

## *Energy and Water Linkages*

### *Phase 1B-Approach to First-Generation Demonstration Basin Model*

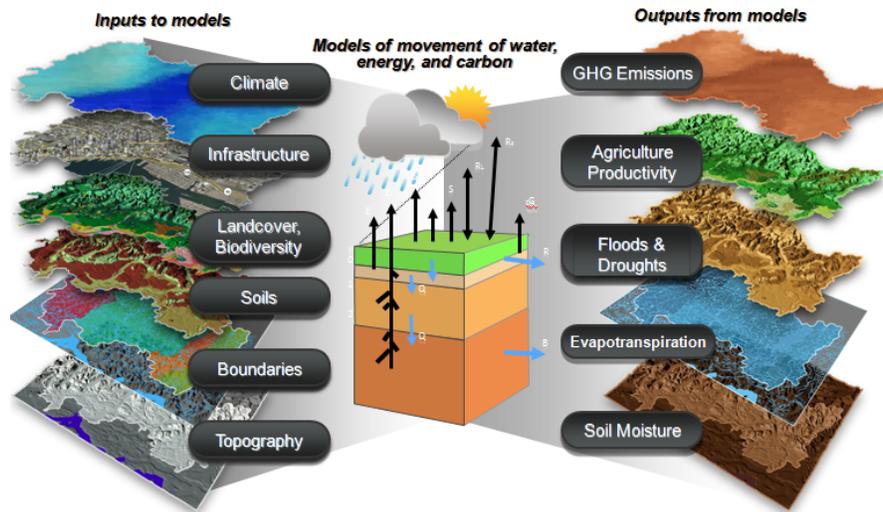
**Introduction.** The overall aim of the ESCC Pillar 3 on energy-water linkages is to build regional energy and water security<sup>1</sup> through enhanced regional cooperation and strategic investment. This initiative<sup>2</sup> in the Central Asia Region (Afghanistan, Kyrgyzstan, Kazakhstan Tajikistan, Turkmenistan, and Uzbekistan) has the aim of strengthening regional cooperation in energy and water resources development and management.<sup>3</sup> The conceptual approach is to develop a decision support system (DSS) to understand the energy-water linkages. The DSS combines the relevant physical, infrastructure, economic, social and environmental data and suitable analytical tools including mathematical models,<sup>4</sup> and supports a multilevel dialogue process among technical specialists and key policy makers at both the national and regional levels. The DSS<sup>5</sup> would be based on a transboundary approach that reflects the unique basin hydrology of the region, the large existing and potential water storage capacity in the region, the uneven distribution of energy resources and agriculture potential across the region and their demand and supply characteristics, and the characteristics and development needs of all the sectors that must utilize the water resources of the region including sustainable ecosystems and the environment.

**Approach to first-generation demonstration model.**<sup>6</sup> Both the World Bank and national energy and water sector technical specialists recognize that despite the numerous national and regional “initiatives” and “models” that have been undertaken these efforts have not addressed the critical question of the energy and water relationships at a broader transboundary scale. Most importantly, they have not engaged country experts and policy makers directly in the modeling and analysis of options. In addition, there have been important technical issues including the completeness and verification of the data used, as well as the transparency in formulation and implementation of these models and reliability of model outcomes. To address some of these disconnects and better understand energy water linkages, in the first phase (1B) of ESCC Pillar 3 implementation, the Bank is supporting the preparation of a first-generation demonstration model to provide an overview of the basin’s hydrology, demonstrate data availability and possible modeling platforms, and understand the key linkages between energy and water in the region. It will also serve as a tool to facilitate dialogue on defining a modeling framework, the model architecture, input data, and output variables, for a transboundary energy-water model for Central Asia.

**Basic premises and elements to build a geospatial basin model.** The premise of a first-generation model of the Amu Darya and Syr Darya drainage basins is that:

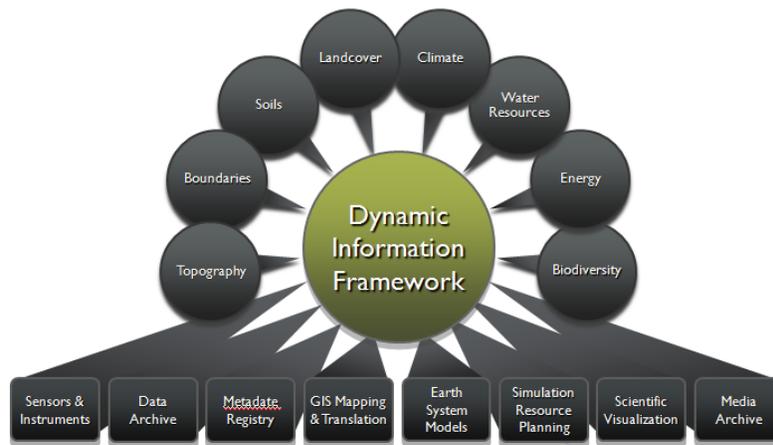
- (i) data will be derived initially from globally available public domain data and modeling platforms<sup>7</sup> that are accessible and neutral;
- (ii) from the available data, the aim is to model the entire transboundary basin’s hydrologic cycle to determine the full mass-balance of water; and
- (iii) the basic hydrologic macro-scale model is scalable, and would be able to illustrate the energy and water linkages, including hydropower, irrigation and other water infrastructure as well as land use practices.

Phase 1B will develop a basin hydrology model, to describe the basic dynamics of water movement across these two basins, with and without political boundaries. As noted, this first-generation model will be developed from accessing available public domain, independent data sources. The core of the modeling environment is built by progressive information layers identified as the required inputs for the geospatial hydrology and landscape models as illustrated in (Figure 1) but can serve multiple purposes as defined by the technical and policy stakeholders.



**Figure 1:** The framework – based on “Earth System Models,” of geospatially-explicit/ and process-based , coupled landscape, climate, and hydrology models.

A dynamic information framework (DIF) for the basins will be established as the means to integrate the public accessible data, information platforms and various modules for the basin. It is a practical mechanism for organizing and processing multi-source information and decision needs an “information laboratory and forum” to achieve a readily accessible decision support framework. A form of “cyber-infrastructure” is necessary to actually execute the DIF as illustrated in Figure 2.



**Figure 2:** Structured (“cyber”) elements of a DIF

Schematically, the functional components of DIF include: (a) base data layers; (b) geospatially-explicit, process-based, cross-sector simulation models requiring data from the directed data layers (a modular structure allows ready swapping of models, while focusing on getting work done); (c) facilitated input/output, including visualizations; and (d) scenario testing capabilities. As the DIF is the means to integrate the data, the Variable Infiltration Capacity (VIC), a macro-scale hydrologic model, is intended specifically for the purposes of representing interactions of land cover, climate, and runoff generation. The VIC is a semi-distributed grid-based land surface hydrological model, which parameterizes the dominant hydrometeorological processes taking place at the land surface-atmosphere interface.

**Simulations.** A major difficulty in water resources and energy management is the often-conflicting objectives for the use of these resources. Scenarios derived from and analyzed using this first-generation model is intended to be illustrative, to provoke discussion, not for project-specific decision-making. Based on a various assumptions, the developing model will examine how to simulate a variety water and energy linkages scenarios. The consultant will show how to simulate water management operations to determine options between hypothetical and competing objectives and the demands on water. However, it is important to note the VIC model “only” the basic components of the hydrological cycle, as a function of climate and landscape. It does not a priori address the “human” components of the “plumbing” of the system. To examine the potential effects of hydropower on riverflow, a modified version of a reservoir model will be tested. An irrigation model will be scoped. For climate change scenarios, access to the models that produce climate scenarios will be required.

**Next Steps.** National level workshops with energy and water technical specialists and policy-makers are proposed to take place in December 2010, to create an initial opportunity to interact with this first generation model.

### **Endnotes**

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<sup>1</sup> In the context of the ESCC Pillar 3 and the Central Asia Energy Water Development Program (CAEWDP), references to the “region” or “regional approach” are referring to the Aral Sea Basin, which includes the Amu Darya and Syr Darya river basins, and to a basin approach that encompasses both of these basins. The present extent of the Central Asia (CA) regional electricity grid and the load sources are also limited to these two basins with the exception of exports (central Afghanistan and Iran) and parts of northern Kazakhstan. Note that the closed Zarafshan basin, which lies between the Amu and Syr Darya rivers in Uzbekistan and Tajikistan, and northern Afghanistan are a part of the “region” and the Amu Darya basin.

<sup>2</sup> ESCC Pillar 3 water energy linkages are consistent with CAEWDP Component 3 energy water linkages.

<sup>3</sup> Pillar 3 had its genesis in the priority actions identified and adopted at the Central Asia Regional Economic Cooperation (CAREC) Energy Sector Coordination Committee (ESCC) workshop in Almaty in September 2009 in which ESCC and donor members, and representatives of the Executive Committee of the International Fund for the Aral Sea (EC-IFAS) and the Scientific Information Center of the Interstate Water Coordination Center (SIC-ICWC), participated

<sup>4</sup> There have been efforts to comprehensively model the region’s water supply and demand system in the past, but these have not included the energy supply and demand, thus not generally accepted and trusted. The models to date have not provided the analytical platform needed to move the energy-water dialogue forward. Whether by greater transparency, verification and testing of results or other mechanisms, this problem must be overcome.

<sup>5</sup> The DSS is a critical element in the approach because it serves two key purposes among others: first, to illuminate the value and tradeoffs among a wide range of strategic options including infrastructure

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investment; and second to inform the dialogue towards a mechanism by which the countries of the region can sustain energy and water security and economic growth. Moreover, such a DSS is an essential tool for determining vulnerabilities and risks associated with global warming (changes in temperature and precipitation) and to evaluating alternative adaptation options.

<sup>6</sup> A first-generation model for this effort is defined as a macro-scale model generated from publically available data and model platforms, capable of generating management scenarios from publically accessible simulation models. This does not imply a first model for the basins, some of which already exist on different platforms and data sets.

<sup>7</sup> The emergence of a new generation of “Earth System Science,” based on the rapidly evolving capabilities for addressing global change issues, involves use of satellites, new generations of dynamic computer “models,” field measurements focused by model requirements covering wide areas, and, especially, a thinking and practice of “integrated systems.” A key aspect to these models is that they are geospatially-explicit, fully distributed, recognize the spatial heterogeneity of the watershed, and are based on the underlying processes of how water moves across the landscape. Because these models can, and must, “meld” information from multiple public sources, they can be functional in specific regions where local data are relatively sparse. A first-generation model for this effort is defined as a macro-scale model generated from publically available data and model platforms, capable of generating management scenarios from publically accessible simulation models. This does not imply a first model for the basins, some of which already exist on different platforms and data sets.