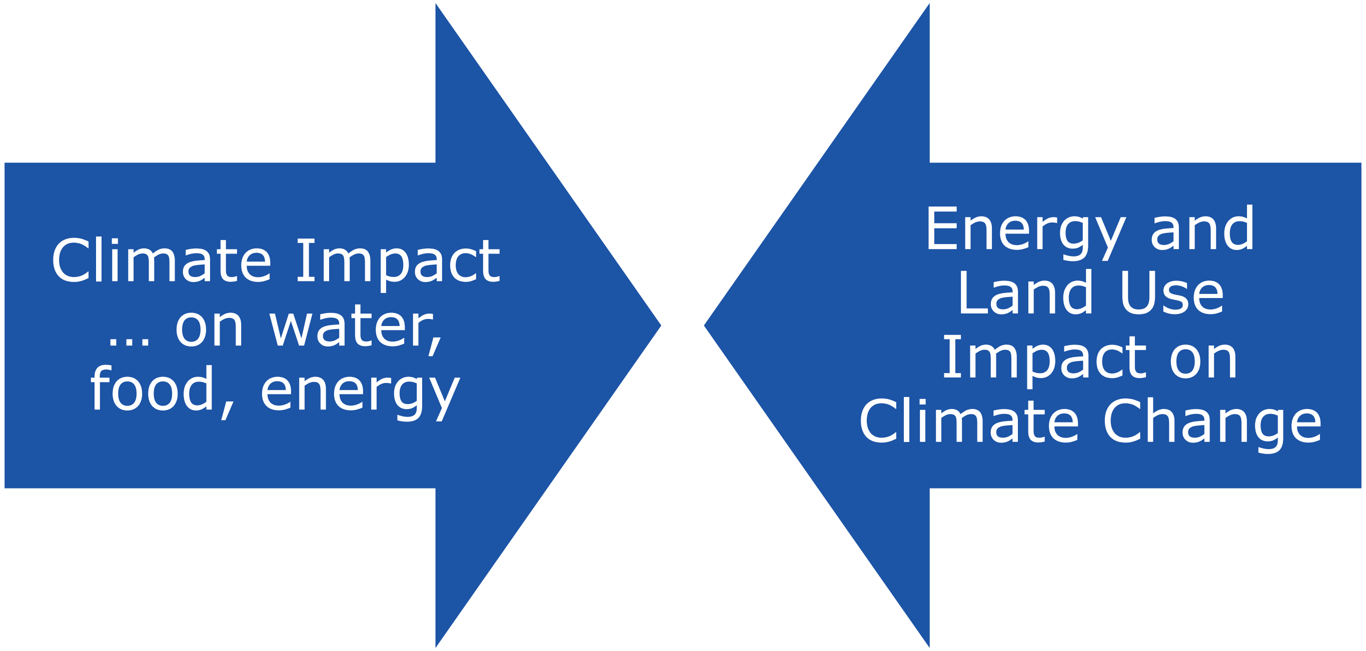
Energy	Water	Land (AEZ)
		
Interconnected Point sources	Rainfall patterns with collection in stream flows and reservoirs	Grid map information

“Squaring the circle”

Integration of Tools and Common Problems and Difficulties

Energy	Water	Land (AEZ)
		
Daily and seasonal pattern	High fluctuation but seasonal pattern	Yearly changes / possibly one, two, three yearly harvests

Integration of Tools and Common Problems and Difficulties



Important additional Factors (boundary conditions):

- GHG emissions
- Land Use Change and Induced Land Use Change

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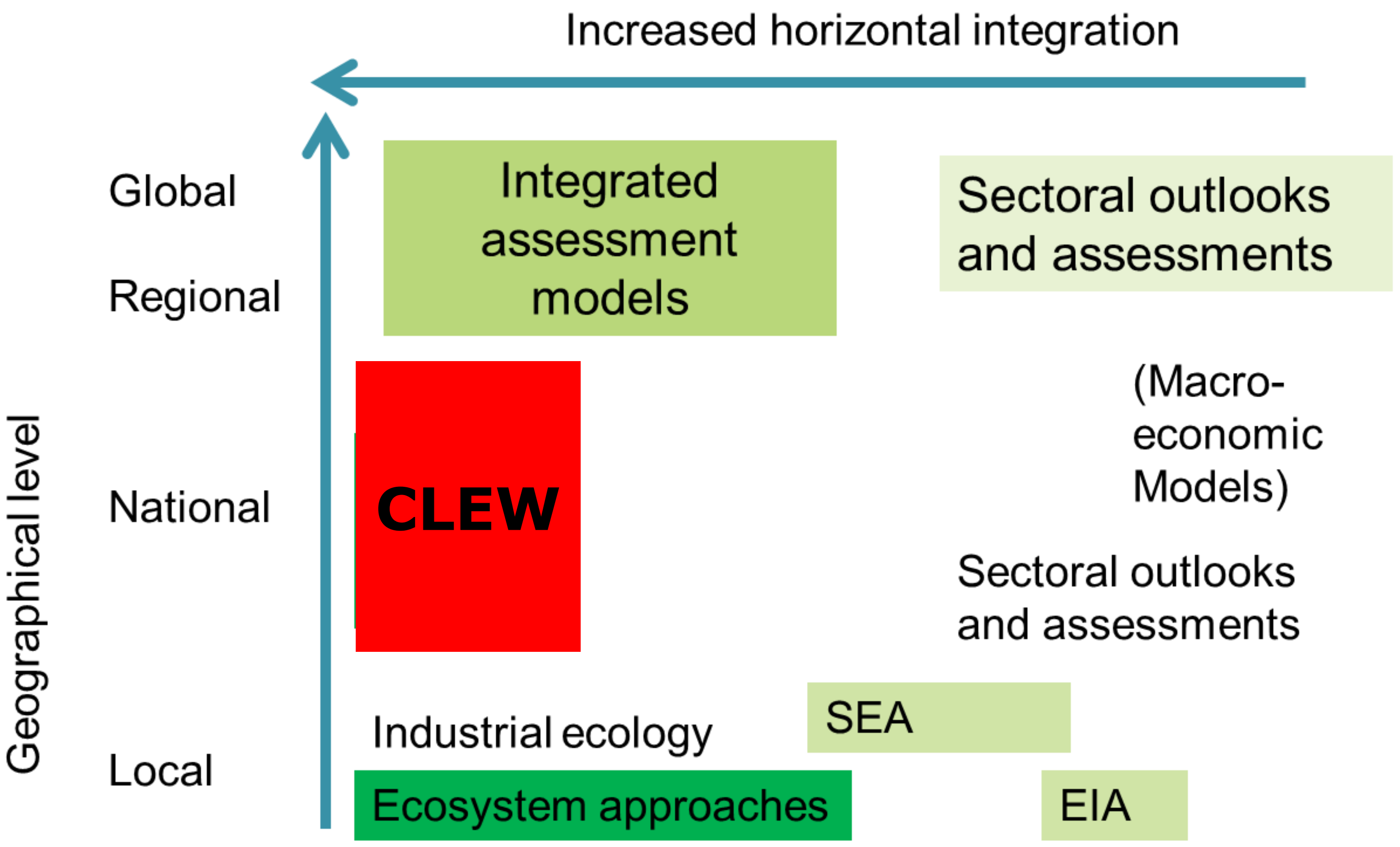
Thank You

Horizontal integration: the Grail of sustainable development

- Lack of horizontal (cross-sector) integration long identified as a major cause for relative lack of progress on SD
  - Economic/ technical choices:
    - misses systemic links, feedbacks,
    - potentially adverse consequences
    - In the CLEW nexus, potential for adverse consequences important
    - Land use/ land use change as the meeting point of conflicting demands: integrated models critical
  - Institutional side (most important)
- Major links/feedbacks well identified a priori
  - See Bazilian et al. (2001), Energy Policy
- BUT relative importance of links varies across countries
  - Messages based on results from global models potentially misleading / not best guide to national policies
  - Actual strength of the feedbacks/links unknown where it matters most

CLEW tool as a crucial missing link



(shade of green: degree of Increased economic – biophysical integration)

Potential CLEW applications and levels of details

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Increasingly challenging

- Prototype (not fully calibrated): awareness raising and capacity building in government
  - Common understanding of the « key » issues, of potential links/ feedbacks
- Full model: shared diagnosis platform
- Agreement on common baseline for different actors (e.g. ministries)
  - Improvement over traditional macro models by design: single actions are intrinsically “checked” regarding their effects on other sectors
  - Common understanding of trade-offs and synergies
- Platform for common (national) vision
  - Shared with broader public, interactive
  - “forces” clarification of priorities
    - Everything has a cost / opportunity cost
    - How do you value food security, energy security, access to water for all?

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International level: what can we learn from CLEW for Rio+20 and beyond?

- Strength of various interlinkages in different socio-geographical contexts
  - Typologies: constraints / limiting factors for development
  - Differentiated national (development) strategies / narratives
  - Needs other case studies!
- Risk-based strategies versus BAU+ strategies (e.g. CC mitigation)
  - Robust national strategies
  - Are incentives from international mechanisms right?
- The three « access » goals (water, clean energy, food security) in practice
  - What does it mean at the national level?
    - Everything has a cost/ opportunity cost: what priorities, and how are they determined?
  - "Aggregating back" to the global level: new story?
    - No "spatial" externalities (e.g. more land in Africa, more renewables elsewhere): does it change the conclusions?

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Tools

Summary

- **Considering the energy, water and food nexus: Towards an integrated modelling approach** Original Research Article *Energy Policy, Volume 39, Issue 12, December 2011, Pages 7896-7906* Morgan Bazilian, Holger Rogner, Mark Howells, Sebastian Hermann, Douglas Arent, Dolf Gielen, Pasquale Steduto, Alexander Mueller, Paul Komor, Richard S.J. Tol, Kandeh K. Yumkella