



Achieving Climate-Land-Energy-Water Sustainable Development Goals in the Indus Basin

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The Indus Basin, home to approximately 300-million people, has a total area of 1.12 million km² (47 % Pakistan, 39 % India, 6 % Afghanistan, and 8 % China) and the highest density of irrigated land in the world. The region's rapid population and economic growth in recent decades is expected to continue in the next decades leading to growing demands for water, energy and food. With no abundant surface water left in the basin for future expansion and accelerating use of groundwater, long-term strategic and integrated management of water and its interlinked sectors (the so called water-energy-land nexus) is fundamental for the sustainable development of the region. We developed the NEXus Solutions Tool (NEST), an open source computing framework that links an engineering-economic model, representing investment and allocation decisions up to 2050 across water, energy and land-use sectors, to a hydrological model, representing the detailed biophysical processes at high spatial and temporal resolutions. We provide insights into (1) the vulnerability of surface water and groundwater resources to future socioeconomic and climatic change; and (2) how policies, technological solutions and investments can improve the sustainability of water, energy and land transformation pathways while avoiding unintended side effects and minimizing trade-offs among sectors. Initial results show very different optimal investment portfolios for each country in the basin, due to the different strategic access to the main river flows. Stability of policies (such as the Indus Water Treaty) will be important, and new investments (especially in renewable energy, water distribution and water treatment technologies) will be required for achieving sustainable development goals in the water, energy, and food sectors. This study also highlights, under different socio-economic and climate scenarios, which provinces and regions might be mostly exposed to water and food scarcity, and what investments are required to adapt to future challenges.