The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2242-15

Joint ICTP-IAEA Workshop on Uncovering Sustainable Development CLEWS; Modelling Climate, Land-use, Energy and Water (CLEW) Interactions

30 May - 3 June, 2011

An introduction to the integrated CLEW approach

HOWELLS Mark Idwal

International Atomic Energy Agency IAEA
Planning and Economic Studies Section, PESS
Dept. of Nuclear Energy NE
Wagramerstrasse 5, P.O.Box 100, A-1400
Vienna

An introduction to the integrated CLEW approach

Mark Howells, IAEA, NE-PESS

Trieste – Italy, 30 May 2011 – 3 June 2011

Uncovering Sustainable Development CLEWS: Modelling Climate, Land-use, Energy and Water (CLEW) Interactions

IAEA

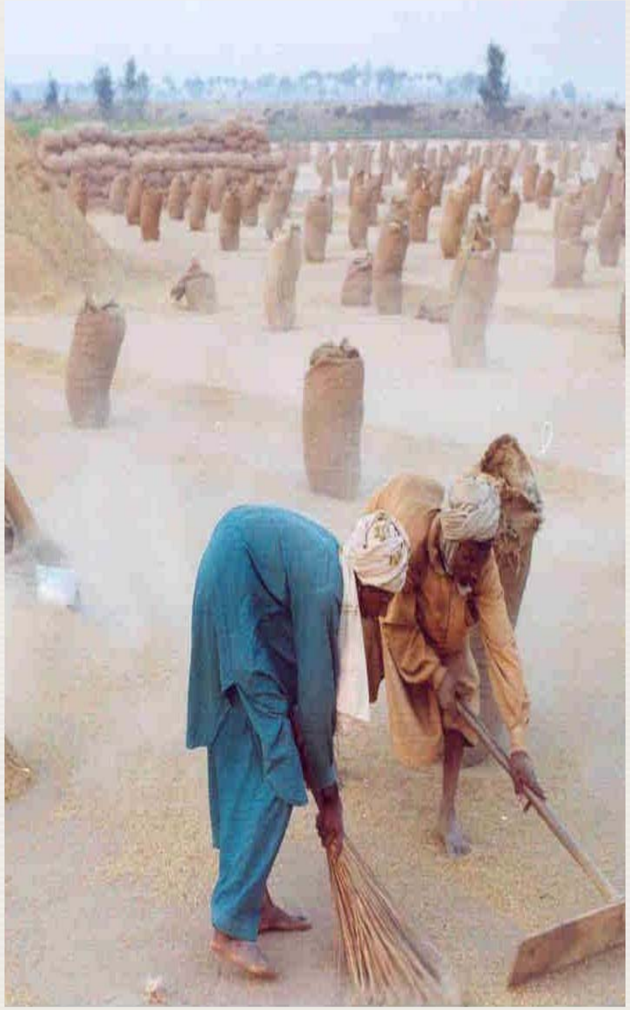
International Atomic Energy Agency

Introduction

- The picture is simple and stark:
  - 1.1 billion people without safe water
  - 1.6 billion without electricity
- The need for more cultivated land drives deforestation
- Energy prices are high
- Greenhouse gas emissions (GHGs) continue to rise
- High oil prices in turn mean high transport costs
- Food prices have been spiking beyond the reach of many of the world's poor
- Without clear strategies these may continue…
- …But these strategies are interdependent

Motivation

- **India:** Punjab: 1.5% of India's land and 50% of rice and wheat purchased to feed more than 400 million poor Indians
- Farmers are pumping ('mining') aquifers faster than they can be replenished,
- As water levels drop, pumping increases
- Fragile and overtaxed electricity grid stretched further
- Farmers in Punjab pay nothing for electricity, they run their pumps with abandon.
- Further depletes the water table and water is pumped from ever increasing depths more electricity is needed
- Overall, irrigation accounts for about 15-20% of India's total electricity use
- The Government recognizes that all these issues are interconnected. But the planning does not.



IAEA

Motivation

- **Columbia**: Climate extremes to increase by 2050
- Regional impacts will include:
  - changes in ecosystems
  - reduced water availability and hydropower generation
  - increasing desertification; aridity; crop pests and diseases.
- Increased fuel imports are:
  - expensive and volatile
  - reducing the country's energy security

IAEA

Motivation

- **Uganda**: Only 9% of Ugandans have electricity
- deforestation is a severe problem
  - Overgrazing, low productivity agricultural methods lead to soil erosion.
  - 93% of energy needs are supplied by wood
- 20% of the urban population and 53% of the rural population do not have access to pure drinking water
  - Wetlands drained for agriculture
  - Water supply is threatened by toxic industrial pollutants.
- Development is essential; coordinated development, urgent.

IAEA

Motivation

- **Bio-Fuels:** Global grain prices are volatile and increasing: oil price hikes, bio-fuel demand, changing diets, agricultural policies etc.
- Increased bio-fuel feed production requires additional fertilizer and irrigation => energy => GHG emissions
- Food, feed and biofuel competition for land
- Might provide economic opportunities for farmers and countries trapped by economic barriers.
- May cause short term opportunism - clearing of forests for extra farmland etc.
- The need is to analyze all these factors CLEW factors.

IAEA

Decision making

- The links are well documented but governmental structures tend to keep the management and development of these sectors separate from one another.
- Different ministries are usually responsible for energy, water and land, and any one of these is sometimes sub-divided among different administrative entities.
  - For example, the responsibility for land use planning may be distributed among separate departments handling agriculture, forestry and urban development.
- Can lead to a lack of broad coherence, and, at times, decisions by one ministry or department can conflict with the objectives of others.

IAEA

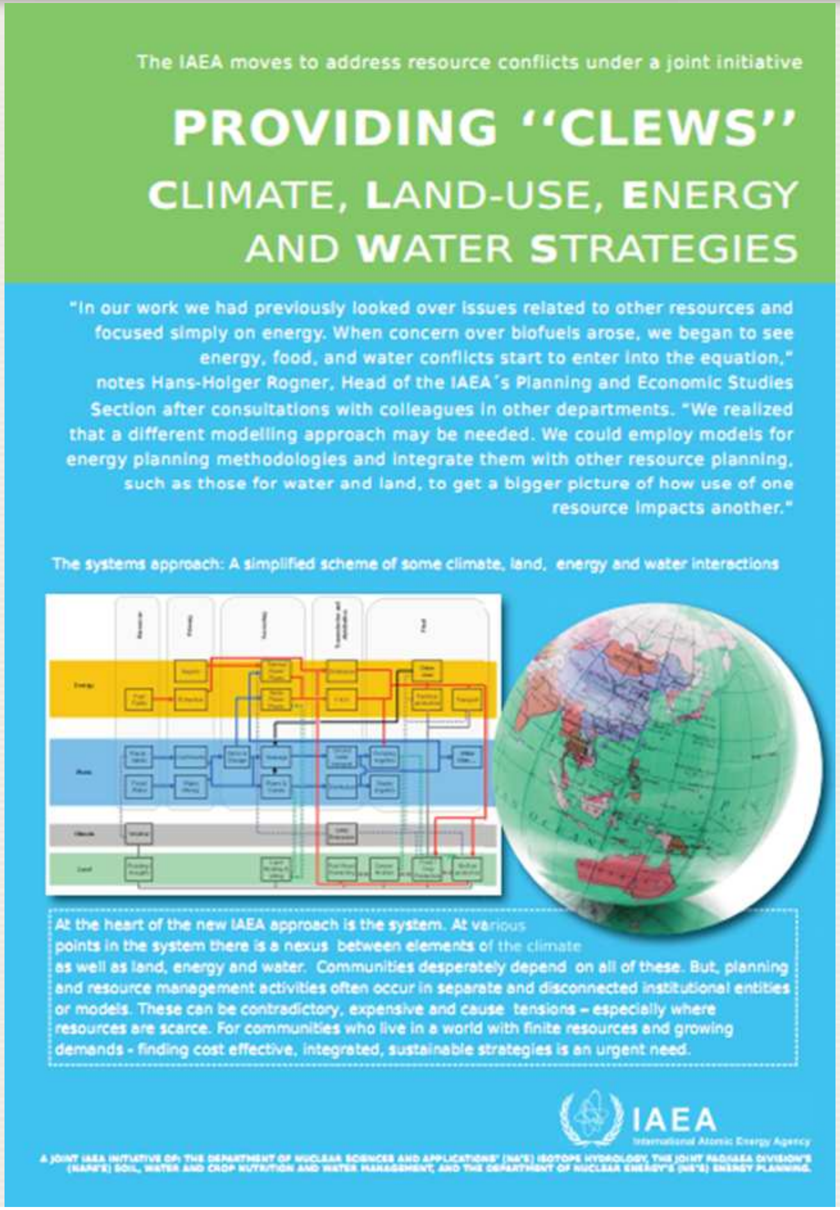
Decision making

- Public policies can, therefore, be inadequately connected or researched.
  - energy supply options might be discussed with little reference to their water demands;
  - water management options can be proposed without assessing their impacts on energy needs;
  - land use development might be planned without thoroughly considering implications for energy and water;
  - and the consequences for all these areas could be insufficiently considered in the light of longer-term climate policies.
- An approach for integrating local and national assessments would significantly improve information flows, and harmonize different departmental data collection, decision and policy making activities.

Goals

Water, energy and food are required for survival and development but they are also integrated. A framework is thus needed to aid:

- Decision making - transparently evaluate the trade-offs reflected in different options.
- Policy assessments - provide a more complete, multi-system policy assessment.
- Facilitating policy harmonization and integration - help harmonize potentially conflicting policies.
- Technology assessments - allow a more inclusive assessment of technological options.
- Scenario development - elaborate consistent scenarios of possible socio-economic development trajectories
- Identifying synergies - considering the multiple benefits of each option will yield better estimates of the overall development potential of each.



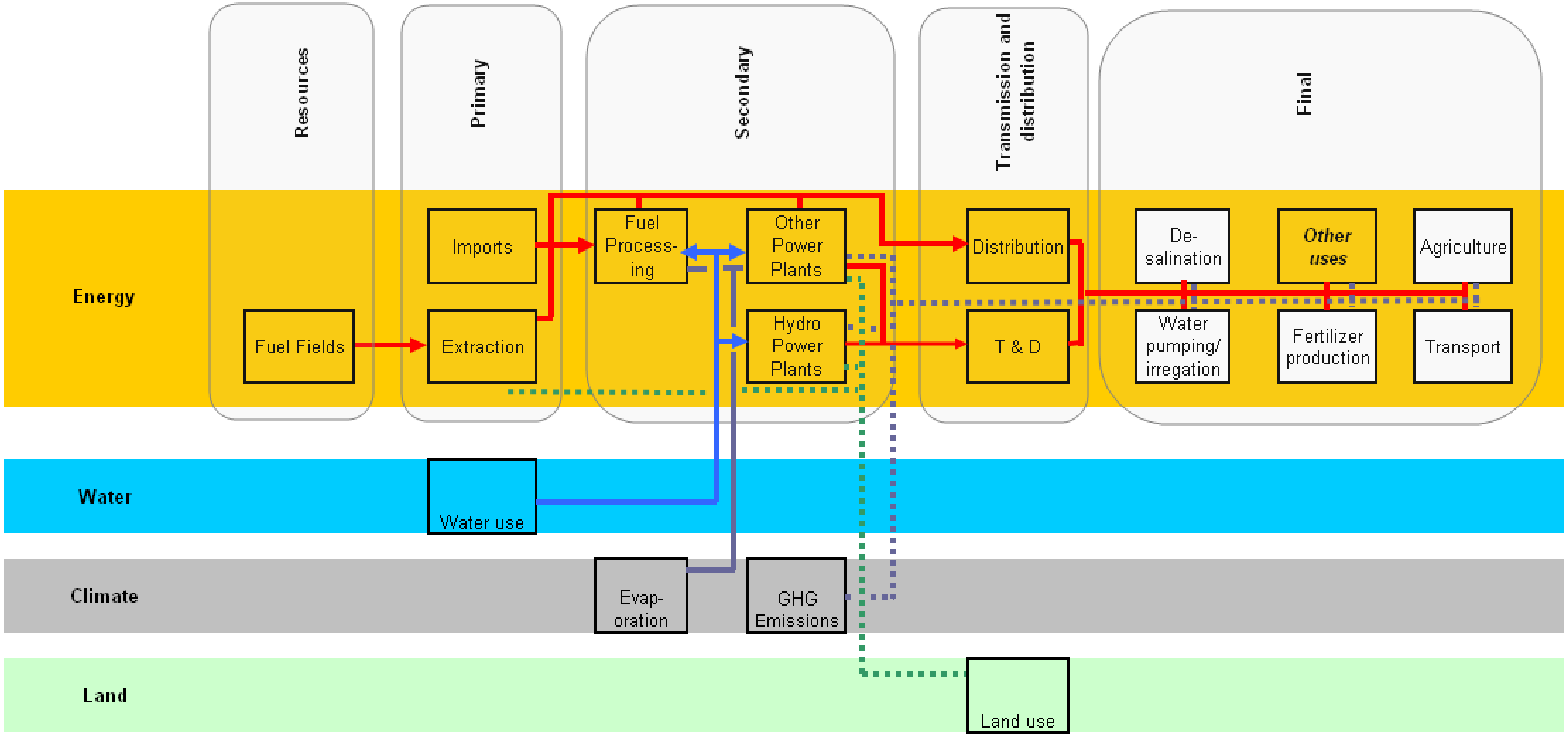
IAEA

Selected inter-linkages: Energy

- Energy and land:
  - Extraction and processing causes land scarring (mining, dams, deforestation etc)
  - Contamination (Oil spills, accidents etc)
  - Large surfaces required, a 60 MW(e) solar thermal power plant, for example, requires about 1 square kilometre of land
- Energy and water:
  - According to US Bureau of Land Management, surface mining and retort operations produce 8–38 litres of wastewater per tonne of processed oil shale
  - Similarly, an estimated 3 bbl of water are required per bbl of oil equivalent of tar sands.
  - Maize needs about 860 liters of water to produce one litre of ethanol.
  - In the face of water shortages in dry areas, special technologies have been developed to reduce water use by about 60% in steam cycle thermal power plants.
- Energy and climate: The largest anthropogenic emitter

IAEA

Selected inter-linkages: energy

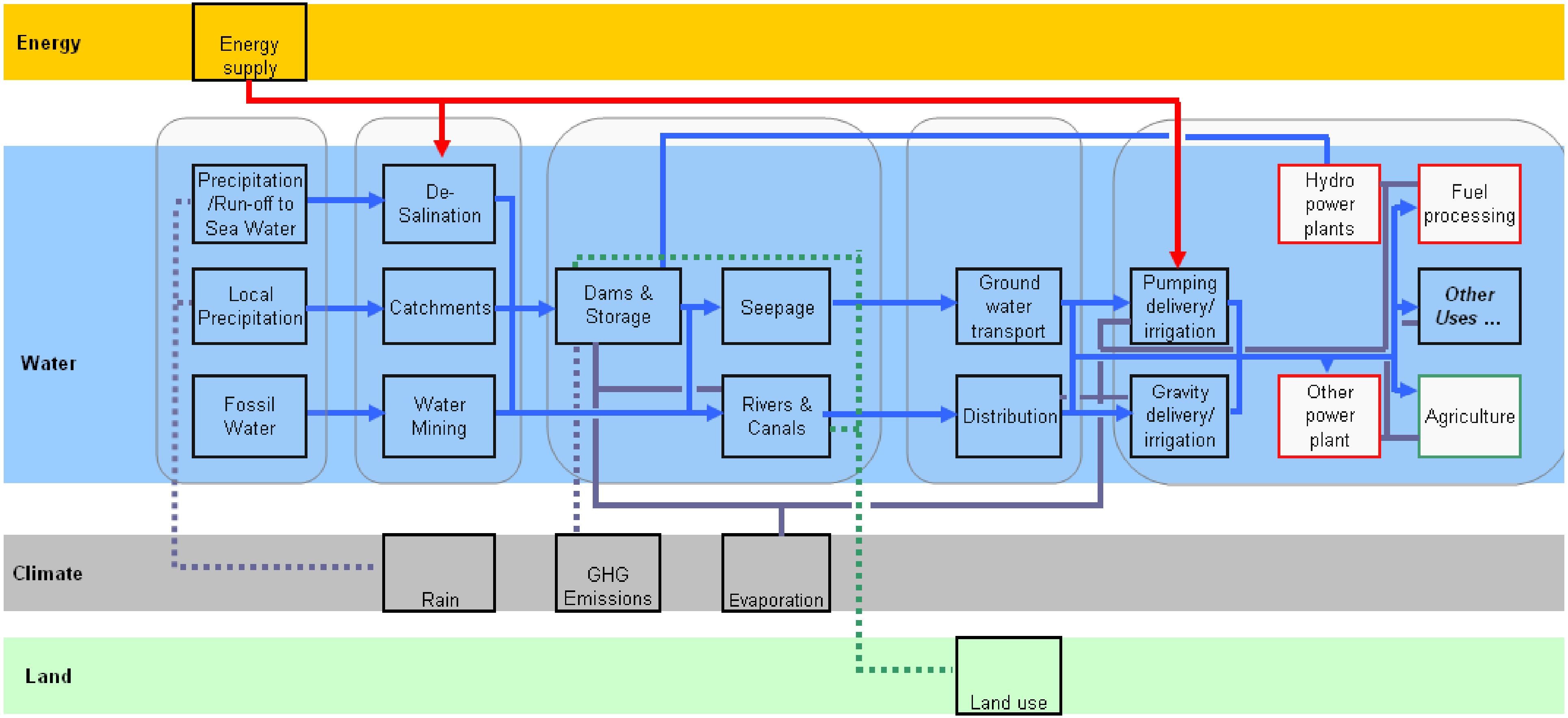


IAEA

Selected inter-linkages: Water

- Water - Energy:
  - In California, up to 3.5 kWhr per 1000 litres can be consumed supplying water.
  - The US Geological Survey estimates 50% of freshwater withdrawals are for cooling thermal power plants
  - Large increases in desalination requirements.
- Water - land:
  - The large land requirements of hydropower can require the relocation of activities and people. Over a million people were relocated because of the Three Gorges Dam Project.
  - Damming the Nile River, for example, caused the silt which was deposited in the yearly floods and made the Nile floodplain fertile to be deposited behind the dam
- Water – climate:
  - Changes in levels, frequency and variability of rainfall
  - Etc,,

Selected inter-linkages: Water



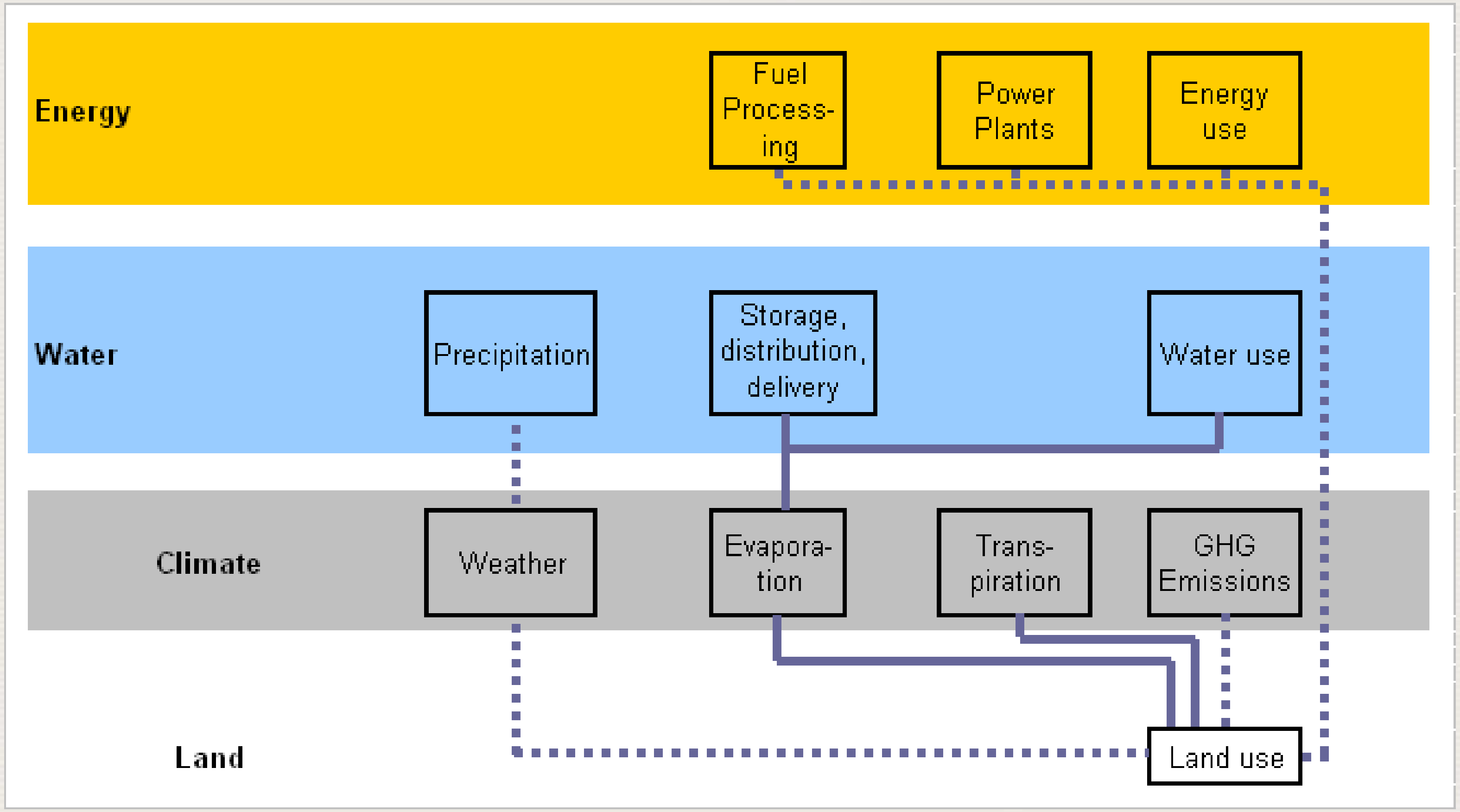
IAEA

Selected inter-linkages: Climate

- The climate is affected by releases of GHGs from anthropogenic activities such as fossil fuel power production, fertilizer production and use, crude oil and biomass refining, transport and land cultivation.
- With changes in the climate come changes in weather patterns. When droughts occur, water for electricity generation is limited, irrigation demands increase and desertification can take place. Conversely flooding can damage crop land, infrastructure and human settlements.
- The IPCC estimates that CO_2 from energy use accounted for 56% of global GHG emissions in 2004. Power generation accounted for 30.5% of total CO_2 emissions and transport for 17%.

IAEA

Selected inter-linkages: Climate



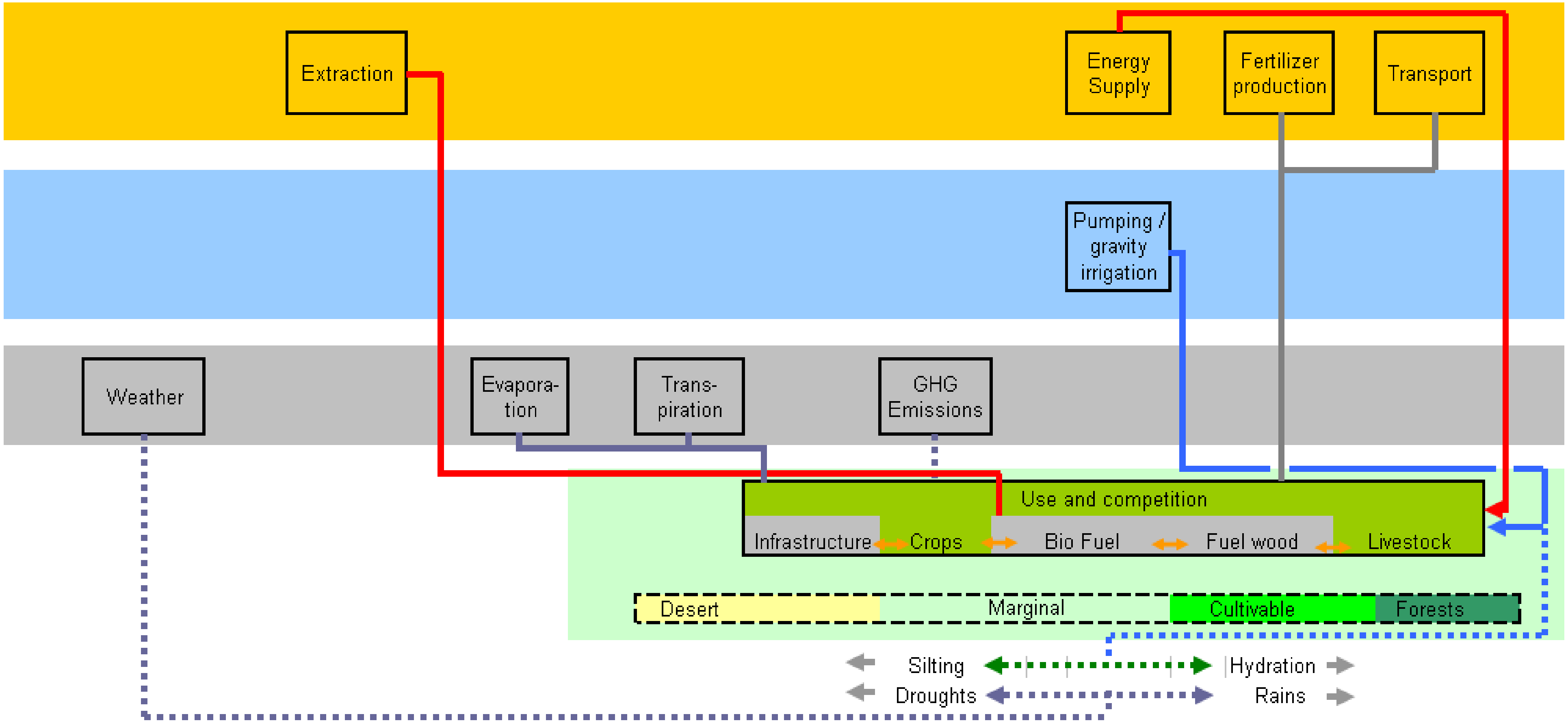
IAEA

Selected inter-linkages: Land

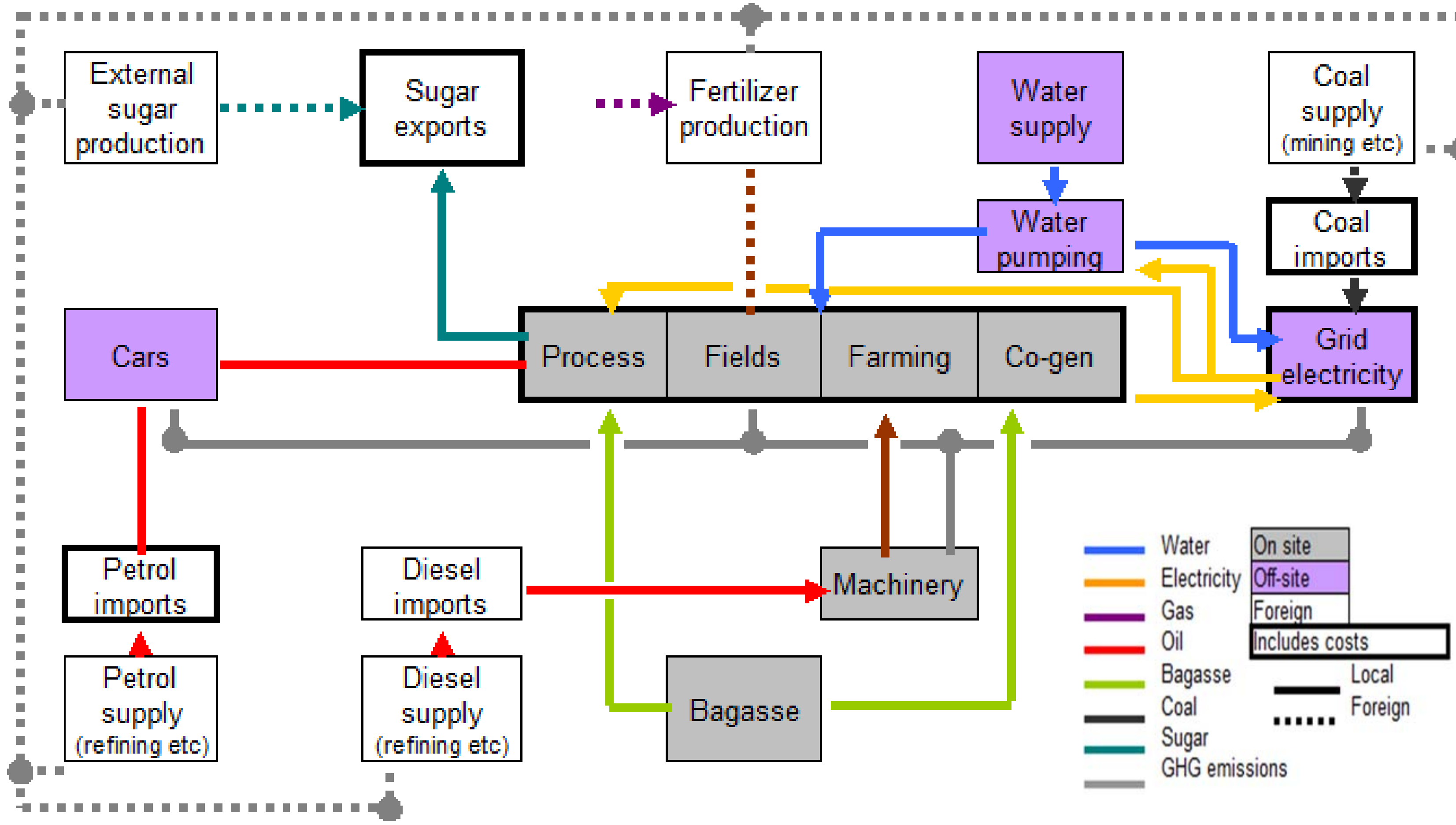
- The quantity of available land is limited. Thus, depending on the value of what it can produce, competition among alternative uses can be high.
- Where practices are poor, land can be damaged by overgrazing, over cropping and fuel wood harvesting.
- As vegetation changes, e.g. as dense forests, which contain substantial carbon in wood, are cleared for crops, significant amounts of carbon can be released to the atmosphere.
- Land can be damaged through excessive silting and erosion related to agriculture and weather patterns.
- Depending on the crop, annual rainfall and quality and type of soil, different amounts of irrigation, fertilizer and land are required, with the production of each of these inputs having important impacts in turn, for example increased energy use and associated emissions.

IAEA

Selected inter-linkages: Land



Towards an integrated framework (1)
A single spreadsheet model..



IAEA

The elements modeled

Climate: **Local:** (1) Fertilizer use, farming emissions, land-use change (2)Electricity production (3) Substitution of gasoline with ethanol **Foreign:** (1) Fertilizer production and transport (2) Indirect land use change (3) Extraction and supply of coal (4) Extraction and refining of oil

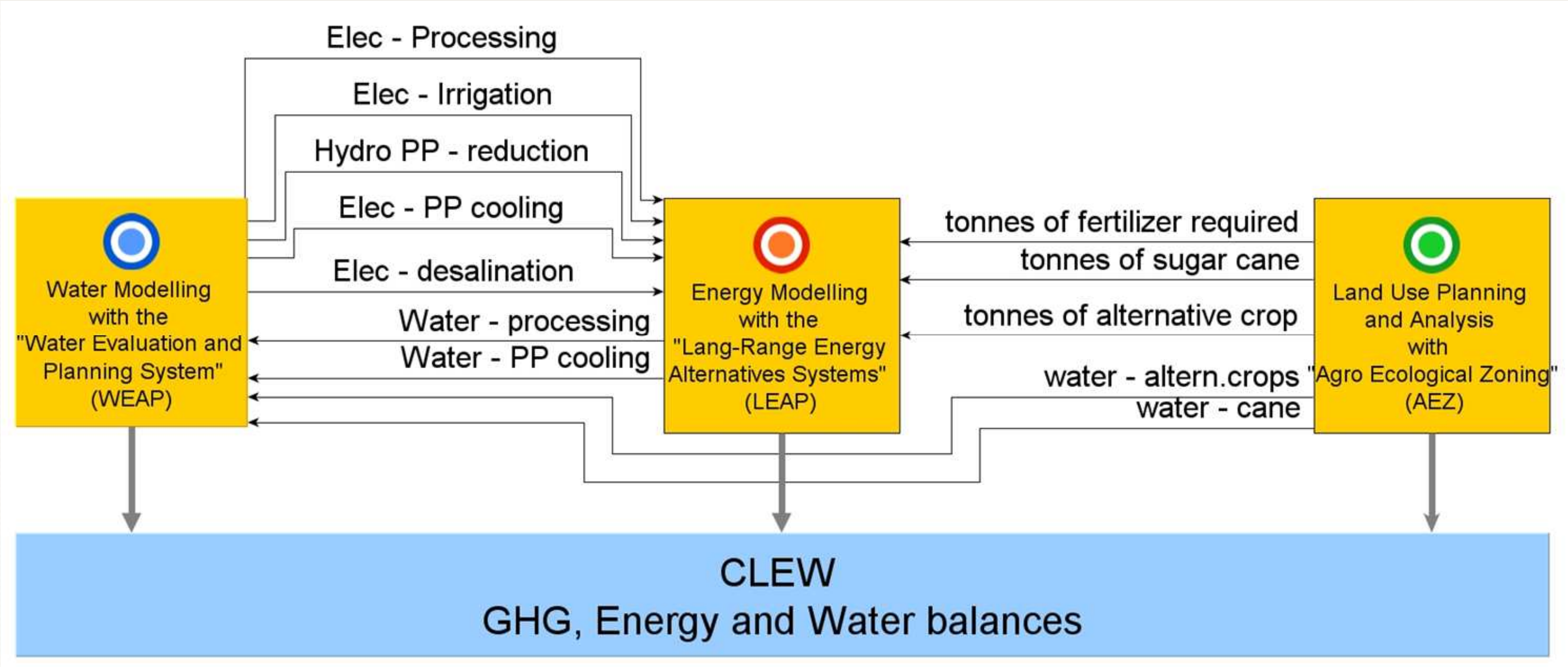
Land: **Local:** (1) Crop yield, (2) Carbon content changes (3) Input requirements (water, energy, fertilizer), (4) Land is a fixed reference and important for determining study boundaries (100 ha of cropland used for sugarcane production, assuming perfect scalability) **Foreign:** (1) Carbon content changes.

Energy: **Local** (1) Energy for farming (2) Electricity production/use (e.g. pumping and distributing irrigation water) on site and (production) off site (3) Petrol displaced by ethanol, **Foreign**: (1)Fertilizer, (2) Production and transport, (3) Coal extraction and transport for electricity production, (4) Oil extraction and refining

Water: **Local:** (1) Water applied for irrigation, (2) Water used for ethanol/sugar processing, (3) And grid power station cooling

IAEA

Towards an integrated framework (2)
Integrated detailed models…



IAEA

Next steps

- Strong engagement with partners
- Deepening the matrix of relationships
- Model development:
  - Defining the toolkit elements and use
  - Determining critical levels of integration
  - Determining critical levels of simplicity
  - Identifying the type of integration:
    - Soft vs hard links
    - Links vs simple meta model
  - Defining the ‘framework for integration’
- Developing policy process options

IAEA

IAEA

…atoms for peace.

IAEA