Building Socioeconomic Resilience in a Climate-Pressured Water-Energy-Food System in Underdeveloped Rural Agricultural Farms in Lebanon

Rania Bou Said\textsuperscript{1}, Rabi H. Mohtar\textsuperscript{1,2}, and Roger Moussa\textsuperscript{3}
\textsuperscript{1}American University of Beirut, Beirut, Lebanon
\textsuperscript{2}Texas A&M University, Department of Biological and Agricultural Engineering, and Department of Zachry Civil and Environmental Engineering, TAMU Energy Institute, Texas, USA
\textsuperscript{3}French National Institute for Agriculture, Food, and Environment (INRAE)

One of the main challenges preventing the sustainable development of the agriculture sector is the lack of a system-thinking approach, which includes economic systems, resource management practices [water and energy], production, and climate change. In Lebanon, the main variables affecting on-farm practices are socio-economic factors and climate change, leading to decreased purchasing power, limiting their access to energy and, thus water for agricultural production. While non-governmental organizations introduced solar power to cut energy costs and enhance water accessibility, they did not account for aquifer depletion resulting from excessive pumping. Additionally, adverse climatic conditions are reducing groundwater recharge, and escalating water demands. Thus, it is crucial to view the agricultural sector as an interconnected system and develop strategic plans for agricultural development where climate, water, energy, and production are collaboratively managed. This paper intertwines the Environmental Nexus and the Sustainable Livelihood Approach (SLA) to study the interlinkages, synergies, and trade-offs between water, energy, food, climate, and livelihood security. To assess on-farm practices and identify farmers’ needs, the study employed a bottom-up approach, utilizing surveys, satellite imagery analysis, and interviews. Subsequently, farmers proposed sustainable solutions, which were tested using hydro-climatic models. Analysis of satellite imagery shows a connection between land-use patterns, drought events, and economic shocks. While drought led to economic losses and a subsequent decrease in land cultivation in the following year, the 2021 national economic meltdown in Lebanon had a contrasting effect, leading to an expansion in land cultivation. People sought to secure their food basket or establish a secondary source of income, intensifying competition for natural resources such as water, and increasing market competitiveness. Consequently, there was a substantial decline in farmers’ net revenue by 500-999 USD per dunum, as revealed by survey findings. Many farmers, though receiving aid, remain vulnerable to climate issues, water scarcity, and economic shocks. The modeling exercise, which is based on solutions proposed by farmers and is tested under the SSP3 Climate Change Scenario, indicates transitioning to crops with low water requirements, and high nutritional and economic value—such as ‘Triticum turgidum var. durum’—is the most effective approach to reduce vulnerability to climate change and its shocks.
While water harvesting and hydropower are considered less effective solutions. Finally, this paper proposes an integration of the Participatory Approach with the Climate-Water-Energy-Food System thinking approach for Socio-economic development.