Assessment of Virtual Water Trade Flows embedded in paddy for Sustainable Use of Water Resources in India

China, India, and USA are among the highest water users in the World. India, in fact, was the largest global water user in 1995 and 2008(Arto et al., 2012). There is a regional variation in water scarcity of India with high scarcity in western and southern regions and low scarcity in north eastern and eastern region. Water-intensive economic activities are concentrated in highly water scarce regions as water endowments was not a crucial component of economic decisions. Therefore, water security both at the regional and national level is a concern. Water security can be achieved through sustainable use; protection of water systems; protection against water induced hazards; sustainable development; safeguarding of access to water functions & services for humans & environment (Schultz & Uhlenbrook, 2007). It is also essential for food security, livelihood security and environmental sustainability.

Virtual Water (VW) is the water embedded in goods and services (Allan, 2011). The concept is at the science policy interface; its rationale is 'to distribute water scarcity' through identifying the unsustainable pattern of water use in trade flows. The study aims to address the research gap on inter-state virtual water trade (VWT) flows in India through determining 'water savings' and unsustainable patterns in inter-state movement of paddy in India during 1996 -2005.

VWT flows conceptual framework encompasses 'water footprints' (WF) and 'water savings' (Hoekstra et al., 2011). It is worth mentioning here that, Spain which is a water scarce economy recognized the utility of 'water footprint' concept in 2009. The country was the first to enact a regulation to use it as a tool for implementation of River Basin Management Plans, as prescribed by EU Water Framework Directive (Garrido, et al., 2010). India is also on the path of setting up institutional framework to recognize its importance. For instance, the conceptual framework figures in the Draft National Water Policy, 2012 of India as the need for assessment of water footprints and water savings in India is recognized for determining efficiency in water use (Government of India, 2012). XI five years plan of India (2007-12) introduced a section on 'water resources'. In the previous five years plans it appeared as a subcomponent of agriculture, energy and other themes. The current five year plan, i.e., XII five years plan aims for 'faster, more inclusive and sustainable growth process'. This is the first time five year plan has integrated the concept of 'sustainability'. In addition, a chapter on 'Sustainable Development and Climate Change' has been introduced in the annual Economic Survey, 2011-12. National Action Plan on Climate Change (NAPCC) of India is an outcome of this paradigm shift. VWT flows research also encompasses the challenges and emphasizes on the policy measures to develop 'water saving strategies', which will bring national as well as global benefits for India.

The VWT flow conceptual framework captures both the direct and indirect impacts, that is both water used and waste water generated. Water used is reflected in the green and blue WF and wastewater generated is reflected in grey WF. The average WF of producing each ton of paddy in India is higher than global average during 1996-2005. Among the three types of WF, green WF is the largest ranging from 40-89%, blue WF is 0-50% and grey WF is the least 7-15%. Total WF of producing paddy in India ranges from 1425 - 3009 m^3/ton with average of 2070 m^3/ton in comparison to global average of 1673 m^3/ton. The concern is that grey WF is very high in India which ranges from 197-282 m^3/ton. Even the minimum of the range is higher than the global average of 187m^3/ton indicating that wastewater generation in paddy cultivation is higher in all the states and UTs of India in comparison to the global average (Mekonnen & Hoekstra, 2010).

The water savings assessment using the Chapagain, Hoekstra & Savinje, 2006 methodology reveals that there were annual national water savings in the movement of paddy during 1996-2005, except in 1999-2000 and 2001-02. The largest national water saving was approximately 127.8 X 10^6 m^3 in 2002-03.Water loss occurs when there is a inter-state flow of goods from a region/ state with low high water footprint to low water footprint, i.e., production is more **water-intensive** in the state from where the good is ***exported from*** compared to the state to which the good is ***exported to.*** This represents an unsustainable pattern in the context of **water sustainability**. Magnitude of water loss in 1999-2000 is 0.3X10^6 m^3 and in 2001-02, it is 0.5X 10^6 m^3. The unsustainable patterns are reflected in flow from Uttar Pradesh to Bihar in 1996-97; Punjab to Assam in 1997-98; Madhya Pradesh to Assam in 1998-99; Rajasthan to Assam in 1999-2000 and others. The unsustainable patterns raise concern of water outflow from water scarce western and southern region to water rich northeastern and eastern region. Research on VWT flows reveals the water losses and unsustainable hotspots which would aggravate water scarcity. With the integration of water as a criteria for making economic decisions in water policy and economic plans there is an impetus to achieve water security through sustainable water use and flows in India.

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