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RESEARCH & INNOVATION

Water-Energy-Agriculture Nexus in Punjab: An Integrated Modeling Approach

The Centers for International Projects Trust (CIPT) is the India office of the Columbia Water Center. The main thrust of CIPTs work is to understand and perform applied research in the fields of water, energy, agriculture, climate, environment and economic improvements related to them.

While studying the nexus, CIPT has explored the relationship between water use and agricultural production, demand and supply of water in agriculture and its impact on the groundwater and power use in agriculture. The nexus explores the demand (or use) for water and electricity from industry, service and other sectors of the economy and the implications on economic outcomes in those sectors. Such an approach is likely to promote climate change adaptation, water sustainability, more effective planning in the agriculture sector and an

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overall higher economic output in the state economy.

Introduction

Water is the most important component of the sustainability debate in India. The total water available in form of precipitation amounts to 4,000 km³, of which 28 per cent (1123 km³) is available as utiliz-

able water in form of surface (690 km³) and groundwater (433km³). There are wide variations in the availability of water across the country with the drier regions having greater fluctuations in rainfall thus increasing the vulnerability of people to water scarcity.

The agricultural sector uses the maximum amount of freshwater in the country (around 85%), followed by the domestic and industrial sector (including water use for energy production). With, accelerated urbanization and agriculture transition, the social and cultural burden on water will change. There is no doubt that irrigated agriculture has led to food security, rise in farm incomes and poverty alleviation but the supply-driven approach has encouraged over-use of water, further widening the gap between water demand and supply (FAO, 2011).

The State of Punjab has experienced the momentum of green revolution during the late

1960s and early-1970s with successful adoption of modern seeds, input technologies and assured access to irrigation. This led to expansion of intensive agricultural practices within the state, resulting in greater access to groundwater resources and rising cropping intensity. This has led to over-exploitation of groundwater resources, which is now threatening the sustainability of agriculture within the state. The situation is further aggravated due to



a number of economic and non-economic factors such as heavy subsidy on electricity, diesel for irrigation and assured government output prices. The policy of free power supply for agriculture has been the most crucial factor for worsening the situation by promoting water intensive crops such as rice and also encouraging wasteful use of water for irrigation. Thus, the gap between demand and supply of groundwater resources has widened overtime.

However, the power subsidies in agriculture are rising substantially and are adversely affecting the productive investments in agriculture. The sub-optimal use of water and energy in agriculture has not contributed to any significant increase in agricultural production but has seriously hit the industrial and other sectors of the economy in terms of the availability of these resources and their resultant economic output. This points towards the need of examining the water-energy-agriculture nexus in Punjab. The nexus seems not only to have peculiar intra-sectoral linkages but also the inter-sectoral dependence, which has long-term implications for the overall economy of Punjab.

The water-energy-agriculture nexus in Punjab

An attempt to examine the water-energy-agriculture nexus in Punjab was undertaken by CIPT. While studying the nexus, we have explored the relationship between water use and agricultural production, demand and supply of water in agriculture and its impact on the groundwater and power use in agriculture. The nexus explores the demand (or use) for water and electricity from industry, service and other sectors of the economy and the implications on economic outcomes in those sectors. Such an approach is likely to promote climate change adaptation, water sustainability, more effective planning in the agriculture sector and an overall higher economic output in the state economy.

The nexus has been examined under different scenarios such as i) business as usual scenario, ii) crop diversification scenario and iii) technologies and practices scenarios. In the first scenario, the projections have been made under the usual production pattern being followed in agriculture without any change in the water and en-

TABLE 1: POWER CONSUMPTION VIS-À-VIS SECTORAL OUTPUT IN PUNJAB DURING THE DROUGHT YEARS

Year	% increase in State GDP over the previous year			% increase in the electricity consumption over the previous year		
	Agriculture	Industry	Overall	Agriculture	Industry	Overall
2002-03	-1.2	3.1	2.9	6.7	1.3	5.4
2009-10	-0.3	8.8	6.3	12.3	1.9	7.1

Source: Estimated by authors from Statistical Abstract of Punjab, Various Issues.

The agricultural sector uses the maximum amount of freshwater in the country (around 85%), followed by the domestic and industrial sector (including water use for energy production)

ergy using practices. However, the crop diversification options and wider adoption of water saving technologies and practices have been considered in the next two scenarios to examine the overall impact on the economy.

Results from the nexus

The inter-sectoral linkages of the nexus may be gauged from a simple example given below. During the drought years, when the rainfall is less than the normal, a significant amount of electric power is diverted to the farm sector to sustain the agricultural production. The diversion occurs from paying to non-paying sector. It causes a substantial rise in power subsidies, adversely affects the industrial and tertiary sector output without any significant improvement in agricultural productivity. The analysis of the data during two drought years of

2002-03 and 2009-10 reveals that the annual increase in power consumption in agriculture was very high (which is 7-12%) and that of the industrial sector was only 1-2%. While the state could not succeed in preventing the decline in agricultural output despite the diversion of electricity and relatively much faster depletion of the groundwater resource during these years

(water table declined by more than 1 meter each year, much higher than the normal years), the industrial sector and overall economy suffered due to rise in cost of production in response to decrease in electricity availability.

The results of the integrated model for the nexus reveal a significant decline in water use in agriculture due to crop diversification and widespread adoption of water-saving technologies and practices. While the crop diversification efforts can save 1.6 million ha meter of irrigation water, technologies and practices add to another 700 thousand meter of water savings. These water savings will not only help in improved allocation of water to the industry and household sectors but will also contribute to the long-term sustainability of this resource. The results further points towards substantial reduction in power subsidies, reduction in operational costs of other sectors and hence an increased economic output.

The integrated nexus modelling approach provides opportunities for optimization of the water and energy resources in a given state under different scenarios, which may yield improved outcomes from all the sectors of the economy. As the conditions of nexus may vary at the state level, greater understanding can help in classifying the regions and the nexus. Further, integrating different nexus typologies into the national level nexus can help in resource optimization of the entire country ◀◀

References

- FAO, 2012. Coping with water scarcity-An action framework for agriculture and food security. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London
- FAO, 2011. The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London.
- Kumar Rakesh, Singh R.D, Sharma K.D, Water resources of India; 2005, Current Science, VOL. 89, NO. 5
- Statistical Abstract of Punjab, various issues.