

# **Science-Policy Interface to Mitigate Water Scarcity in India: An Assessment of Virtual Water Flows**

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## **ABSTRACT**

Freshwater resources are essential for functioning of the economy, environment and society. From the perspective of sustainable development, the economy is considered as a subset of the environment. Therefore, freshwater resources act as both the source to, and the sink of the economy. Water security integrates the role of freshwater resources as a source as well as the sink of economy, through emphasis on 'sustainable use' of freshwater. Sustainable use of freshwater resources necessitates strengthening of science-policy interface to bridge the knowledge-governance gap in translating scientific knowledge into policy actions.

Virtual water (VW), which is an indicator of freshwater embodied in goods and services, was developed to induce and enhance sustainable use of freshwater resources in water-scarce regions of the world. VW-flows concept is at the science-policy interface. This is because it is based on the rationales of 'distribution of water scarcity' among regions with different water endowments, enhancing 'global water use efficiency' and 'net water savings'.

Sustainable use of freshwater resources is considered crucial for mitigating water scarcity, especially in emerging economies, like India. This is because while achieving higher economic growth and development, India's water sector is facing persistent challenges, as a result of which India has become the largest global freshwater user despite high water scarcity. The highest water using economic sector in India is agriculture, as it uses approximately 65-70% of

freshwater resources. The sector is also crucial for food security and livelihood security. With many regions in India facing water scarcity, there is a concern over sustainable water use in agriculture.

With this research background, the thesis aimed to carry out an assessment of inter-state VW-flows embedded in two major categories of agriculture goods, i.e., food grains and oilseeds, in India to quantify net water savings/losses of the state. The inter-state VW-flows assessment was carried out for two important phases of agriculture, i.e., *post-reforms period (1996-2005)*, the *period of recovery (2005-2011) up to 2014*. These periods were considered crucial for understanding the sustainability of inter-state VW-flows because they represent the period of transformation in water policy of India towards sustainability and water security, in addition to, recovery in agriculture growth after the reforms. The thesis also aimed to link these net water savings/losses of the states with their respective water scarcity levels, and water policies to identify the sustainability of VW-flows, i.e., whether the VW-flows are leading to the distribution of water scarcity or not. Therefore, the research intended to *firstly* provide evidence for mainstreaming water as a factor of production in policy decisions for sustainable use of freshwater resources. *Secondly*, to emphasize the importance of science-policy interface for the formulation of well-informed policies in order to address the issue of water scarcity adequately.

Interestingly, the findings of water scarcity assessment reflect that there is a variation in water scarcity of states in India. It ranges from low to moderate water scarcity in states of North-East zone; moderate in states of Central and East; moderate to high in states of North, South, and West; to high water scarcity in states of South, North, and West zones. It is crucial to emphasize here that the states experiencing moderate to high and high water scarcity are also major

producers of food grains and oilseeds. This leads to a concern of aggravation of water scarcity with continued production of food grains and oilseeds.

The inter-state VW-flows assessment revealed that there were net water savings of 89235 GL, and net water losses of -2124 GL due to the inter-state movement of food grains, and oilseed during post reforms period (1996-2005), respectively. The water savings increased to 207452974 GL and 84504 GL through inter-state movement of food grains, and oilseed in the period of recovery up to 2014 (2005-2014), respectively. This is attributed to increase in quantum of inter-state movement of food grains and oilseeds, yield, and water productivity.

At sub-national scale, unsustainable flows are seen as major VW-flows embedded in food grains from highly water-scarce North to highly water-scarce West and South, which is not distributing water scarcity. Unsustainable VW-flows embedded in oilseeds are from highly water-scarce South to North. The driving force of net VW- imports and VW-exports is larger population and arable land, respectively. As a result of inter-state movement of food grains and oilseeds during the post-reforms period (1996-2005), Maharashtra had the highest water savings while Punjab had the highest water losses. During 2005-2014, Tamil Nadu had the highest water savings, while Punjab continued to have the highest water losses. While both, Maharashtra and Tamil Nadu, water savings states in the two periods, regulate and manage water resources through state water policies, Punjab, the water losing state in both the periods, does not.

Linking the finding of net water savings/losses of the states with their respective water scarcity levels, and water policies revealed that absence of state-specific water policy cripples sustainable use of freshwater resources and water management, for instance, in Punjab. Based on five key indicators of science-policy interface - water scarcity inducers, water allocation priorities, water

use efficiency, water savings, and stakeholder's participation and water literacy to mitigate water scarcity, it can be inferred that there is a need to rethink water policy to strengthen science-policy interface which would enable formulation of evidence-based water policies as well as effective implementation.

Therefore, the research argues that internalizing water as a factor of production (water as a source and a sink to the economy), i.e. through VW research, in policy decisions on production, and inter-state movement of food grains and oilseeds is essential for sustainable use of land and water to mitigate water scarcity; and it is crucial to strengthen the science-policy interface for formulation of well-informed policies in order to address the issue of water scarcity adequately.

