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The Way Forward

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The Way Forward

The years 2009–11 offer a perspective on the current challenges of water and agriculture, along with mounting future uncertainties Pakistan's government faces at both federal and provincial levels. From the dramatic increase in food prices to the floods of 2010 (resulting in US\$10 billion in damages and losses), managing these many forms of resource variability and uncertainty has become vital for this agricultural and water economy. The prospects of climate change may amplify these concerns. Moreover, with continued growing populations and increasing water demand across all sectors, these risks must be anticipated and managed.

This study focuses on the impacts of climate risks and various alternatives faced by water and agriculture managers on water and crop productions in the Indus Basin of Pakistan. This study analyzes the inter-relationships among the climate, water, and agriculture sectors to support the prioritization and planning of future investments in these sectors. The important role that water management plays in the productivity of the agriculture sector and overall food security is recognized in many different forums and policy reports in Pakistan. However, these linkages are not always comprehensively addressed (with systems-based models) in federal and provincial planning documents and budgeting. This study provides a systems modeling framework for these purposes.

Several different models are integrated in this work. This includes a model of Upper Indus snow and ice hydrology (critical for determining overall water availability), an optimization agro-economic model of the Indus Basin Irrigation System (IBIS), and an updated computable general equilibrium (CGE) model of Pakistan's wider macro-economy. This integration of models helps to frame recommendations for strengthening water, climate, and food security planning, policies, and research priorities for the Indus Basin.

This analysis first identified some of the key hydroclimatic sensitivities and more robust aspects of the IBIS. Second, the models used here are among the best mathematical representations available of the physical and economic responses to these exogenous future climate risks. However, like all modeling approaches, uncertainty exists as parameters may not be known with precision and functional forms may not be fully accurate. Thus, careful sensitivity analysis

and an understanding and appreciation of the limitations of these models are required. Further collection and analysis of critical input and output observations (for example, snow and ice data) will enhance this integrated framework methodology and future climate impact assessments.

Key Messages

- *Given the orographic complexity of the Upper Indus Basin, future climate impacts are highly uncertain.* The variability of the system is moderated by snow and ice dynamics. Using a simple model of the dynamics of the water and energy balance in the Upper Indus Basin, glacier melt contributes an estimated 15 percent of flow to the total. That is, the system is largely a snowmelt-dominated basin in which future changes will largely be dependent on changes in winter precipitation. Thus, future changes are difficult to predict because of counterbalancing effects of changes in temperatures and precipitation. Because of the complexities at these high elevations, general circulation models (GCMs) are unlikely to have much value for forecasting purposes. There is a need for major investment in snow and ice hydrology monitoring stations, further scientific research, and forecasting to improve the hydrologic predictability of the Upper Indus Basin.
- *The 1991 Provincial Water Allocation Accord (DIVACRD) is a critical hydrologic constraint in the system.* According to model results, if the Accord is relaxed and optimal economic allocation between and within provinces is allowed, both Punjab and Sindh could benefit. The system-wide net revenue will increase by about PRs 158 billion (almost US\$2 billion): PRs 83 billion additional in Punjab and PRs 82 billion additional in Sindh. Moreover, by relaxing the Accord and implementing an economically based water allocation mechanism, provinces will be better able to manage extreme events by more reliably meeting system-wide demands. This would need to be supported by investment in effective, transparent, real-time water delivery measurement systems; capacity-building in Indus River System Authority (IRSA) and Water and Power Development Authority (WAPDA) for technical decision-support systems and forecasting; and equally substantial investment in trust-building among stakeholders. Even though it is unlikely and probably unwise that the Accord constraint should—*by itself*—be relaxed, there is room for flexible policy adjustments and mechanisms within the wider framework of the present Accord (for example, interprovincial exchange of surplus allocations, water banking, and leasing arrangements), which the modeling results suggest should be pursued on agro-economic grounds.
- *Future climate risks are estimated to impact the macro-economy and households.* Gross domestic product (GDP), Ag-GDP, and household income are estimated to decrease on average in the future by 1.1, 5.1, and 2.0 percent, respectively. In the most extreme future (when inflow is 90 percent exceedance probability

and the temperature increases +4.5°C), GDP, Ag-GDP, and household income are estimated to decrease by 2.7, 12, and 5.5 percent, respectively.

- *Future climate change risks could impact crops in Sindh more than in Punjab.* Sugarcane, wheat, cotton, and irrigated rice demonstrate the greatest climate sensitivity. The model results indicate that under the most extreme climate condition, crop production in Sindh is estimated to decrease by 36 percent, compared to 5 percent in Punjab. Sugarcane will be affected the most both in terms of production (20 percent) and revenue (13 percent). Furthermore, these impacts are conservative as the model used the assumption that the biological crop yield response is unchanged due to the heat stress, disease, and extreme events caused by climate risk (beyond those changes due to water requirement). To be effective, especially in the context of changes under the 18th amendment to its constitution, Pakistan's new climate change policy will require substantial advances in coordination among federal, provincial, and local agencies—and new mechanisms for the transparent real-time information exchange with private-sector and civil society organizations.
- *Non-farm household incomes will suffer more under climate risk scenarios due to increased crop prices.* In general, crop production is estimated to decrease and crop prices increase. Since the increase in prices is larger than the decrease in production, farm-related households will likely benefit. However, non-farm households (for example, urban) will have to pay more for food, thus resulting in decreasing household incomes.
- *An increase in basin-wide storage will increase the hydropower generation and minimize the impacts of extreme events.* However, additional storage will not significantly increase agricultural benefit (assuming no expansion of the current irrigated area). A modeled storage-yield relationship is determined and demonstrates that in terms of food production, additional storage will not have a significant influence, especially for high flow or normal flow years. Only during the drought years can additional storage maintain food production at a normal level and probably only for a year and not for multiyear sustained events. The frequency of future extremes is inconclusive. The main economic benefits from storage will be from power generation. This finding recommends that a near-term modeling priority be the integration of energy security, both in the power sector, which includes hydel, and the petroleum sector, which includes light diesel oil used by the majority of tubewells in Pakistan.
- *Different adaptation investments show potential to minimize the impacts of future climate risks and meet food security objectives.* Investments in canal and watercourse efficiency and in crop technologies are estimated to increase average crop production by 5–11 percent. This will have positive impacts on

the macro-economy and households. These investments are still vulnerable under low-flow drought conditions. On the other hand, investment in additional storage (NEWDAM) significantly reduces these impacts and this inter-annual variability.

- *Climate change is estimated to impact future food availability on a nationwide scale.* The supply of protein and carbohydrates from wheat will be lower than the forecast future demand under climate change by the 2050s and 2080s. Model results suggest that the investment in crop technologies to improve yields can help to balance this. Disaggregating these findings by province shows that Punjab is able to meet its protein and carbohydrates demands, even out to the 2080s. The real challenge will be in Sindh, even as early as the 2020s, under the assumption that interprovincial patterns do not change. This concern is amplified by the regionally low level of current food security in Sindh in the 2011 National Nutrition Survey.
- *Groundwater depletion in the fresh water area and basin-wide salinity issues will become worse if no policy intervention is made.* The analysis reveals that groundwater is a key resource in the Indus and that the net revenues lost (as a percentage of the baseline) are not that significant under a scenario where safe groundwater yields are enforced. However, the long-term trends are troubling. The net recharge in fresh groundwater areas are negative in all provinces with the largest values estimated in Punjab, which suggests continued declining water tables. This also contributes to increased saline water intrusion. In addition, salt accumulation is positive in all provinces and in both fresh water and saline areas. Given the scale of these issues, a new phase of truly visionary planning is needed for conjunctive management of surface and groundwater management.

Final Thoughts

The precise impact of these climate risks on the Indus Basin remains to be seen. This much is known, however: climate change will pose additional risks to Pakistan's efforts to meet its water and food security goals, which are key to reducing poverty, promoting livelihoods, and developing sustainably. As the Pakistan population grows, the ability to meet basic food requirements and effectively manage water resources will be critical for sustaining long-term economic growth and rectifying widespread food insecurity and nutrition deficiencies. These are challenges above and beyond what Pakistan is already currently facing, as evidenced during the 2009–11 time period. Strategic prioritization and improved planning and management of existing assets and budget resources are critical. These strategic choices will be largely dependent on a sound assessment of the economics of these impacts.

The integrated systems framework used in this analysis provides a unique, broad approach to estimating the hydrologic and crop impacts of climate change

risks, assessing the macro-economic and household-level responses, and developing an effective method for assessing a variety of adaptation investments and policies. In assessing the impacts, several different modeling environments must be integrated to provide a more nuanced and complete picture of how water and food security interrelate. Moreover, such a framework allows for extensive scenario analysis to identify and understand key sensitivities. This is critical to making decisions in a highly uncertain future. Finally, through this integration of multiple disciplines, a richer and more robust set of adaptation investment options and policies for the agriculture and water sectors can be identified and tested. Continued refinements to the assessment approach developed in this volume will further help to sharpen critical policies and interventions by the Pakistan Government.

