Seeking Sustainable Climate, Land, Energy and Water (CLEW) **Strategies**

Introducing the development of an integrated systems approach to meet sustainable development challenges

A. Introduction

The picture is simple and stark. Given growing global demands, the world's resources of water, land and energy are relatively scarce; the use of each affects demand for the others; and the use of all affects the climate. There are 1.1 billion people without safe water and 1.6 billion without electricity [1]. The need for more cultivated land drives deforestation. Energy prices are high, and anthropogenic greenhouse gas emissions (GHGs) continue to rise. High oil prices in turn mean high transport costs. Those, together with biofuel crops competing with food crops for land, recently caused food prices to spike beyond the reach of many of the world's poor — a trend some analysts do not see abating [2].

These interdependencies mean that energy policies based on energy analyses alone, for example, might have adverse unanticipated effects on water resources, land resources and the climate. The same is true for water policies based only on analyses of water issues, and for land policies based only on land-use analyses. Better methods and models are therefore needed that consider all the linkages among climate, land, energy and water (CLEW). This annex analyses that need by reviewing the models available today, by summarizing examples where they fall short, by reviewing the history and remaining challenges of 'systems approaches', and by outlining a way forward.

The specific focus is on the expansion of a systems approach to underpin the analysis of sustainable development with an emphasis on CLEW resources. Analyses of individual systems such as energy and water systems are undertaken routinely. The IAEA provides and supports detailed analyses of a country's or region's energy system with the MESSAGE model[1]. A commonly used model for water planning is the Water Evaluation and Planning system (WEAP[2]), and for water scarcity and food security planning, the Global Policy Dialogue Model (PODIUM) is well established[3]. However, these and other models are, in one way or another, all lacking, especially if one wants to use them for policy analysis for developing countries. Generally, they either focus on one resource and ignore interconnections with other resources, have overly simplified spatial representations or analyse scenarios which are impractically long term.

What is needed is an integrated analysis tool that includes all CLEW aspects in a manner that is accessible and useful to analysts and planners in developing countries. Key improvements over existing approaches should include: finer geographical coverage, simplified data requirements, a medium term temporal scope, multi-resource representation (including their interlinkages) and software accessible to developing country analysts. Such a tool would help decision makers assess different technological options with diverse benefits and disadvantages; estimate the impacts of different development scenarios; and analyse and evaluate policies.

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[1] MESSAGE (Model of Energy Supply Systems and their General Environmental Impacts) is a systems engineering optimization model which can be used for medium to long term energy system planning, energy policy analysis and scenario development. The model provides a framework for representing an energy system with its internal interdependencies [3].

[2] The WEAP energy model is maintained and supported by the Stockholm Environmental Institute: http://www.weap21.org/

[3] PODIUM is maintained and supported by the International Water Management Institute http://podium.iwmi.org/podium/

The IAEA is ideally suited to develop such an integrated tool by virtue of its expertise in a number of key areas, such as energy systems planning[4], water resources and isotope hydrology[5], nuclear desalination[6], and food and agriculture in cooperation with the FAO[7]. The Agency also has a strong mandate as part of the UN system to support Member States, through its technical cooperation programme[8], in their development and implementation of strategies for sustainable development. In particular, Member States have clearly and frequently articulated their concerns about sufficient water supplies, food security and energy security[9]. However, the IAEA's current assistance is necessarily limited and compartmentalized. An effort such as this will help better meet the needs of Member States, drawing on significant existing in-house capacity. Further, it is envisaged that after initial incubation of the concept within the IAEA, consultation with other experts and agencies in the UN system will take place.

The next section briefly summarizes key past examples of related modelling efforts, presents some motivating examples of uncoordinated development, and introduces the challenges faced by policy makers. The subsequent sections discuss aspects of the CLEW system and suggest a simple integrated framework and goals for a systems tool.

B. Modelling the CLEW systems

While the proposed tool will be unique and designed specifically to better meet the needs of IAEA Member States, it will build on previous work and an established methodological approach.

The most famous systems analysis to address some of the CLEW issues was the study *The Limits to Growth*[10] in the early 1970s [4]. While providing important insights, the analysis was of little use to national policy makers because it had a very coarse geographical resolution in that it modelled the world as a whole, rather than a country or local area; it did not account for changes in technology, knowledge or behaviour; and it did not account adequately for the effects of price changes. A second approach, developed around the same time to analyse the provision of energy services, focused on five connected resources: water, energy, land, materials and manpower (WELMM) [5]. However, this approach was never developed into a manageable software package that could be used by national analysts.

Since then a large range of planning models, which, to lesser or greater extents, overcome those limits, have been developed and applied regularly. However, these are generally focused only on a single resource, such as water, land or energy[11]. Integrated assessment models attempt to include more aspects of the CLEW system, but these are aggregate, focused at the global or regional level, and often designed for long term analysis. They are not useful for medium term national analysis[12]. Further they can be limited by requiring data and computational support beyond the reach of local analysts in some developing countries.

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[4] http://www.iaea.org/OurWork/ST/NE/Pess/

[5] http://www.iaea.org/programmes/ripc/ih/

[6] http://www.iaea.org/OurWork/ST/NE/NENP/Desalination/

[7] http://www-naweb.iaea.org/nafa/index.html

[8] http://wwwtc.iaea.org/tcgc/gc/gcstart.html

[9] See for example the recently completed Country Program Framework (CPF) of Cameroon, 2009–2013, and others.

[10] In 1981, another global study, focused specifically on energy issues, was published by the International Institute for Applied Systems Analysis (IIASA) under the title *Energy in a Finite World* [6].

[11] A notable exception is the (albeit limited) combined energy and water planning being undertaken within certain US districts [7].

[12] Examples include MINICAM [8], IMAGE [9] and TIAM [10].

The ‘systems approach’ referred to in this annex is extensively used (although its application to CLEW is still missing). It refers to a physical accounting of resource, technology and other requirements to meet certain needs and services, with the accounting extended far upstream. For example, water, crop, fertilizer and land requirements can be calculated for a given food production level. Each of these inputs in turn requires its own inputs, which are also accounted for. Fertilizer, for example, requires transport and production, both of which require energy, water and technologies and emit greenhouse gases. In turn, those energy and water inputs are associated with their own inputs, technologies and emissions, etc. The accounting continues until satisfactory estimates of resource and other needs, as well as impacts, are calculated. In some instances, the proposed development path may prove to be limited by resource constraints, in which case an alternative can be investigated.

At each step in the systems approach, costs can be calculated, and a systems model can be programmed to identify which development path, given various constraints, is the most economic.

B.1. Notable examples of CLEW challenges

The following examples of interconnected CLEW relationships highlight the need for integrated planning to meet energy, water and land related service requirements.

- Punjab has only 1.5% of **India**’s land, but its output of rice and wheat accounts for 50% of the grain the government purchases and distributes to feed more than 400 million poor Indians. The problem is that farmers are pumping (‘mining’) aquifers faster than they can be replenished, and, as water levels drop, increased pumping is sapping an already fragile and overtaxed electricity grid. Moreover, because farmers in Punjab pay nothing for electricity, they run their pumps with abandon. This both further depletes the water table and, as water is pumped from ever increasing depths, requires ever more electricity to maintain a constant level of irrigation water [11]. Overall, irrigation accounts for about 15–20% of India’s total electricity use [12]. The Government recognizes that all these issues are interconnected, but the planning does not.

- The United Nations Environment Programme (UNEP) expects the frequency of weather and climate extremes in **Colombia** to increase by 2050 [13]. Regional impacts will include: changes in the composition of ecosystems and biome distribution; reduced water availability and hydropower generation; increasing desertification; aridity; crop pests and diseases. Colombia will face hydropower shortages caused partly by increased El Niño events, which will force a further reduction in agricultural activity and, possibly, the future import of fuels for electricity generation. Such fuels are expensive, and, particularly in a volatile market, increased imports reduce the country’s energy security.

- Uncoordinated development efforts in **Uganda** have slowed development and increased environmental stresses. Limited access to electricity (only 9% of Ugandans have electricity access) is a major drag on development, and major environmental problems include overgrazing, deforestation, and (often) low productivity agricultural methods, all of which lead to soil erosion. 93% of the country’s energy needs are supplied by wood. The resulting deforestation is a severe problem, although its pace has slowed significantly, from a 67% loss of forests and woodlands between 1962 and 1977 to a 7.7% loss between 1983 and 1993. Wetlands have been drained for agricultural use, and the nation’s water supply is threatened by toxic industrial pollutants. Mercury, for example, from mining has been found in the water supply. Roughly 20% of the urban population and 53% of the rural population do not have access to pure drinking water [14]. Development is essential; coordinated development, urgent.

- **South Africa** is a semi-arid country. 90 % of the country lies within arid, semi-arid or dry sub-humid zones. Yet the country is of key importance to Africa and its development. South Africa is the continent's largest exporter of agricultural products [15] and requires large quantities of electricity to pump irrigation water. In addition, South Africa is a major electricity exporter, supplying over 40% of Africa's electricity. It is also an important exporter of international commodities, such as coal and gold, both of which consume substantial electricity in their production. But development is being retarded by inadequate investments in new electricity generating capacity. This supply shortage is estimated to cost the region billions of dollars as power shortages affect the international supply of commodities. Shortages in 2007, for example, forced gold prices to increase globally by 5% [16]. As this was a result of a cost increase (rather than a demand increase), higher prices are likely to reduce sales and profit. Further, any increases in power supplies will require more water. Thus, if such increases are not coordinated with policies concerning other water uses, they may decrease water availability for such uses, including agriculture. On the other hand, expanding the cultivation of marginal lands for maize, together with overharvesting of fuel wood by the poor, are important causes of accelerated desertification. To address all of these issues, an integrated approach is clearly required.

- Global grain prices are volatile. Recent spikes were caused by many factors, including increased prices for fuel and thus transport, increased demand for **biofuels** driven by energy security and climate change concerns[13], as well as changing diets in populous fast growing developing countries. Diets that include more meat and more calories require substantially more land, both for livestock and for feed production. Increased feed production requires additional fertilizer and irrigation. Both fertilizer and irrigation (pumping) require energy, and if that energy is fossil fuel based, GHG emissions will increase. Moreover, as the demand for food, feed and biofuel grows, and as food requirements grow, so does the competition between the two for land. Similarly, there is competition between biofuels and food for fresh water and for fertilizers, especially as more marginal land is cultivated. Important positive impacts of increased biofuel production might include much needed economic opportunities for farmers and countries trapped by economic barriers. On the negative side it may cause short term opportunism, such as unsustainable clearing of forests for extra farmland, which may have long term consequences. Sorting out all the interconnections to provide useful insights for policy and decision makers requires better integrative analytical methods than are available today.

B.2. Decision making and analysis

The intricate links among energy, water, land use, climate and other features of the environment, have been well documented for a long time, but governmental administrative 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. As a result, there can be a lack of broad coherence, and, at times, decisions by one ministry or department can conflict with the objectives of others. 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

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[13] The actual impact of biofuels on climate change can be negative as well as positive, depending on the resulting land-use changes, and production, harvest and conversion methods. The need to analyse all these factors together reinforces the need for better methods and models that consider all the linkages among CLEW factors.

the consequences for all these areas could be insufficiently considered in the light of longer-term climate policies.

A method for integrating local and national assessments would significantly improve information flows, and harmonize different departmental data collection, decision and policy making activities. Some assert that such a method is essential and that without such an integrated systems analysis tool, development, planning, policies and therefore development will not be sound and sustainable [17 and 18].

C. Goals

Given the desirability of a CLEW analysis and planning tool, it is important to clarify what the output of the tool should be. First, it should simulate, or account for, the CLEW system interactions both now and in the future. The primary target for its application should be developing Member States, and thus the tool should calculate the resource and service requirements to meet socio-economic goals — such as the Millennium Development Goals — in a growing economy. Thus, the tool should simulate important interactions within the CLEW system to meet energy, water and food related service demands, within constraints imposed by the physical and economic environments. In order to do this, a clear mapping should be made of relations within the CLEW system, and between it, other important resources and the economy.

In addition to incorporating such a mapping and quantification of key relationships, the tool should be designed for use in the following applications.

- Decision making: A well formulated integrated CLEW tool would help decision and policy makers assess options in terms of their likely effects on the broad CLEW system. The tool should be able to transparently evaluate the trade-offs reflected in different options.
- Policy assessments: Given limited resources, it is important for policy makers to ensure that policies are as cost-effective as possible. If multiple objectives can be achieved by a single policy, it may advance development more than policies focused separately on single objectives[14]. A CLEW tool should therefore provide a more complete, multi-system policy assessment.
- Facilitating policy harmonization and integration: In the examples in Section B.1 there are instances of very contradictory policies, e.g. electricity subsidies that accelerate aquifer depletion, which in turns lead to greater electricity use and subsidy requirements. A CLEW tool would help harmonize potentially conflicting policies.
- Technology assessments: Some technology options can affect multiple resources, e.g. nuclear power could reduce GHG emissions and reduce the exposure to volatile fossil fuel markets. Although it would use water for cooling, nuclear power can generate electricity for seawater desalination. As with policies, a CLEW tool should allow a more inclusive assessment of technological options.
- Scenario development: Another goal is to elaborate consistent scenarios of possible socio-economic development trajectories with the purpose of identifying future development opportunities as well as understanding the implications of different policies. This is important for understanding whether current development is sustainable, and for exploring possible alternative development scenarios and the kinds of technology improvements that might significantly change development trajectories.

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[14] See, for example [19], which shows how different industrial energy efficiency options could affect water use, employment, GHG emissions and energy investment requirements. Analyses that consider the multiple benefits of each option will yield better estimates of the overall development potential of each.

D. Developing a CLEW system analysis framework

This section provides an initial outline of a CLEW system. It provides only an indication of substantive interactions in the CLEW system, which are represented in simplified aggregate reference system diagrams (RSDs). This initial attempt is meant to provoke future quantitative investigations, and many aspects are therefore deliberately aggregated.

D.1. Energy

An aggregate simplified RSD featuring the energy segment of a CLEW tool is shown in Figure VI-1. Figures VI-2–4 will focus on the water, climate and land use segments.

Primary energy (on the left of Fig. VI-1) is needed to provide energy services (on the right of the figure), such as lighting, cooking, heating and motive power. Primary energy is extracted from renewable or depletable resources[15]. Extraction, whether from wind farms or mines, scars and requires land[16]. Biofuel production requires water[17] and cultivable land[18], thereby reducing their availability for other activities. Often biomass collected for fuel wood in poor regions with growing populations contributes to deforestation and land degradation.

After energy is extracted, it is processed into forms which are easier to use or transport. For hydropower, electricity is generated from run of river turbines or water stored in reservoirs. This can require the use of large land areas and the significant alteration of water flows. Where vegetation is flooded, it will decompose and release GHGs such as methane. For other energy sources electricity and heat are the most common forms in which energy is transported or used. Crude oil, biofuel feedstocks, coal and natural gas can also be transformed into petroleum products and other liquid fuels.

Generally, primary fuel extraction, fuel processing[19] and electricity generation require large amounts of cooling water[20]. The combustion of fossil fuels commonly releases GHGs such as CO_2.

Fuels are then transported, distributed and converted into the energy services mentioned earlier. Conversion devices range from the simple to the complex, for example from appliances (like a kettle) to equipment (like a compressor) to more complex technologies (like an automobile). Energy services are important in all socio-economic sectors. For integrated CLEW analyses, noteworthy energy services include the transportation of biofuels and crops, pumping of water for irrigation, and energy consuming chemical processes for manufacturing fertilizer. In most cases, GHGs and various pollutants are emitted either directly if non-renewable fuels are burned, or indirectly if they are burned to produce the fuel that is used to produce the energy service.

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[15] Note that where a renewable resource such as fuel wood is consumed faster than it is regrown, it is also in a sense depletable, especially where land is damaged due to overuse.

[16] A 60 MW(e) solar thermal power plant, for example, requires about 1 square kilometre of land [20], and more land might be required to provide back-up power to augment the intermittent nature of solar energy.

[17] The biofuel feedstock maize, for example, needs about 860 litres of water to produce one litre of ethanol.

[18] For example, over 3000 square kilometres of land can be required to produce 18 million tons of the biofuel, palm oil, annually [21].

[19] According to the United States Bureau of Land Management, surface mining and retort operations produce 8–38 litres of wastewater per tonne of processed oil shale [22]. Similarly, an estimated 3 barrels of water are required per barrel of oil equivalent of tar sands.

[20] 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 [23].

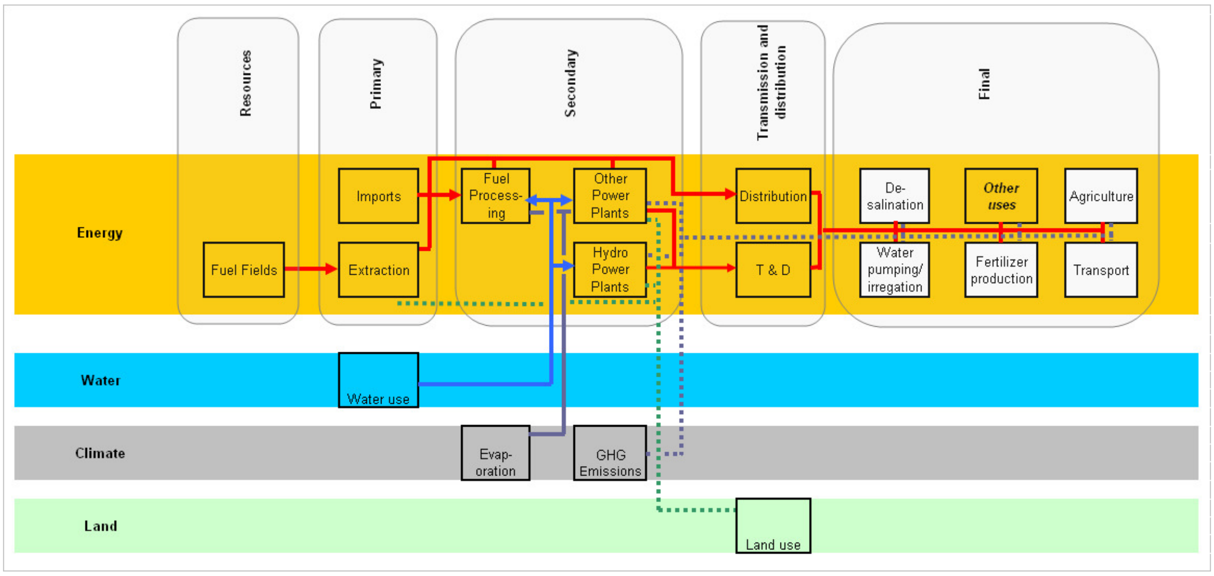

FIG. VI-1. Aggregate reference system diagram: energy

D.2. Water

An aggregate simplified RSD featuring the water segment of a CLEW tool is shown in Figure VI-2.

Water, like energy, provides a number of essential services. Broadly speaking, there are three water sources: the sea, local precipitation and aquifers (or ‘fossil water’). Seawater can be desalinated using energy for evaporation or reverse osmosis. Local precipitation fills river basins and lakes with fresh water, and fossil water can be mined. Where water supplies are far from demand, water is pumped or fed to users via canals or pipes and can be stored in reservoirs. When aquifers are depleted faster than they are replenished, their levels will drop, and more pumping (and therefore fuel) may be required to supply the same amount of water. Such pumping can be an extensive user of energy[21].

In the power sector, thermal power plants[22] use large amounts of water for cooling — much of which is lost to evaporation. Hydropower plants use significant quantities of land[23] and interfere with existing water flows, changing silting patterns in river basins[24]. Significant quantities of water are also required for other energy processing activities, such as refining oil products or manufacturing synthetic fuels[25]. However, new ‘dry cooling’ technologies offer reduced water consumption in many activities which use water for cooling.

Water has a particularly important role to play in agriculture. In arid developing countries, irrigation can account for as much as 90% of total water use [24], and irrigation together with sufficient nutrients can transform marginal land to cultivable land (although overfertilization and irrigation can also damage land). Irrigation can be gravity driven but increasingly requires energy for pumping.

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[21] In California, for example, up to 3.5 kW·h per 1000 litres can be consumed supplying water. More energy can be required for local irrigation and treatment [25].

[22] The US Geological Survey [26] estimates that over 50% of freshwater withdrawals are for cooling thermal power plants, with the majority of that water returned to rivers, lakes or the ocean after use.

[23] The large land requirements of hydropower can require the relocation of activities and people. Over a million people, for example, had to be relocated because of the Three Gorges Dam Project [27].

[24] 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. This lowered the water storage capacity of Lake Nasser. Poor irrigation practices further waterlog soils and bring the silt to the surface.

[25] In New Mexico, for example, refineries currently use 50–180 litres of water per barrel of crude oil and generate 30–120 litres of wastewater [28].

After use, water has a high potential for purification and recycling, which, however, require energy[26].

As available water can be scarce, its management to reduce evaporation can be important. Thus low evaporation storage, drip irrigation, recycling, ‘grey’ water use, and other techniques and technologies are important in improving the efficiency of the water system.

Finally, water is returned to the atmosphere via evaporation and transpiration, with the greatest quantities released by evaporation from the ocean.

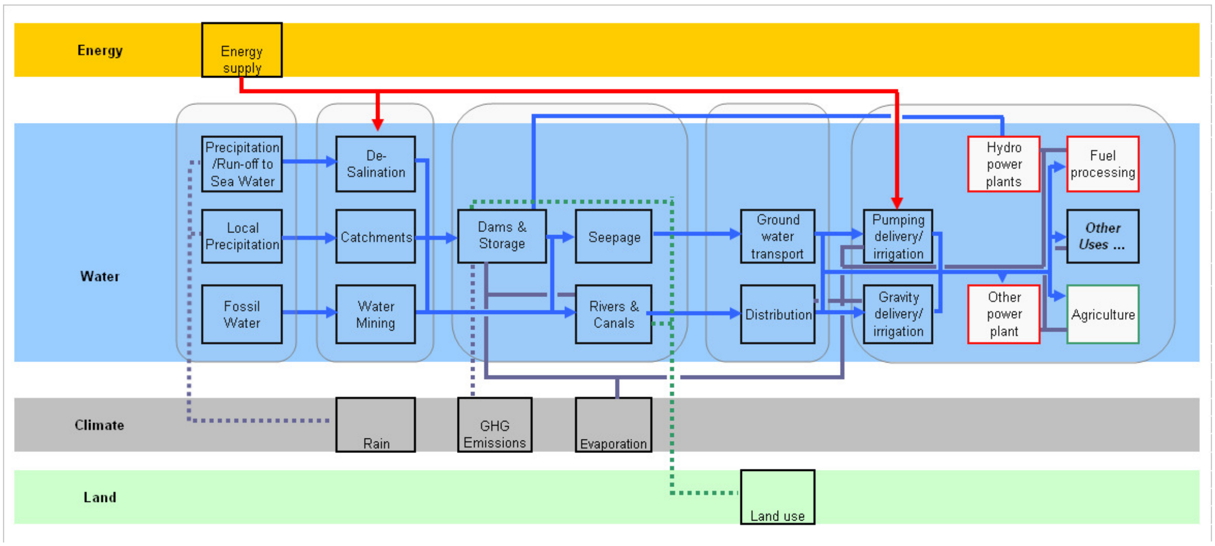

FIG. VI-2. Aggregate reference system diagram: water

D.3. Climate and weather

An aggregate simplified RSD featuring the climate segment of a CLEW tool is shown in Figure VI-3.

The climate is affected by releases of GHGs from anthropogenic activities[27] such as fossil fuel power production, fertilizer production and use, crude oil and biomass refining, transport and land cultivation [29]. Fossil fuel combustion accounts for the bulk of emissions[28].

There is a significant drive to adopt energy technologies which mitigate or reduce the quantities of CO_2 emitted. Examples include nuclear energy and renewable energy such as hydropower, wind power and biofuels (such as diesel or ethanol produced from crops). Other methods of reducing CO_2 emissions include sequestering CO_2 in forests and the future use of CO_2 capture and storage technologies.

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.

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[26] For example, the energy required in California to treat wastewater for reuse ranges between 0.1 and 4.0 kWhr per 1000 litres [25].

[27] Important contributors to anthropogenic releases include burning fossil fuels, land use, land use change, forestry, cement production, waste water processing, natural gas flaring and chemical processes and products [30].

[28] 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% [31].

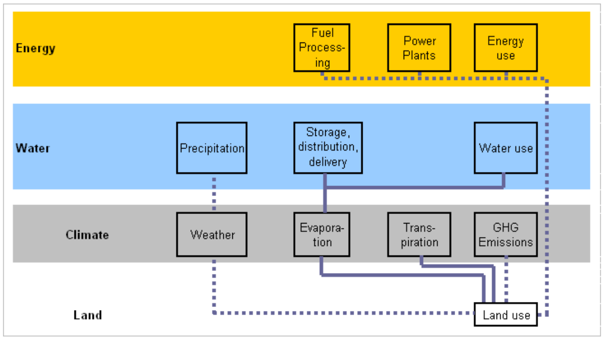

FIG. VI-3. Aggregate reference system diagram: climate

D.4. Land

An aggregate simplified RSD featuring the land segment of a CLEW tool is shown in Figure VI-4.

Land that has the potential for cultivation can be classified into four categories: deserts, marginal land, cultivable land and forests or other natural vegetation such as savannahs. The quantity of cultivable land increases as either forests are cleared or marginal lands and deserts are made cultivatable by irrigation and fertilization.

The quantity of available land is limited. Thus, depending on the value of what it can produce, competition among alternative uses can be high. Typical land uses include habitation (such as in towns and cities), grazing of livestock, crops for food, biofuel and other products, fuel wood and infrastructure such as roads, cities, canals and dams. Where practices are poor, land can be damaged by overgrazing, overcropping 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 also 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.

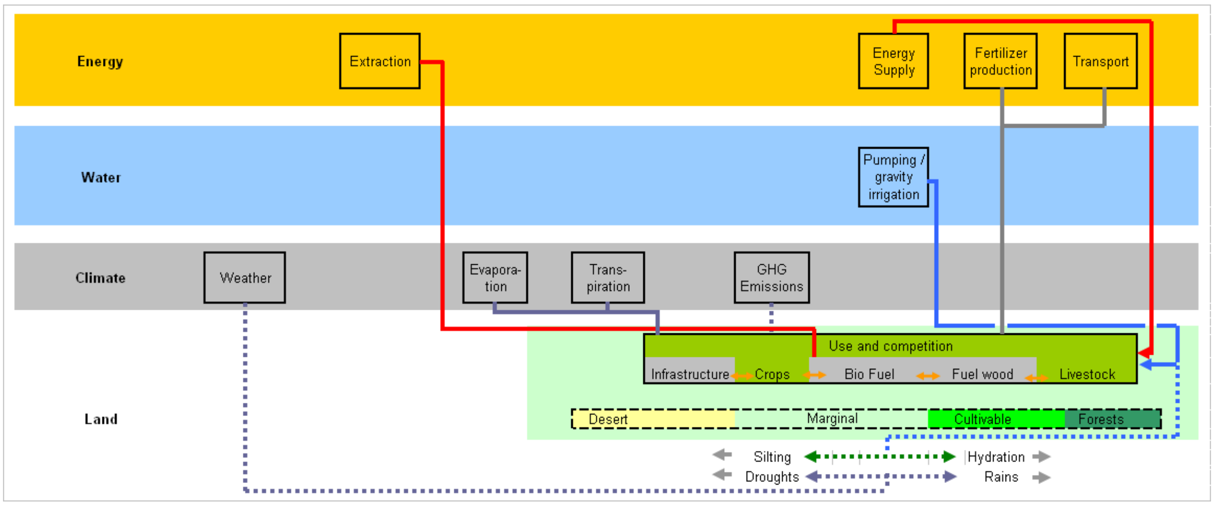

FIG. VI-4. Aggregate reference system diagram: land

D.5. Towards a CLEW system representation

Figure VI-5 combines Figs. VI-1–4. The result is an initial simplified single CLEW reference system diagram (RSD).

The RSD is a useful tool for visualizing relations which need to be represented by simplified mathematical expressions. Each line represents a ‘flow’ and each box an activity, or group of activities, that change various flows. This approach is common, particularly in energy modelling where the RSD is known as a reference energy system (RES).

Once the flows, activities and their linkages are defined, the levels of each flow need to be calibrated in terms of physical quantities, and the activities need to be calibrated in terms of their historical capacities (where systems of equipment are used), operational costs, investment costs, and technical characteristics (such as their efficiencies). Each system should meet a range of demands for services as an economy, or population, grows. However, flows and activities may be limited by physical or financial limits, and there may be restricted interactions between the demands for services and the manner in which they are provided. For example, a computer can be run only on electricity, not coal. Taken together and further developed, the set of relationships in a CLEW reference system can be implemented in a software tool and used to determine scenarios of how future needs can be met within the constraints inherent in the system.

This discussion provides only an outline of selected features of a CLEW tool. The final section addresses possible next steps and the unique role that the IAEA could play, within the family of UN organizations, in the development and application of such a tool.

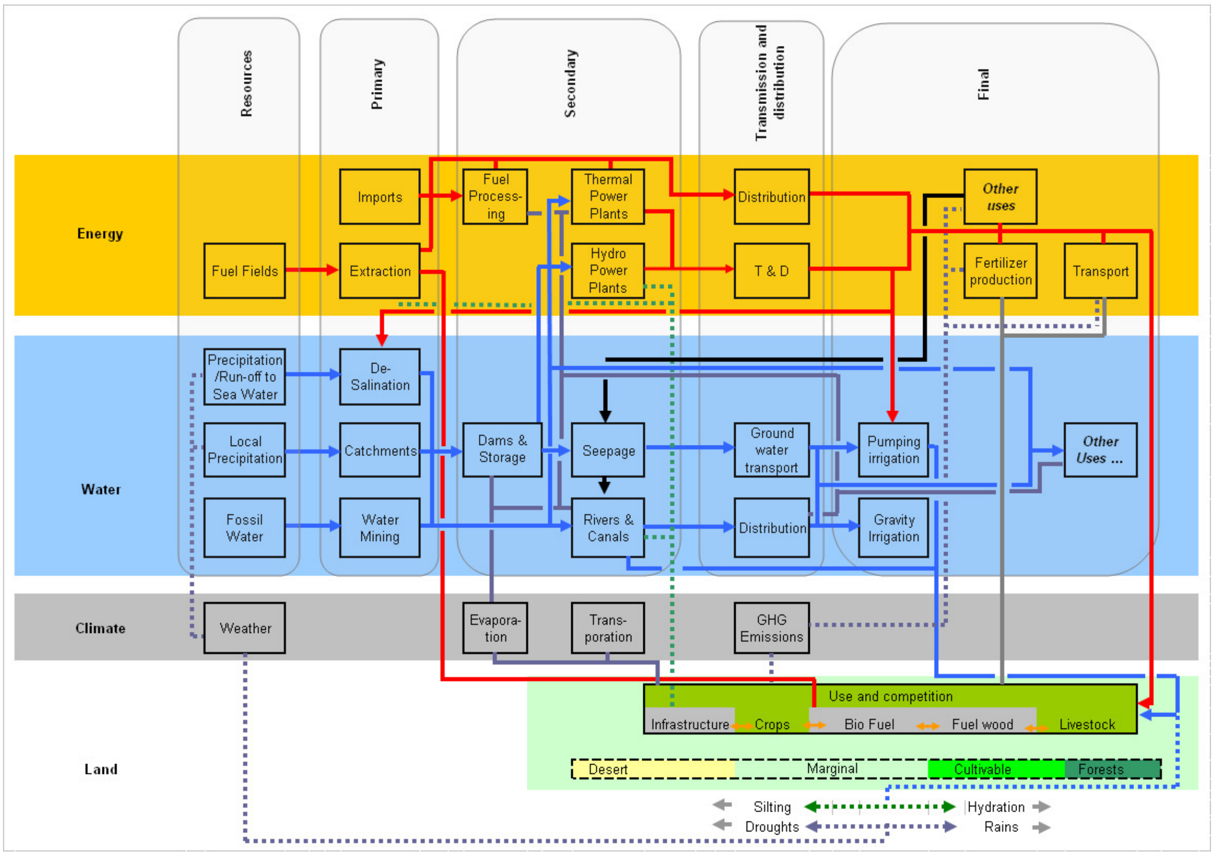

FIG. VI-5. Aggregate CLEW reference system diagram

E. IAEA services

The UN has a broad mandate to help its Member States develop sustainably. It has adopted the Millennium Development Goals (MDGs) in the short term with the objective of meeting these goals by 2015. The commitment to sustainable development, however, reaches far beyond the MDGs. As an organization within the framework of the UN, the IAEA has a unique capacity to further contribute to these aims and support Member States and other agencies once a CLEW tool is available. The MDGs, and sustained longer term development, require services which all draw on the CLEW system either directly or indirectly. Without efficient policy design informed by a CLEW tool, development may be retarded.

The IAEA has a specific mandate to efficiently meet the needs of its Member Sates. The concerns of developing Member States include the provision of clean water, energy security and food security. Through its own mandate to promote the peaceful use of nuclear technologies and techniques, the IAEA currently supports many projects on energy planning, nuclear desalination modelling, isotope hydrology and, through a joint Division with FAO, crop improvement. These services are provided to Member States through the IAEA's Department of Technical Cooperation. The initial incubation of, eventual application of and training on a CLEW tool would form a very natural extension of these services.

Further, it is envisaged that after initial incubation of the concept within the IAEA, consultation with other experts and agencies in the UN system will take place.

F. Conclusion

A tool to assess the interrelated aspects of climate, land, energy and water (CLEW) is definitely needed. This is essential in the context of sustainable development, the key challenge for the coming decades. Moreover, in order to meet growing demands for energy, water and food services, the CLEW system needs to be managed. Although the components of the CLEW system are closely interrelated, decision and policy making for each component usually take place separately. This can result in suboptimal resource allocations, counter-productive policies and, at worst, accelerating long term unsustainable development. Particular attention needs to be given to apparently short term gains which undermine longer term development opportunities.

A CLEW system would be a valuable addition to the IAEA suite of energy analysis and planning tools, especially for comparative technology and policy assessments, policy harmonization and designing and testing future scenarios of development. The IAEA provides an ideal setting to incubate a pre-prototype of a CLEW modelling tool. This tool could contribute to stimulating integrated CLEW analysis and planning in Member States and to supporting the achievement of broad UN development goals, and it could provide a natural and useful extension of current IAEA technical cooperation activities.

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