INTER-AMERICAN DEVELOPMENT BANK

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INTRODUCTION: THE NEXUS OF WATER-ENERGY-FOOD

Stockholm Environment Institute

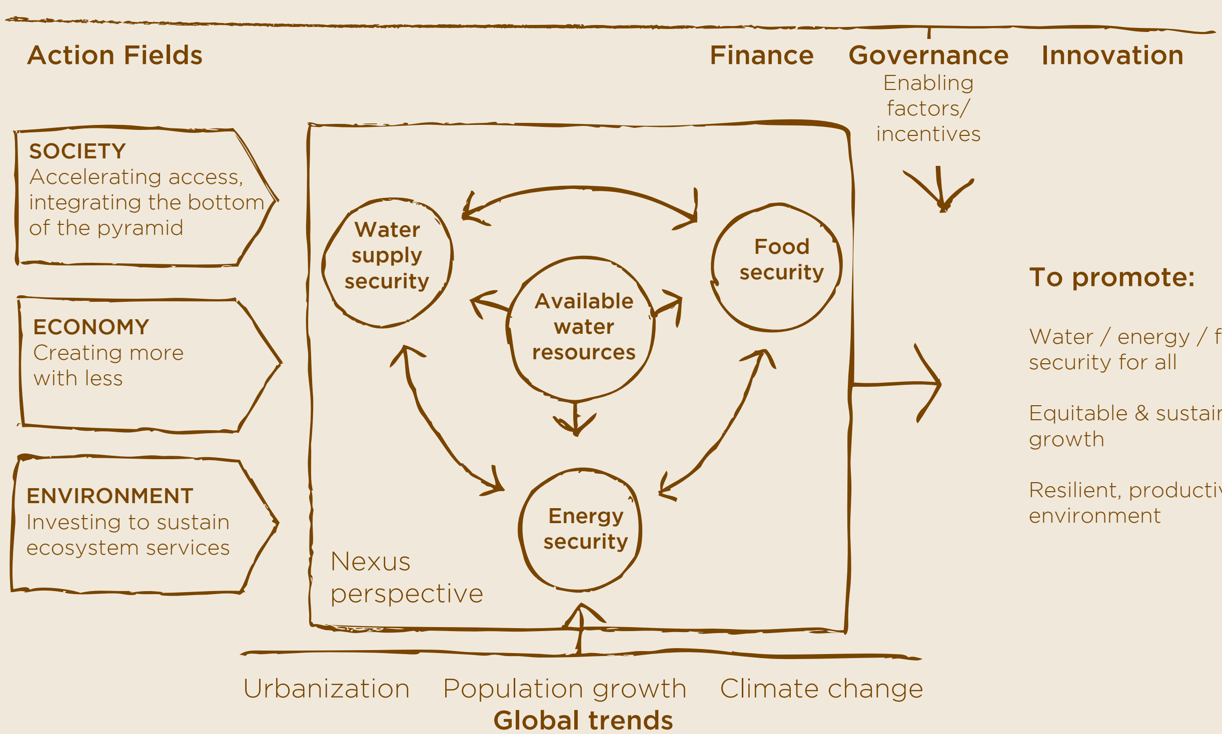
As the world prepares for the United Nations Conference on Sustainable Development (Rio+20), there is growing recognition that the greatest challenges facing us today—feeding people, fighting poverty, addressing climate change, and procuring energy for all—cannot be solved piecemeal. While the 1992 Rio conference produced agreements on climate change, biodiversity, and drylands, there is now a push to take an integrated approach that recognizes the critical nexus between water, energy, and food and the complex interactions between ecosystems and human activity, especially in a changing climate.

The four articles in this year's *Sustainability Report* examine how climate change, ecosystem services, low-carbon development, and sociopolitical change affect agriculture, emphasizing the need to adopt an integrated-systems view of the world to achieve sustainability.

A model developed by the Stockholm Environment Institute distills the components of the water-energy-food nexus, framed around the availability of water. This model illuminates interactions and trade-offs among water management, energy management, and food production, using as an entry point the availability of water resources. The model also emphasizes the importance of sustaining biodiversity and ecosystem services as the basis of a resilient and productive environment. For all sectors, and in particular for food production, understanding these interactions can help decision makers find solutions that will maximize benefits across all three realms.

Several global trends are highly relevant in Latin America and the Caribbean. Income is rising across all social strata, accompanied by increases in both production and consumption. Accelerated development linked to globalization is also hastening urbanization and concentrating large numbers of poor

The water-energy-food nexus



people in peri-urban zones, where they are vulnerable to constrained availability of water, energy, and food. In rural areas, intensified agriculture responding to global demand for commodities, energy development, mining, and the expansion of infrastructure are degrading resources, disproportionately affecting the poor. Finally, climate change poses particularly acute threats to many areas, in particular the high mountain ecosystems in the Andes and some Caribbean islands. Viewing these challenges from an integrated systems perspective is useful for stakeholders and decision makers in order to chart development pathways where the trajectories of social and ecological systems remain within acceptable thresholds.

The countries in Latin America and the Caribbean are physically and socioeconomically diverse. Some areas have ample rainfall; others struggle to irrigate crops. Some countries rely on hydropower to meet large shares of their energy needs; others use mostly fossil fuels. Some countries are embracing biofuels production with its accompanying concerns about ecosystem loss and competition with food crops. An integrated systems approach can help set priorities for investments that promote socioecologically resilient development. A focus on efficiency, on creating more with less, is also relevant in the face of increasing regional productivity and consumption. A number of key interactions exemplify the water-energy-food nexus in the region:

- **Water is needed for food production:** 90 percent of the region's agricultural land is rain-fed. In the water-constrained Andes, there is sufficient water to produce a diet of 3,000 kcal with 20 percent animal products. But changing precipitation patterns and growing demand for food are increasing the need for irrigation. Combined with urbanization, this is increasing pressures on rural landscapes and on water supplies.
- **Water is needed for energy generation:** Hydropower supplies 46 percent of the region's electricity, far above the 16 percent global average, but only 38 percent of the region's potential hydropower has been tapped. In addition, growing and producing biofuels can require large amounts of water.
- **Energy is needed for food production:** This is the least well understood link, but food production, harvesting, transport, processing, packaging, and marketing all use up significant energy resources.
- **Energy is needed for water:** Energy is needed for desalination (which could become important mostly in the Caribbean), water distribution, and irrigation.

These examples highlight the importance of applying integrated systems models. Similarly, reduction in glacier water contributions will affect water supply for upstream and downstream uses, including small- and large-scale agriculture, urban water utilities, and hydropower. The situation in La Paz–El Alto, Bolivia, illustrates this: the rapid urbanization of El Alto in the last decade has created several challenges, including increased demand for tap water. The current water supply system is connected to the system of La Paz, and the water utility serves about 1 million of the 1.65 million residents of both cities, but this includes only 35 percent of households in El Alto. Irrigation for peri-urban agriculture consumes 10 percent of the water available to El Alto. Water sources for the cities come from glaciated watersheds that have lost up to half of their glacier area over the last few decades.

To solve the shortages in water supply for these two cities, various infrastructure options are being analyzed—many of which are proposed by funding agencies taking a top-down approach to climate adaptation. These initiatives need to incorporate local social processes so that they can respond to local needs. In El Alto, it is important not only to provide water for households but also to consider the subsistence agricultural uses of the peri-urban zone, as well as the agro-pastoral uses of the upper watershed, where infrastructure projects are envisioned. Climate trends should also be incorporated into infrastructure design to accommodate uncertainty and variability in water supply.

All across the region, development is the top priority, along with providing the energy to support development. At the same time, there is pressure to minimize carbon emissions, which often leads to the promotion of hydropower and the increasing attractiveness of biofuels production. Where water is plentiful, these may be successful strategies. But in regions with limited water resources, hydropower and biofuels may compete directly with food crop production and other ecosystem service flows. An integrated systems approach will highlight these trade-offs and help ensure that benefits in one realm do not come at the expense of another.

To apply the nexus framework effectively in this region, however, we will need to fill several important knowledge and policy development gaps, including:

- Watershed-level information on land use, terrestrial ecosystems, and water balances.
- Studies on impacts of hydropower development on ecosystems and their services.

- Integrated policy frameworks that take into account climate change adaptation in the water sector, mitigation in the energy sector, and food security measures.
- Better integration of analytical frameworks for water and energy planning.
- Integration of informal participatory bottom-up processes with formal top-down interventions.

An analysis of what we know and don't know about water may provide interesting content for a future *Sustainability Report*.

Using integrated water-energy-food systems approaches in Latin America and the Caribbean will improve understanding of key trade-offs and better inform decision making. In many cases, such analyses are best served by examining and taking decisions about watersheds. In northern Peru, for example, the department of Piura is home to close to a million people. The valleys of Chira and Piura, with a combined irrigated area of 82,985 ha, face water shortages due to the low regulation capacity of the Poechos reservoir, which has high sedimentation rates, and to increasing water demand to irrigate biofuels. Rice covers half of the Chira valley and 30 percent of the Piura valley; biofuels are now grown on 3 percent of the total irrigated area, and there are plans to add 10,000 ha. Other major crops include cotton, plantain, corn, citrus, and tubers.

A scenario analysis of the situation in this area, including reservoirs, canals, and irrigated areas, allowed investigation of changes in water demand and supply as a function of increases in population and in areas for different biofuel crops (maize, sugarcane, and sorghum). The analysis indicated that the current water supply and infrastructure cannot support the desired increases in irrigated area for biofuel crops. It also showed an urgent need to integrate water resources and land use planning to address erosion and increase water productivity through changes in biofuel crop choices and agricultural practices.

Another example illustrates the importance of a participatory approach to planning. Colombia's Coello-Combeima watershed provides water to more than half a million people in several cities and one of the largest irrigated areas in the country (24,000 ha). The watershed also supports subsistence and small-scale agriculture on the margins of the main stem of the river, as well as hydropower electrical production for the national grid. Hydrologic regulation for the system is provided by two sensitive ecosystems in the headwaters: páramo and cloud forest. The competing water demands for urban and agricultural uses have caused water shortages and conflict between users. Urban contamination and erosion reduce water availability in some river sections. The discovery of gold is creating additional pressures on water quality. Through a participatory process, stakeholders have identified opportunities for resource conservation that may also contribute to reducing conflict—for example, through conservation of the páramo.

Resource management is complex, but integrated systems models can help stakeholders better understand interactions among biophysical, sociocultural, and economic resources and systems. More-complex models can incorporate economic and political drivers of change that can advance understanding, improve decision making, and ultimately promote socioecological resilience in the face of global socioeconomic and climate changes. The articles and commentaries in this report examine food production in complex social, environmental, and political contexts. Ultimately, policies and decisions for sustainability must be based on an understanding that embraces this complexity. Integrated systems models like the nexus approach can help stakeholders come to terms with the critical interactions that are the basis of complexity.

The Stockholm Environment Institute (SEI) is an international non-profit research organization that has worked on environment and development issues at local, national, regional, and global policy levels for more than 20 years. This Introduction was prepared by David Purkey and Marisa Escobar. Purkey runs the Northern California office of SEI-US and is actively involved in the development, dissemination, and application of the Water Evaluation and Planning system. Escobar is a senior scientist at SEI-US, leading initiatives on water resources and benefit sharing in Latin America through capacity building in collaboration with local universities.