CONCEPTUAL OVERVIEW
National Water-Energy Nexus & Climate Change

Francisco Flores (co-Principal Investigator) and Stephanie Galaitsi
Stockholm Environment Institute – US Center.
David Yates (co-Principal Investigator) from the National Center for Atmospheric Research.

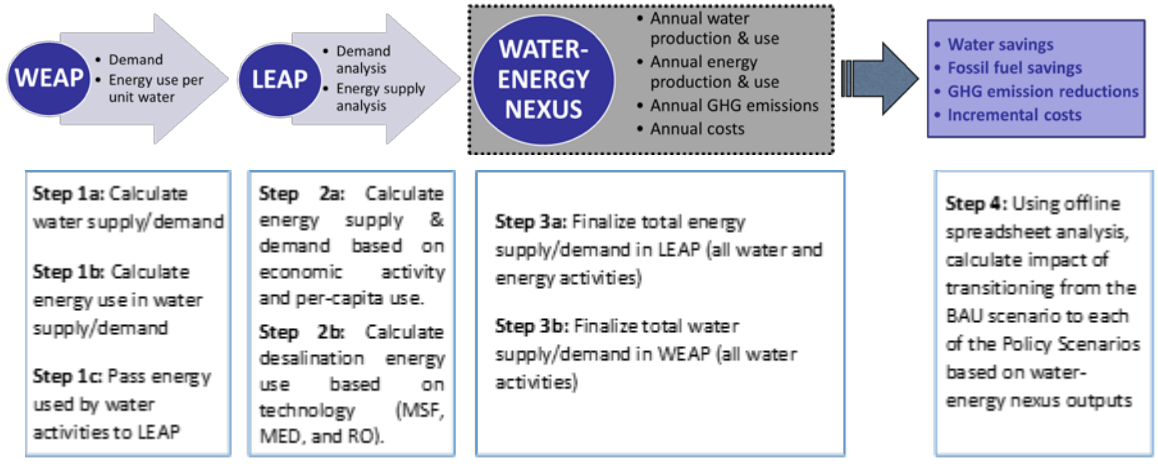
In the UAE, water resource management has been recognized as a serious emerging challenge to long-term sustainable development. Domestic, agricultural, and industrial water consumption have increased at annual rates roughly consistent with the population growth rate, suggesting that little conservation or efficiency improvement is taking place. Energy management has also been recognized as a serious challenge to long-term sustainable development. This is in large part due to the role of energy-intensive desalination activities which accounts for an increasing share of water supply. This suggests that reliance on desalination is as much of an energy challenge as it is a water challenge in the UAE.

Effective water and energy resource management at the national level, already challenging, will be exacerbated by climate change. To capture the interactions between water, energy, and climate change, a "water-energy nexus" framework has been applied. The "Water-Energy Nexus" (W-E nexus) is a framework that views water as part of an integrated water and energy system, rather than as an independent resource. For the UAE, this is an important assessment framework for several reasons. First, climate change has already begun to affect rainfall and temperature patterns across the UAE and the rest of the region, with an intensification of change in the coming years. Second, socioeconomic growth trends indicate that the population in the country's arid environment is likely to continue to increase and will require additional desalination capacity to satisfy increasing water demands, further affecting the management of electricity and water systems. Finally, a W-E Nexus strategic approach could help to inform the technology research, development, demonstration, and deployment currently underway at several centers of excellence in the country.

The overall goal is to better understand the water-energy nexus challenge in the UAE in the face of climate change and socioeconomic development. The major research questions underlying the methodological approach were twofold. First, what would be the future benefits - as measured in water savings, energy savings, and greenhouse gas emission reductions – associated with various scenarios that aim to promote efficiency and conserve natural resources under climate change? Second, what would be the costs associated with shifting to such scenarios and away the current baseline development trajectories?

Addressing the goal and research questions required an analytical framework capable of accounting for water, energy and climate interactions in an integrated way. On the water side, the Water Evaluation And Planning (WEAP) system was used; on the energy side, the Long Range Energy Alternatives and Planning (LEAP) system was used. WEAP and LEAP are integrated modeling tools that can track water and energy resources associated with extraction, production, and consumption, throughout the UAE's economy, including seawater desalination, groundwater pumping, and the transmission of water. Moreover, the models have been coupled (i.e., outputs of one model are used as the inputs to the other) to enable an analysis of the interplay between water management and energy management policies under changing future conditions. A planning period of 2010 through 2060 was considered in the analysis. The results of the LNRCCP's regional atmospheric modeling and desalination studies were incorporated into the analytical framework of the national water-energy nexus study. An overview of the analytical sequence is summarized in Figure 1.

Figure 1: Sequence of steps used to analyze the national water-energy nexus under climate change



The validated water-energy nexus model was used to analyze the costs and benefits of several policy scenarios that could promote resilience of water and energy systems in the UAE in the face of climate change. Establishing a plausible policy scenario framework is fundamental for using the coupled model to explore challenges and opportunities for transitioning to more climate-resilient development paths. This scenario framework consists of five scenarios: a "Business-As-Usual scenario, without climate change"; a **"**Business-As-Usual scenario, with climate change"; a "High Efficiency and Conservation scenario"; a "Natural Resource Protection scenario"; and an "Integrated Policy scenario".

The results of the study confirm that green growth objectives that will increase the resilience of the water-energy nexus in the UAE under climate change. Moreover, this can be achieved cost-effectively. Specifically, the pursuit of an economic diversification agenda employing a green growth framework can lead to significant environmental benefits. These benefits can be achieved at net economic savings in the case of a scenario emphasizing

energy/water efficiency investments (-$10.2 for each tonne of CO2e avoided), and at modest economic cost in the case of a scenario emphasizing renewable energy investments ($13.2 for each tonne of CO2e avoided). Taking advantage of the synergies across efficiency and renewable green growth strategies achieves maximum benefits at very low cost ($3.4 for each tonne of CO2e avoided).