Environment

Water Community

Food and Nutrition Security Community

Solution Exchange for the Water Community
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Discussion Summary

Developing an Indian Water Footprint

Compiled by Nitya Jacob, and Gopi Ghosh Resource Persons, Raj Ganguly, Consultant and Sunetra Lala and T. N. Anuradha Research Associates

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From Sudhirendar Sharma, The Ecological Foundation, New Delhi

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I work with The Ecological Foundation in New Delhi, a think-tank on environmental issues. We are currently working on the concept of Virtual Water (VW), propounded by Professor John Anthony Allan (http://en.wikipedia.org/w/index.php?title=John_Anthony_Allan&action=edit&redlink=1) from King's College London (http://en.wikipedia.org/wiki/King%E2%80%99s_College_London) and the School of Oriental and African Studies (http://en.wikipedia.org/wiki/School_of_Oriental_and_African_Studies). The VW content of a product (commodities, goods or services) is the volume of freshwater used to produce the product, measured at the place where the product was actually produced (production-site definition). 'Virtual' refers to the fact that most water used to produce a product is not physically contained in it. It measures how water is embedded in the production and trade of food and consumer products. You can read more on the website, http://www.waterfootprint.org/?page=files/home.

VW has had a major impact on global trade policy and research, especially in water-scarce regions, and has redefined the discourse on water policy and management. 'Virtual' has become 'real' in water policy discourses across the world, more so as the world grapples with the twin issues of water scarcity and food security. Members may recall a debate on VW in Punjab a few years ago, that called for cropping changes to replace water-guzzling crops like paddy and wheat. It was argued that while contributing food grains to the national food kitty, the State was exporting its precious water; each kilo of paddy consumes over 3,000 litres of water and wheat, between 1,000-1,500 litres.

Given the fact that water scarcity is a very real problem, VW is fast becoming an economic and political tool. However, it is not politically neutral, as it influences control of a country's agriculture, industry, livelihoods and food sovereignty (what should farmers grow, and for whom, etc.?). We are thus, trying to evolve an Indian VW Footprint. We request members' experiences, advice, and views on the following:

- The parameters and methods to calculate regional and national water footprints
- A suitable pricing mechanism for products and services that reflects their 'virtual water footprint'
- Share experiences from India or abroad where farmers have been encouraged to reduce their water footprint
- Virtual water becoming a soft option to the 'hydraulic mission' of large projects such as interlinking of rivers

We will use members' inputs and suggestions to develop an India-specific VW footprint that will be shared back with the Communities.

Responses were received, with thanks, from

1. **Mahtab S. Bamji, Charitable Trust, Hyderabad**
2. **Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad (Response 1; Response 2; Response 3; Response 4)**
3. **J. David Foster, Administrative Staff College of India, Hyderabad (Response 1; Response 2)**
4. **A. Prabaharan, Public Action, New Delhi**
5. **B. R. Mangurkar, Consultant, Nashik**
6. **Sunetra Lala, United Nations Children's Fund (UNICEF), New Delhi (Response 1; Response 2)**
7. **Jyotsna Bapat, Independent Consultant, New Delhi**
8. **Pravakar Rath, Department of Library and Information Science, Mizoram University, Aizawl**
9. **Abhishek Mendiratta, Consultant, New Delhi (Response 1; Response 2)**
10. **Saju C. Mannarath, Global Water Partnership (GWP), Bangalore**
11. **Sanjay Singh, Independent Consultant, Bhopal (Response 1; Response 2)**
12. **Satya Prakash Mehra, Rajputana Society of Natural History (RSNH), Rajasthan (Response 1; Response 2; Response 3)**
13. **S. Vishwanath, Biome and Arghyam, Bangalore**
14. **Sudhirendar Sharma, The Ecological Foundation, New Delhi**
15. **Ravi Singh, Margshree Farm, Agra**
16. **B. C. Choudhury, Wildlife Institute of India, Dehradun**
17. **Mamta Borgoyary, Winrock India, Gurgaon**
18. **A. J. James, Environmental and Natural Resource Economist, Gurgaon**
19. **Jos C. Raphael, CECOD, Trichur**
20. **Alice Lakra, University of Edinburgh, United Kingdom**
21. **Ajay Rastogi, The Viveka Centre, Ranikhet**
22. **Abhishek Mendiratta, Consultant, New Delhi (Response 1; Response 2)**
23. **Himanshu Thakkar, South Asia Network on Dams Rivers and People, New Delhi**
24. **Devendra Sahai, Global Warming Reduction Centre, New Delhi**
25. **Kamala Krishnaswamy, Independent Consultant, Hyderabad**
26. **K. A. S. Mani, Andhra Pradesh Farmer Managed Groundwater System, Hyderabad**
27. **Rajesh Shah, blog.peerwater.org, Bangalore**
28. **Nitya Jacob, United Nations Children's Fund (UNICEF), New Delhi**
29. **Virendra Kumar, Indian Farm Forestry Development Cooperative, New Delhi**
30. **Chris Morger, Intercooperation, Switzerland**
31. **Kalyan Paul, Pan Himalayan Grassroots Development Foundation, Uttarakhand**
32. **Vijayakumar V. Sarraju, National Institute of Hydrology, Deltaic Regional Centre, Andhra Pradesh**

33. **Arun Jindal, Society for Sustainable Development, Karauli**
34. **Arunabha Majumder, Presidency College, Kolkata**
35. **Manjula Menon, M. S. Swaminathan Research Foundation, Chennai**
36. **K. K. Datta, National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi**
37. **K. V. Peter, Kerala Agriculture University, Thrissur**

Further contributions are welcome!

Summary of Responses
Comparative Experiences
Related Resources
Responses in Full

Summary of Responses

The Virtual Water Footprint (VWF) is a measure of the quantity of water used, directly and indirectly, by a consumer or producer. It denotes how much water consumption is necessary to create one unit (usually a tonne) of a product. "Virtual" implies the water is either physically contained in the product, used to manufacture it, or utilized to grow it, as in agriculture. Therefore, each commodity, individual and country has a VWF. VWF helps determine the water intensity of products, and the two components, internal and external, aid in figuring out whether a country or region is a net water exporter or importer.

Discussing the development of an Indian VWF, members suggested a rough framework for calculating an "Indian VWF" based on India's climate, geography, agricultural practices and ecology. This is a first step towards a model that will reflect Indian priorities and practices, as existing models have evolved in the West, reflecting western farming and industrial processes in the formulae.

Regarding the **need for an Indian VWF**, while some members felt it was an abstract concept, others said the Community has the responsibility to develop an Indian VWF, and explain the concept to laypersons. The first group thought it would be hard to explain to the farming community and stressed the water crisis in India is 'real', rather than 'virtual'.

To **calculate a national VWF**, it is necessary to calculate water footprints for individual products as well as the parameters for agriculture. A water footprint for an agricultural community in a region is the amount of water used to produce a unit weight/volume of a commodity or the amount of water embedded in unit weight/volume of that commodity multiplied by the total weight/volume of that commodity consumed per capita in a year multiplied by the population size.

There are well-established methods for measuring the amount of water used to produce a unit of a commodity. Using this method, it is possible to determine the Water Footprint of a community or nation. For example, for milk, it is a function of the water productivity of various inputs for dairying such as fodder (dry and green), the feed and drinking water consumed by the livestock in the region and the milk yield. The International Water Management Institute developed an equation - called "Effective Agricultural Water Withdrawal" that measures each component of water use.

The next step towards determining a national VWF, for which the formula is *IWFP (Internal Water Foot Print) = AWU (Agricultural Water Use) + IWW (Industrial Water Withdrawals) + DWW (Domestic Water Withdrawals) –* VWE_{dom} (*Virtual Water Exports*) with respect to domestically produced goods.

Along with working out a calculation for India, VWFs helps determine if a region or country is a **net exporter or importer of water**. For example, Egypt saved 2,700 million cu. m. in global water transfers by importing maize. Using VWF, governments/organizations can help pinpoint places where cropping patterns or industrial production processes do not match water availability and take corrective action. It also helps in figuring out where a crop can be grown most water-efficiently. This takes into account renewable water availability instead of resource availability linked to the amount of arable land. For example, wheat grown in Punjab has a smaller virtual water component than that grown in Bihar, even though Punjab has less physical water than Bihar; the result is a net water transfer from Punjab to Bihar. States with a large VWF, such as Mizoram, members pointed out, can reduce their footprint through appropriate watershed management.

Farmers in several instances have reduced the water-intensity of their crops. For example in **Andhra Pradesh**, farmers achieved this by switching to more efficient irrigation techniques and improved groundwater management. Another method is the System of Rice Intensification that reduces the water needed to grow rice by 40 per cent. In **Pune, Maharashtra**, a pilot project examined farmers' existing water management practices, supplements it with improved practices and creates a tool that can be used by a range of stakeholders; it is being tried out on 30 sugarcane farmers. In **Agra**, a farmer switched to growing barley, a crop that was traditionally substantially grown in the region along with pulses before the Green Revolution. In **Andhra Pradesh** and **Karnataka** farmers rotate crops to match the water available in wells.

Another issue raised was how VWF can affect food and livelihood security as in India. Sixty percent of the population is directly or indirectly dependent on farming for their income. For the footprint to have a positive impact, members felt is it necessary for an expert to explain the concept of water footprints to farmers, to help persuade them more easily to shift to less water-intensive crops. For example, the region around Bharatpur, Rajasthan, used to receive abundant rainfall, but has had a drought for the past several years. Instead of changing their cropping patterns, farmers have sunk deep borewells and agitated for water from distant sources.

The **limitations with using the Water Footprint**, is it assigns the same value to water regardless of its source, which is misleading. It needs to incorporate a variable dependent on the source of water – stating whether the water is available naturally or because of a human intervention (dam, canal, etc) - and its ecological cost. The concept ignores other factors that affect productivity, as in Kerala**.** VWFs are also commodity-specific and do not factor in the economic capacity of the producer. This is critical to understand in India where most farmers are subsistence farmers, because though they are often more water-efficient than large farmers, they bear the brunt of commodity price fluctuations. Determining crop prices based on VWFs could affect them more adversely.

VWF cannot be used to calculate the true price of products because water is not the sole input, and is seldom accurately priced. It is also not a determinant of international trade, because water tends to flow from water-poor to water-rich countries and from water-poor regions to water-rich regions. Trade is generally more dependent on government policies and comparative advantages than water footprints.

In spite of these limitations, overall the discussion indicated the need for an Indian VWF and a mechanism for working it out. However, members cautioned against using it as the sole means of determining agricultural practices, while simultaneously agreeing the Water Footprint was a useful tool for making farmers understand the need for water efficiency. Finally, they advised not to blindly adapt existing tools for calculating the VWF of a particular crop, commodity or individual to the Indian context.

Comparative Experiences

Andhra Pradesh

Adoption of Water Efficient Technologies Help reduce Water Footprint, Hyderabad *(from K. A. S. Mani, Andhra Pradesh Farmer Managed Groundwater System, Hyderabad)*
The Andhra Pradesh Farmer Managed Groundwater Systems (APFMGS) project has enabled farmers to reduce their groundwater use in 650 villages in seven districts. 30,000 groundwater users have reduced their groundwater pumping by adopting new practices and improving the water-use efficiency. The farmers have been contributing in reducing water footprints by striking a balance between the total water demand and available renewable water sources through the use of new technology. Read more

Maharashtra

Agricultural Water Initiative Proves an Effective Assessment Tool, Pune *(from Mamta Borgoyary, Winrock India, Gurgaon)*
The Agriculture Water Initiative was a pilot project that sought to explore improved agricultural water management practices in sugarcane cultivation. This tool was administered across 30 sugarcane cultivators during the 2006-07 planting season. Applying the assessment tool to sugarcane cultivators revealed that use of the application is not limited to areas where water availability is a constraint but also to water abundant areas, and may be useful for VW concepts as well. Read more

Uttar Pradesh

Switching from Wheat to Barley Reduces Water Usage, Agra *(from Ravi Singh, Margshree Farm, Agra)*
A farmer shifted from wheat to barley in 2007. Barley required half the water that wheat cultivation did. Less water usage has also meant less fertiliser inputs (reducing expenses on ferliliser). Along with cutting costs and water uses, the farmer also substantually increased the yield and received a good price for barley crop, due to the global shortage.

Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Orissa and West Bengal

System of Rice Intensification (SRI) Helps Reduce Water Footprint *(from Sunetra Lala, UNICEF, New Delhi; response 1)*
The SRI method of rice cultivation was introduced in over thousands of hectares and has proved beneficial, increasing rice yield by 8 tonnes per hectare irrigated, and reducing by half the amount of water under the traditional method of rice cultivation. Changing cultiavtion methods has also helping reduce the regions's water footprint, allwoing more virtual water to be consumed and exported. Read more

Andhra Pradesh and Karnataka

Crop Rotation Helps in Water Management *(from Ajay Rastogi, The Viveka Centre, Ranikhet)*
The Pani Panchayats set up by Tarun Bharat Sangh talked farmers into planning long-term crop rotation and restricting their water intensive crops to certain acreages. Under a FAO led project, farmers have been planning crop rotations on a wider scale to match the water availability in the wells. This has helped farmers select the crops to be grown based on the recharge of well determines and water availability.

Related Resources

Recommended Documentation

From Mahtab S Bamji, Dangoria Charitable Trust, Hyderabad

Status of Virtual Water Trade from India

Article; by Vijay Kumar and Sharad K. Jain; Current Science, Vol. 93, No. 8,25 ; October 2007
Available at http://www.ias.ac.in/currsci/oct252007/1093.pdf (PDF Size: 84 KB)

Presents a review of virtual water content of various products estimated for India and gives the status of virtual water trade taking place from India.

Virtual Water Trade
Article; by Mahtab Bamji and Vijay Kumar annd Sharad K Jain; Current Science, Vol. 94, No. 3; 10 February 2008
Available at http://www.ias.ac.in/currsci/feb102008/293.pdf (PDF Size: 34 KB)

Clarifies that crops that require less water have a higher virtual water content because of the vast gap between potential and actual productivity

Virtual Water in Global Food and Water Policy Making: Is There a Need for Rethinking? (*from Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad)*
Paper; by M. Dinesh Kumar and O. P. Singh; Springer Netherlands; 10 September 2004; Permission Required: Yes, paid publication
Abstract available at http://www.springerlink.com/content/y354865rq7t51532/

Analyses the availability of renewable freshwater and the net virtual water trade in 146 nations, demonstrating that a country's virtual water trade is not determined by its water situation.

Common Wealth (*from A Prabaharan, Public Action, New Delhi)*
Book; by Jeffrey Sachs;The Penguin Press; 2008; Permission Required: Yes, paid publication
Abstract available at
http://www.amazon.com/gp/reader/1594201277/ref=sib_fs_top?ie=UTF8&p=S00N&checkSum=O9P20VaEQHpXdK3RJgbZe8Uwu7CywcRG3rlhXIlh6qg%3D#reader-link

Elaborates on the world's water problems and suggests a new economic paradigm that is scientifically-based on environmental considerations, including using tools like virtual water

New Hope for India's Agriculture and Water Resources? (*from Sunetra Lala, UNICEF, New Delhi; response 1*)
Newsletter; by Himanshu Thakkar; South Asia Network on Dams, Rivers and People; April 2005
Available at http://www.narmada.org/sandrp/MarApr2005.pdf (PDF Size: 560 KB)

Mentions a new system of rice cultivation, that could help reduce India's Water Footprint, has been 'discovered'- only requires half the amount of water currently used

Agricultural Water Initiative (*from Mamta Borgoyary, Winrock India, Gurgaon)*
Project Details; Winrock International India, September 2007
Available at http://www.winrockindia.org/act_proj_nat_agric_water_initi_3.htm

Seeks to examine low-cost, water efficient methods for sugarcane cultivation through research on existing and improved water management practices to avoid higher water prices in future

From Nitya Jacob, UNICEF, New Delhi

Water Footprints of Nations: Water Use By People as a Function of their Consumption Pattern
Article; by A. Y. Hoekstra and A. K. Chapagain; Water Resources Manage; 2006
Available at http://www.waterfootprint.org/Reports/Hoekstra_and_Chapagain_2006.pdf (PDF Size: 434 KB)

Study has calculated the water footprint for each nation of the world for the period 1997–2001 and is a valuable tool in developing local footprints

Going Against the Flow

Report; by S. Verma, D. A. Kampman, P. van der Zaag and A. Y. Hoekstra; UNESCO-IHE Institute for Water Education; Netherlands; March 2008
Available at http://www.waterfootprint.org/Reports/Report31-India.pdf (PDF Size: 580 KB)

Critical analysis of the virtual water trade in the context of India's National River Linking Programme

Appraisal and Assessment of World Water Resources *(from Chris Morger, Intercooperation, Switzerland)*
Paper; by Igor A. Shiklomanov; State Hydrological Institute, St.Petersburg, Russia; International Water Resources Association (IWRA), Vol. 2, No. 1; March 2000
Available at http://www.ifu.ethz.ch/GWH/education/undergraduate/Wasserhaushalt_GZ/mat2.pdf (PDF Size: 372 KB)

Analysis of how global water resources assessments are made regarding virtual water, the pitfalls and the assumptions

Groundwater Management in India *(from Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad; response 2)*
Book; by Dinesh Kumar; Sage Publications; February 2007; Permission Required: Yes, paid publication
Abstract available at
http://www.sagepub.co.uk/booksProdDesc.nav?currTree=Subjects&level1=B00&level2=B20&level3=B23&prodId=Book230893

Documents new methodologies, analytical procedures and criteria to analyze groundwater use in agriculture and water intensity of milk production, in order to reduce the water footprint

Water Footprints of Nations *(from Manjula Menon, MSSRF, Chennai)*
Report; by A. K. Chapagain and A. Y. Hoekstra; UNESCO Institute of Water Education; November 2004
Available at http://www.waterfootprint.org/Reports/Report16Vol1.pdf (PDF Size: 2.6 MB)

Recommends using the water footprint concept as a practical tool to analyse how consumption patterns affect water use and future water use changes

From T. N. Anuradha, Research Associate

Water's Vulnerable Value in Africa
Report; by P. Van der Zaag; UNESCO-IHE Institute for Water Education; Netherlands; July 2006
Available at
http://www.waterfootprint.org/Reports/Report_22_Water_vulnerable_value_in_Africa.pdf (PDF Size: 400 KB)

Argues water obtains value in the process of utilising it, reviews four aspects of water use and explores the effects these have on how the water is valued.

Global Water Governance
Thesis; by Maarten P. Verkerk; University of Twente; Netherlands; July 2007
Available at http://www.wem.ctw.utwente.nl/onderwijs/afstuderen/afstudeerverslagen/2007/Verkerk.pdf (PDF Size: 600 KB)

Suggests using Water Footprint Permits and Business Agreement to promote a sustainable approach to water governance by governments, civil society and businesses.

Valuing and Charging for Water
Report; UN Department of Economic and Social Affairs
Available at http://www.unesco.org/bpi/wwap/press/pdf/wwdr2_chapter_12.pdf (PDF Size: 1.6 MB)

Page 421 explains virtual water in Middle Eastern nations that have altered trade and development policies to promote the import of water intensive products

The Concept of 'Virtual Water' — A Critical Review
Report; Frontier Economics; Victorian Department of Primary Industries; January 2008
Available at
http://www.dpi.vic.gov.au/DPI/nrenfa.nsf/LinkView/A1F945CE4D56F40ACA257412002310642B72296A5108C4FFCA25734F0009F96F/$file/Virtual%20Water%20-%20for%20release%20-%20STC%2008-03-07.pdf (PDF Size: 246 KB)

Examines the methodology for estimating virtual water and identifies several important flaws in the virtual water concept.

From Sunetra Lala, Research Associate

Globalization of Water
Book; by Arjen Hoekstra and Ashok Chapagain; University of Twente; Blackwell Publishing; December 2007; Permission Required: Yes, paid publication
Abstract available at http://www.blackwellpublishing.com/book.asp?ref=9781405163354

Review of the critical relationship between globalization and sustainable water management, explores the impact of international virtual water trade on local water depletion

The Price of Water: Studies in Water Resource Economics and Management
Book; by Stephen Merrett; IWA Publishing; 2007; Permission Required: Yes, paid publication
Abstract available at
http://books.google.com/books?id=Y2Df_e1hBlEC&dq=virtual+water%2Bbook&source=gbs_summary_s&cad=0

Topics include the virtual water controversy, farmer's water rights, the economic demand for water, the cost and use of irrigation water, etc

Everything You Know About Water Conservation Is Wrong
Article; by Thomas M. Kostigen; Discover-Science, Technology and the Future; USA; May 2008
Available at http://discovermagazine.com/2008/jun/28-everything-you-know-about-water-conservation-is-wrong

Explains how thinking about water differently should be a moral imperative, and discusses the geopolitical implications of virtual water trading

When the Rivers Run Dry: Water--The Defining Crisis of the Twenty-First Century
Book; by Fred Pearce; Beacon Press; 2006; Permission Required: Yes, paid publication
Abstract available at http://www.amazon.com/When-Rivers-Run-Dry-Water/dp/0807085723

Addresses how the world is running out of water. The book contends that the Western water "footprint" on the rest of the world is a major problem

Recommended Organizations and Programmes

Water Footprint Network, The Netherlands (*from Sudhirendar Sharma, The Ecological Foundation, New Delhi)*
c/o University of Twente, Horst Building, P.O. Box 217, 7500 AE Enschede, The Netherlands; Tel: 31-53-4894320; Fax: 31-53-4895377; info@waterfoorprint.org;
http://www.waterfootprint.org/?page=files/home

Increases awareness on water footprint among various stakeholders how consumption of goods and services relate to water use and impacts on fresh-water systems

Andhra Pradesh Farmer Managed Groundwater Systems (APFMGS), Hyderabad *(from K. A. S. Mani)*
Block No. A-2(c), First Floor, Huda Commercial Complex, Tarnaka, Hyderabad 500007, Andhra Pradesh; Tel: 91-40-27014730; Fax: 91-40-27014937 info@apfamgs.org;

http://www.apfamgs.org/Default.aspx

Enabling farmers with skills, capacity and knowledge to reduce their water use thereby their water footprint striking a balance between total water demand and available water sources

Redefining Progress, United States *(from Rajesh Shah, blog.peerwater.org, Bangalore)*
1326 14th St. NW, Washington, DC 20005 USA; Tel: 202-234-9665; Fax: 901-234-9665; http://www.rprogress.org/sustainability_indicators/genuine_progress_indicator.htm

Advocates the "Genuine Progress Indicator" as an alternative to the gross domestic product measuring resource depletion (including water), health, safety and other indicators of well-being

Recommended Portals and Information Bases

Virtual Water, World Water Council *(from T. N. Anuradha, Research Associate)*
http://www.worldwatercouncil.org/index.php?id=866

Provides relevant documents, reports and links on virtual water to help people consciously choose the virtual water trade as an effective way to promote water saving

From Sunetra Lala, Research Associate

The Virtual Water Project, Germany
http://www.traumkrieger.de/virtualwater/

Contains a series of posters which show how much freshwater is used to produce selected products - hoping for people to rethink their water footprint

The Concepts of Water Footprint and Virtual Water, India
http://www.gdrc.org/uem/footprints/water-footprint.html; info@waterfootprint.org

Provides information on the concept of water footprint and virtual water and provides information on the Virtual Water Trade Research Programme

Recommended Tools and Technologies

Water Footprint Calculator *(from Nitya Jacob, UNICEF, New Delhi)*
Software; Copyright of Arjen Y. Hoekstra, Ashok K. Chapagain and Mesfin M. Mekonnen
Available at http://www.waterfootprint.org/index.php?page=cal/waterfootprintcalculator_indv_ext

Water footprint calculator assesses unique water footprints, the calculations are based on the water requirements per unit of product in country of residence.

Global Water Tool *(from Sunetra Lala, UNICEF, New Delhi; response 2)*
Software; Owned by World Business Council for Business Development
Available at
http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?type=p&MenuId=MTUxNQ&doOpen=1&ClickMenu=LeftMenu. (Excel; Size: 5.2 MB); GlobalWaterTool@wbcsd.org

Tool for companies and organizations to map their water use and assess risk relative to global operations and supply chains

Recommended Upcoming Events

Reforms in the Irrigation Management for Effective IWRM, Bangalore, 18-20 December 2008
(*from Kamala Krishnaswamy, Independent Consultant, Hyderabad)*
Organized by Central Board of Irrigation and Power, New Delhi. Information available at http://www.solutionexchange-un.net.in/environment/cr/res08100803.doc (Doc, 253kB); Contact Central Board of Irrigation and Power; Secretary; Fax: 91-11-26116347; sunil@cbip.org

Focus on diagnosing existing irrigation services and modernization options, new economy and investments and other pathways for high irrigation efficiency and to reduce water footprint

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Responses in Full

Mahtab S. Bamji, Dangoria Charitable Trust, Hyderabad

An interesting article entitled 'Status of virtual water trade from India' by Vijay Kumar and Sharad K. Jain appeared in Current Science vol.93: No 8, 25 October 2007. This article gave a table according to which virtual water content of millets, sorghum and lentils is higher than that of rice and wheat. I was quite surprised and discussed this issue with some agriculture scientists.

My response was published in Current science Vol 94: February 2008. A copy of my letter and the authors' response are at http://www.solutionexchange-un.net.in/environment/cr/res08100801.doc (Size: 40 KB). The bottom line is: the so called dry land crops which grow in lesser water, and are believed to be less water guzzling, have higher virtual water content because of vast gap between potential and actual productivity - almost 300 per cent according to a recent lecture of Prof. M. S. Swaminathan. This perhaps explains why the farmers prefer to cultivate paddy as long as there is water to grow it, in the dry land area where we work- Medak district of AP. Better management practices to improve productivity of millets and pulses which are nutritious crops is needed.

Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad *(response 1)*

I have got another unpleasant surprise for some of you on the virtual water trade front. While it has been argued (for the past 15 years or so) that virtual water can be used as an economic tool for dealing with water scarcity of water-scarce countries and that it would improve global water use efficiency, the research we undertook in IWMI-TATA water policy programme showed that at the operational level, it is near to impossible at the global scale.

What is interesting is that virtual water flow is from water-scarce countries to water-rich countries and from water-scarce regions to water rich regions within countries. The factor which influences virtual water trade is not renewable water resource availability, but access to arable land (all expressed in per capita terms). The amount of virtual water trade/capita is a function of per capita gross cultivated land. Many water rich countries of the world are net importers of virtual water, and they do so because they do not have sufficient arable land to produce food.

So, if we think that water-scarce countries can start importing food from water-rich countries, you can go thoroughly wrong! Most of those countries which are exporting large quantities of agricultural commodities are land rich, but water-scarce countries. With a given amount of land to cultivate, a fixed quantum of soil moisture is guaranteed for crop production. Therefore, we coined a new term called Effective Agricultural Water Withdrawal by countries, which takes into account water in soil profile used by crops, along with diversion from annual runoff and groundwater pumping. Analysis showed that this is a linear function of arable land, and it directly impacts on virtual water trade.

This is what emerged from an analysis of data from 145 countries. Of course, the agricultural and trade policies also influence these. But, agro-hydrology is the primary governing factor.

The same trend was seen when we analyzed certain regions within countries. North China plains (arid and semi arid, water scarce) produces a major chunk of china's agricultural outputs, though small in geographical area--goes to water rich south west China, which is land scarce. North Gujarat produces a lot of milk, which is exported to other parts of India, and account for 2,200 MCM of groundwater pumped annually. Reversing this trend is not difficult, but almost impractical. The only thing which can be done is to improve water use efficiencies in crop production in water scarce regions (like Punjab, north Gujarat, north China plains), which are agriculturally prosperous.

Thereby, one can reduce the virtual water export and resource depletion in those regions. In nutshell, what is happening with food trade most often is not virtual water trade, but virtual land trade! When Bihar imports food grain from Punjab or AP, it is not gaining water, but virtual land which is scarce there.

If anyone of you are interested in the paper which was published in Water Resources Management "Virtual Water Trade in Global Food and Water Policy Making: Is There a Need for Rethinking? by Dinesh Kumar and O. P. Singh, we would be more than happy to share.

J. David Foster, Administrative Staff College of India, Hyderabad *(response 1)*

Congratulations on the development of a very useful concept. I believe that many of the benefits of Virtual Water can be accomplished by getting the prices right. If the real value of subsidized irrigation water was reflected in its price then far less of that water would be wasted and water intensive crops would no longer be grown in water scarce areas.

Likewise if the crops reflected the real value of the water used in raising them then fewer crops would be used for raising meat. Ultimately it is the well intended but economically wasteful use of subsidies to hide the true value of scarce resources that creates many of these problems to begin with.

A. Prabaharan, Public Action, New Delhi

Virtual water trade front is a novel measure to solve the perennial water crisis. It is not only the Indian states are fighting every day for water but also the global battle is very grim. Although the new proposals like virtual water are exciting to hear the crux of the problem lies elsewhere. In the cyber age, virtual is prefixed to any age-old phenomenon and given a new twist. Some of the virtual ideas got transformed into action. I wish virtual water takes off the ground.

More than the introduction of virtual water, researchers must go into the bottom of the water problem. A root digging into water issue will reveal more socio-political angle to it than the user dimension. Jeffrey Sachs in his recent book Common Wealth elaborated water problems in the world in detail. Several non-technical studies have proved many dimensions to water problem. Prof. Andre Betlie's study about the Gujarat drinking water crisis shows that women walk four kilometres for gossipping rather than fetching water.

I must request you to check these twisting issues before widen virtual water theory for implementation in India.

B. R. Mangurkar, Consultant, Nashik

I shall very much appreciate receiving a copy of the paper titled, "Virtual Water Trade in Global Food and Water Policy Making: Is There a Need for Rethinking?"

Sunetra Lala, United Nations Children's Fund (UNICEF), New Delhi *(response 1)*

As the largest water user, accounting for over 80 per cent of the global total water withdrawal, food production is directly constrained by water scarcity. Nearly 60 per cent of the water used in agriculture is wasted; this means 1,500 trillion litres of the 2,500 trillion litres of water used in this sector goes to waste. Farming accounts for 70 per cent of the world's accessible water. Rice is one of the most water-intensive crops and India has the world's large area under rice cultivation, despite a major water crisis.

I had attended a presentation and discussion on the System of Rice Intensification (SRI) by Professor Norman Uphoff from Cornell University, which was organised by the South Asia Network on Dams, Rivers & People. The discussions revealed how the adoption of new methods such as the SRI can help India meet the ever-increasing water needs of the country and reduce India's water footprint.

SRI was initially developed in the 1980s in Madagascar and has been demonstrated to be effective in 28 countries. It is based on eight principles, which are different from conventional rice cultivation. They include developing nutrient-rich and un-flooded nurseries instead of flooded ones; ensuring wider spacing between rice seedlings; preferring composts or manure to synthetic fertilizers; and managing water carefully to avoid that the plants' roots are not saturated.

Under SRI, tried over thousands of hectares in states such as Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Orissa and West Bengal, it has been shown that rice yield can be raised to 8 tonnes per hectare with half the water. If this method is adopted by just half of the 24 million hectares in which rice is grown, we can add 6 million hectares of irrigated areas with the water saved, thereby reducing India's water footprint. It will also bring down the Virtual Water (VW) we consume, as well as export.

The concept of VW (water content of the products consumed, traded and exported) will become an important factor in the future to determine what a country produces and exports. Can we as a country afford to continually export rice, sugar, etc, which are very water intensive or is there a need to reconsider India's water footprint and, therefore, our agricultural products and trade policies? The only argument favouring VW exports is more efficient use of water in agriculture but this can happen only once we understand the VW of products consumed and exported.

VW trade generates water savings for importing countries but may create deficiency in exporting countries. In 2000, the maize imports in Egypt and the related VW transfer thus generated global water savings of about 2,700 million cu. m. The global real water savings are significant, as recent estimates show that water savings from VW transfer through food trade amount to 385,000 million cu. m. Globally, the trade in VW is rising rapidly. It increased in absolute value from about 450 cu. km in 1961 to 1,340 cu. km in 2000, reaching 26 per cent of the total water required for food production, including equivalence for sea products and sea fish.

Agriculture will have to respond to changing patterns of water availability and the demand for food, especially among marginalised communities. It will have to compete for scarce water with other users and reduce pressure on fast dwindling water resources. Water will be the key instrument in this drive to raise and sustain agricultural production to meet these multiple demands. Agriculture policies and investments will need to become much more strategic and will have to unlock the potential of agricultural water management practices to raise productivity, spread equitable access to water, and conserve the natural productivity of the water resource base. And, it is here that the concept of virtual water will gain increasing significance.

Jyotsna Bapat, Independent Consultant, New Delhi

The immediate image of water and food sectors combined throws up for me are the floods and droughts, and issues of disaster management that Indian states have been dealing with over the past several centuries. So while negotiating water sharing for food security is an important topic, I feel water and disaster management would be an important topic for discussion.

But the water sector should be treated as a loose matrix and water uses such as drinking, transport, fishing, sewage, waste water, industrial pollution, irrigation, etc., with different people and communities associated with that would have to be included in such a disaster impact analysis.

Thus developing a water footprint needs to go beyond the food and include other sectors under three types of circumstances, surplus precipitation, drought and 'normal' conditions.

Pravakar Rath, Department of Library and Information Science, Mizoram University, Aizawl

Thanks for sending this write up on "Virtual Water".

This issue is in fact a concern the world over, which requires a policy at both national and international level. Scarcity of water is a major issue today and is likely to be a bigger global concern/warning in future; this may not only affect human life but agricultural, industry and trade as well.

The UN Solution Exchange in general and "Water Community" in particular may come up with some solutions to this problem through a national level workshop or symposium of experts and research to address this issue and the measures needed to be implemented by government and non-government sectors.

Abhishek Mendiratta, Consultant, New Delhi *(response 1)*

I think we should be practical rather than virtual. If you try to create something virtual, you will always forget natural. We should always remember Gandhi ji's talisman (How this will help the poorest of poor) before creating any new concept.

Saju C. Mannarath, Global Water Partnership (GWP), Bangalore

For a layperson to the Water Community, the terms virtual water and water footprint are abstract and difficult to understand. And naturally, it will be not easy to influence the ordinary people to respond in a 'responsible' way to the growing (virtual) water crisis. People understand water scarcity when their taps run dry for few days or their wells dry up. They wonder why not all the water flooding some parts of country could not be saved and used later or diverted into areas where there is deficit. These are issues related to 'real' water which we 'see'. And, we need to strengthen workable solutions for effectively using the 'real' water. Integrated Water Resources Management (IWRM) plays a vital role in this area.

It is indeed necessary to understand the consequences of depending on food that require high consumption of water. But, it is like talking about depletion of ozone layer and global warming. They are good ideas but have very few takers. Yet, someone has to be concerned about it with an eye on the future.

Sanjay Singh, Independent Consultant, Bhopal *(response 1)*

I do agree with Saju Mannarath's concern. Being in the sector does not mean to make the communication more complex like virtual water. Sunetra Lala had mentioned in her response to the community that "Nearly 60 per cent of the water used in agriculture is wasted; this means 1,500 trillion litres of the 2,500 trillion litres of water used in this sector goes to waste".

We know that over-extraction of ground water is because of over reliance of irrigation on groundwater not because of drinking water which ultimately effects the availability of drinking water also. Why don't we think about saving this 60 percent of water instead of getting in to virtual water which is purely for the intellectuals and would take another decade to understand by the commons?

We need to think and implement integrated resource management (which should include cropping patterns, etc) waste water reuse and management in a broader perspective.

Satya Prakash Mehra, Rajputana Society of Natural History (RSNH), Rajasthan *(response 1)*

I am from the largest state of Republic of India, i.e., Rajasthan. As we all know that 60 per cent of the geographic area of this state is desert. Water scarcity and drought are very common and frequent in this belt but last decade has been especially severe. Take the example of Barmer and Bharatpur. Barmer is a desert but heavy rains in last few years flooded it completely. On the other hand, Bharatpur, which is prone to flooding, faced an acute water scarcity and now water crises are common.

What are the thoughts in the minds of the residents of the two areas? The people of Barmer know what drought is and conserve every drop of water. Now the excess water is a problem for them in many ways.

The people of Bharatpur never thought of the water conservation but now water conservation is becoming a major issue.

These were just two examples. There are lots of examples where flooded water and/or water crises are/is creating problem.

What I would like to state is the following:

In Bharatpur, water intensive crops were common in the past when the area received heavy rainfall and was prone to flooding. However, the crop pattern has not changed with the change in the rainfall patterns. The only change was a decrease in the production. The farmers used to draw water from deep bore wells and were not willing to shift their traditional crop patterns. For them, a water shortage means non-availability of drinking water.

What can one suggest to them in such cases? They are not ready to think of the excessive requirement of water consumed by their usual crops. Is it possible to share the concept of virtual water with them? It is worthwhile to make them shift their cultivation habits.

In their views the government/administration should try to solve their water problem. The Bharatpur region is well-known for its water-induced conflicts such as happened with the construction of the Panchana Dam and the subsequent stoppage of the Gambhiri River. This affected the 500 downstream villages and the world heritage site - Keoladeo National Park.

So I would like to support the views of Saju. Concept of virtual water in Indian concern is somewhat difficult, whatever the cause may be.

J. David Foster, Administrative Staff College of India, Hyderabad *(response 2)*

I like your candid opinion. Would Rajasthan be better off with water and power subsidies that camouflage the true scarcity of these resources, augmented by policies that then seek to restore balance by "virtual water", and regulations that attempt to tell farmers what they can plant and not plant.

Or should this be done by real prices that reflect the true value of the resources and provide incentives for conservation and use of less water-intensive crops in water-scarce regions?

S. Vishwanath, Biome and Arghyam, Bangalore

Virtual water with its pros and cons does not make the situation complex; it seeks to understand an already complex situation with water and food trade. The groundwater extraction mentioned in Sanjay Singh's response is also very much part of virtual water.

The last two arguments are very curious to me: “We don't understand it/common man does not understand it, it is difficult to communicate to people, so let us forget about it”.

I would request the group to keep Sudhirendra Sharma’s question in mind and answer it based on their experiences. Let us share experiences because this is the strength of the community.

With no offence to anybody.

Sudhirendar Sharma, The Ecological Foundation, New Delhi

The responses to the virtual water query have been interesting, tossing up new insights. Let it be clear that `virtual water footprint' is becoming more of a norm than exception in global food and water discourses. Much before we realise, someone will provide us information on `our' water footprints. Whether or not virtual water footprint as a concept gets accepted here, it is likely that information on water footprints will get developed by ‘others'.

Therefore the challenge is to develop parameters, considering our agro-climatic and socio-economic variations, to determine our water footprints – which may not be same in Punjab as compared to, say Rajasthan. This may help determine food movement and food distribution across states, in addition to its pricing. Further, it will provide insights on whether or not food from water scarce area is moving to water rich areas, and what indeed should be the rationale for ascertaining food production, movement and distribution. Like the markets, collapse on the fresh waterfront is imminent and hence the urgency to get our acts together in building a new understanding on water.

Ravi Singh, Margshree Farm, Agra

Being a farmer, this is very interesting. Many years ago, I did the sums (quantity of water) for wheat. I figured out then that I should be bottling water rather than farming!! Another way of looking at it is you should perhaps be paying more for my wheat!!

The Government of India has also been making the right noises about evaluating crops and output in terms of water efficiency.

Last year I switched to barley, a crop that was traditionally substantially grown in the Agra region along with pulses before assured water and the Green Revolution. This has half the water requirement of wheat. My fellow farmers questioned this as we have fixed monthly electricity billing for our pump set. But what they forgot was less water also means less fertiliser inputs and interestingly I got a staggering yield and very firm prices for barley with a global shortage.

If farmers continue to guzzle water, we have an environmental time bomb in the making.

Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad *(response 2)*

The most recent responses on water footprint from Mr. Satya Prakash are quite thought provoking. But, it also motivates me to write about the notions of water scarcity. Mr. Satya Prakash mentions "water scarcity in Rajasthan" in the passing. So, also for many of us it is water-scarce. Traditionally, we have looked at water resource availability of a region in terms of rainfall, and later on in terms of renewable water availability per capita. But, now there are increasing evidences to suggest that there are less than adequate to draw any inference about water availability for human populations, for various social, economic and environmental uses, and also for the ecology.

If we actually look at the renewable water availability in Rajasthan, it is 784 m3/capita/annum, against 1513 m3/capita per annum in water-rich Kerala. So, as per M. Falkenmark's index of physical water-scarcity, the state can be called "water-scarce". But, by the same norm, Kerala will not be water rich, but "water-stressed" as the renewable water is below the 1700 m3/capita mark.

Now, if we actually also consider the amount of water really available to communities in this region (Rajasthan), through direct use of rainwater (green water), the per capita effective water availability becomes 1612 m3/annum in Rajasthan; but it rises to only 1780/annum in Kerala. This basically shows that the direct water use from rainfall in crop production is a critical element in deciding the water availability and water scarcity situation in Rajasthan, which has a net cultivated area of 15.6 m. ha. Whereas in Kerala, the total net cultivated area is only 2.19 m. ha!

Things don't end here. The actual water utilized in Kerala is much less than what is "utilizable". For instance, only 15 per cent of the utilizable groundwater is actually withdrawn (nearly 1.0 BCM), where as it is higher than the replenishable groundwater in Rajasthan (CGWB estimates of 2004). For surface water, the percentage is slightly higher (around 22-25 per cent). So, the actual water accessible to the people is much less than the figure of 1780 m3/capita. The real reason is the very low per capita land available for cultivation (0.07 ha) against 0.27 ha per capita in Rajasthan in most cases. As a result, Kerala has to import nearly 75 per cent of the food it consumes from AP and Punjab (if I remember correctly).

So, if we call Rajasthan water-scarce, what category, Kerala will fall under?

You don't have to believe these figures. But, what is important is to recognize the fact that we need to change the way we look at food security and water management challenges faced by regions and communities. Currently, green water (water directly used by crops from the soil profile, which is available through precipitation) is not considered in renewable water availability calculations.

Also, it is important to recognize the fact that there is very high inter-annual variability in low rainfall regions of India, including Rajasthan and many parts of Gujarat (as high as 60-80 per cent in many parts). Such regions will face droughts, and floods. This is not an uncommon phenomenon in these parts of the world. But, unfortunately, this "climatic variability" is confused with climate change. What is important is to have long term observations to see the cycles, rather than looking at 5-10 years of data.

Hope this note is useful. I am attaching an excel sheet I used for calculations, for your ready reference http://www.solutionexchange-un.net.in/environment/cr/res08100802.xls).

B. C. Choudhury, Wildlife Institute of India, Dehradun

I can not agree less with Mr. Satya Prakash. I was in the Thar Desert last week and spent a considerable time travelling through the desert, but was surprised to see increasing efforts by farmers (perhaps prosperous ones) to shift their attention to water intensive crops, perhaps due to the recent floods and/or the gradual intrusion of the Rajasthan canal in to the desert.

It is completely another matter how and what ecological impact the canal water will have for the desert-evolved flora and fauna and the lifestyle of people in the region, but what needs to be looked at is how justified is the intention of our planners to promote water-intensive crops to the desert while it is well-known that sharing of water is a perpetual socio-political problem. Does it not make sense to promote less water-intensive traditional crops, which in any case are now far too expensive and are probably grown in far lesser degree than before?

Virtual or real water, the issues are largely to bring more and more land under some form of agricultural productivity, not necessarily to increase the food production but perhaps enhance the value of land in the real estate. A case in point is the enhanced purchase of land in the Rajasthan desert areas by fictitious personalities which has also been a cause of worry for security reasons.

How does the ICAR and our Agriculture Ministry look at the so-called disproportionate but natural water regime of our country and plan eco-compatible cropping patterns for various Agro-climatic regions? Does it not make sense to subsidize and even provide a higher purchase price for less water-intensive crops in arid and semi-arid regions by promoting and encouraging farmers to grow them, rather than spend a fortune to create irrigation infrastructure which only inflates the per unit area cost of irrigation?

Mamta Borgoyary, Winrock India, Gurgaon

The Agricultural Water Initiative launched by Business for Social Responsibility, USA (www.bsr.org) was piloted by Winrock International India, New Delhi in collaboration with MITCON Consultancy, Pune in western Maharashtra, India in 2007. This pilot project sought to explore improved agricultural water management practices in sugarcane cultivation. It aimed to pilot test a water management tool to assist farmers in assessing, monitoring, and improving their water management practices. This tool was administered across 30 sugarcane cultivators for the 2006-07 planting season. By helping assess water used in sugarcane cultivation, the tool may be useful in working on a larger virtual water footprint.

The rationale for this project is that with the continuing depletion and degradation of surface and ground water, sugarcane cultivators will almost certainly face higher prices for water in the future which will result in higher prices further up in the supply chain. Further, increasing water scarcity could lead to more and more farmers abandoning the cultivation of water-intensive crops, such as sugarcane.

The overall purpose of this project is to examine farmers' existing water management practices, supplement it with improved practices and create a tool that can be used by a range of stakeholders. These include farmers, food and agri-business companies. It would help assess and evaluate water management activities at the farm level. More specifically, this pilot project aims to test and develop a water management tool to assist farmers in assessing, monitoring and improving their water management practices in sugarcane cultivation This phase of the project aimed to pilot test the assessment tool in order to gauge its applicability and refine it to enhance its effectiveness.

The tool (developed by BSR and modified to local context by WII) being piloted is based on five impacts that it aims to assess, nine indicators that assist in assessing these impacts and twenty metrics that help define the indicators. The expected outcomes from applying this tool are to:

1. Create farmer profiles based on the identified indicators
2. Identify areas for improvement in crop production
3. Facilitate development of efficient water and crop management strategies, in terms of:
    a. Technology
    b. Change in practice
    c. Access to information / knowledge

The tool was tested across 30 farmers, 10 each from three Cooperative Sugar Mills situated in and around Pune district in Maharashtra. Based on the three rounds of data collection profiles of each of the 30 farmers were prepared and translated into the local language (Marathi) and distributed to each of these farmers for their own records.

Application of the assessment tool revealed that almost two-thirds were over-irrigating their crop. Despite this, around 90 per cent were still making varying degrees of profits on the sale of their cane to sugar mills. This current disjunction between excessive irrigation and profits is possibly one of the significant reasons for the general reluctance of farmers towards shifting to improved water management practices and technologies. However, in the long term the correlation between the two could become more evident if remedial steps are not taken. Further, over-application of water impacts soil health which consequently would affect the productivity of other crops that are sown following the sugarcane crop.

Applying the assessment tool to sugarcane cultivators revealed that its application is not limited to areas where water availability is a constraint but also to water abundant areas. This indicates that the tool is focused on water management, independent of water availability and that it aims to promote cost efficient and sustainable agricultural practices.

It is also critical to note that it is not only do decisions made at the farm level, that affect the productivity and returns to the farmers, but there are other influencing factors, both internal and external. Soil type is an on-farm factor that will influence productivity and thereby the returns, whereas larger market and policy issues strongly influence returns from the sale of the crop.

A. J. James, Environmental and Natural Resource Economist, Gurgaon

Yes, I agree that virtual water is an interesting theoretical concept, but understanding it enough to change water use patterns is a much more difficult concept. The basic idea is simple enough: water is embodied in products made by consuming water (e.g., crops). So, if water-scarce areas import crops (or other products) produced in water-rich areas (and presumably using more water), then it is as if water itself is 'virtually' imported into the water-scarce area.

Such trade could allow residents in water scarce areas to enjoy products that require more water to produce, than is available locally. But this critically presumes that water availability is the main determinant of price – with water-abundant areas having lower prices than water-scarce areas for the same products. This need not be true, and in fact, as Dinesh had pointed out, there are other factors that affect trade, such as land scarcity. In fact, trade theory (e.g., Nobel Prize winning economist Paul Krugman) shows that areas with similar endowments trade with each other in similar commodities!

Economists would argue that for the common man, the main factor determining the demand for commodities, whether they contain more virtual water or not, is price. Similarly, the main factor affecting the use of commodities, whether water or fertilizers or vegetables or cars, is the cost. While other factors such as terms of credit, relationship with the seller/agent and brand preference definitely affect consumer behaviour, the main factor remains price. And the Indian consumer is notoriously price conscious, as all companies trying to penetrate the rural Indian market have found out.

Thus, the (relative) price is undoubtedly the most potent force to curb wasteful water use, or the use of scarce water to grow sugarcane or paddy price. Raise the price of water, or of the electricity used to pump the water and lower the support prices for paddy or sugarcane, and the production for paddy or sugarcane will come down - as will the demand for water. The remaining paddy or sugarcane producers will be the efficient ones, using sprinklers, drips, modern cultivation techniques and successfully negotiating input and output prices with market agents.

Yet, such a move will have a high social (and political) cost of forcing less efficient farmers out of business. These costs are likely to fall more on small farmers, even though large farmers could be the more wasteful ones! This is because small farmers will be adversely hit even by small changes in profits. Larger farmers affected will usually have past savings to fall back on, and may sell and move to urban areas. Affected small farmers will normally migrate to urban areas to work as labour.

However, the interesting question is what will happen to agricultural production overall: will total agricultural land remain the same with a redistribution of land from the small and marginal farmers (60-70 per cent of all landholders) to the larger landholding 'commercial farmers'? Or will total agricultural come down with farmers 'cashing in' on the prospect of selling to non-agriculturists (e.g., SEZs)? Even if such a scenario may not result from changing prices - because of the political backlash - such change is happening in rural India, quietly and through the market forces. Agricultural is no longer profitable for the small farmers, who are migrating in large numbers to urban areas, and the educated, commercial farmers are reaping the benefits of modern technology and practices and generating profits by even exporting crops.

Thus, ironically, although the small farmer is extremely efficient in input use, including water, there is not enough surface and groundwater to support them - due to wasteful use by larger farmers and the neglect of traditional water management practices. So, either they will just survive as subsistence farmers or get into debt chasing groundwater through bore wells. Wasteful water use by the relatively well-off does not affect their profits much, because of the low price of irrigation water.

Thus, efficient water use will happen more easily with 'smart' farmers - with the understanding to use technology to save on scarce resources (like water) and the business acumen to target profitable crops and markets - and the foresight to produce in response to changing market trends. The survival of the small farmer depends on how quickly and how well they can imbibe these lessons - but the danger is that their surface water sources can be affected badly by wasteful water use by urban areas and pollution and over-extraction of groundwater sources by their neighbours. Changing water use patterns throughout the country is the need of the hour - and it does not look as if the notion of 'virtual water' will help much in this regard.

Perhaps a more profitable area of enquiry is 'adaptation to water scarcity' rather than 'mitigation of water scarcity' - just as in the case of climate change.

Jos C. Raphael, CECOD, Trichur

To me, water security does not always leads to food security. IWMI - Tata Water Policy Research Programmes have analysed these issues.

To share my experience from Kerala, the state has abundant uncultivated paddy fields which are shrinking due to pressure on land. People instead get their rice from other southern states. The younger generation of farmers (paddy) compares it opportunity cost or time and money with other secondary or third sector jobs, and prefers them to paddy farming. Paddy farming also has problems of non-availability of labour, unexpected rains and other risk factors. At the same time, Kerala gets better rainfall for Kharif and Rabi seasons than is supported by irrigation canal water. It looks "virtual water" may not be able to fully address the food production scenario.

Coming to Sudhirendar Sharma’s request for evolving an Indian VW Footprint, I share my observations and experiences below:

The parameters and methods to calculate regional and national water footprints: Education and attitude of farmers; societal appreciation about a farmer in comparison with other sector jobs; wage rate comparisons; food habits; culture, availability of labour; political will and congenial environment; market fluctuations of factors of production; urbanization; visual communication influences; interest and knowledge of youth for food cultivation; geography; hydrology; water administration; credit administration; fertilizer supply; rainfall fluctuations; water charges; subsidies; water recharge; opportunity cost comparisons for food crop with other sector employment and; many other factors related with water and agriculture.

A suitable pricing mechanism for products and services that reflects their ‘virtual water footprint’: As David Foster commented, subsidy reductions of various natures may be helpful.

Share experiences from India or abroad where farmers have been encouraged to reduce their water footprint: Local experience given above.

Virtual water becoming a soft option to the 'hydraulic mission' of large projects such as interlinking of rivers: Replicable models tested elsewhere are to be modified suited to local conditions and to be treated with caution.

Satya Prakash Mehra, Rajputana Society of Natural History (RSNH), Rajasthan *(response 2)*

I agree with David Foster's statement. I feel, based on observations from the Bharatpur region, farmers will not adopt any new concept until they feel secure about it. Instead of explaining to them virtual water or similar concepts, we have to develop a practical and applicable model to assure water security.

The farmers in this belt will not consider any option when water is scarce but instead demand more water, and get it by hook or by crook, no matter how deep they have to bore. If they are financially sound, they will dig deep bores rather switching to crops that are less water-intensive; otherwise, they will not grow anything. These habits aggravate the situation.

Therefore, farmers have to be exposed to experiences from target areas that give them a sense of security. Things may go well in laboratories, but have to work in real life and this is possible only when they are field tested in these deprived regions. We draw up policies and concepts in ideal situations but ground reality if somewhat different. For the concept of virtual water to work, it has to be associated with the ground realities of farmers from different regions.

I could only present my views that while framing the concept diversity of land should be considered along with the living standard/ lifestyle and perception of the people dependent on agriculture. These are only my views and observations, which I discuss with the rural people from targeted areas of our studies.

Sanjay Singh, Independent Consultant, Bhopal *(response 2)*

Apologies if I have offended anybody. My comments are based on my own experiences. I feel we have lot of things to do to ensure water for communities instead of discussing virtual water which, while it is important, may be mistimed in the Indian context where we are struggling issues of scarcity and wastage.

We have to come up with innovative solutions to supplement water, its management, management of sources and conservation. Conservation would cover groundwater and waste water reuse by education at the lowest level.

Nearly 60-70 per cent of water supplied to households comes out as grey water that can be easily treated and put under to use. Cisterns used in urban toilets require 10 to 15 litres of water. A family of 5 in a house will use the toilet at least thrice a day times, and therefore, waste almost 200 litres of water. The water used in toilets is the same as used for drinking or cooking, and the waste from toilets is combined with grey water (from kitchens and bathrooms). However, grey water can be recycled for use in toilets to avoid wasting potable water through a dual water supply system.

Dinesh Kumar, Institute for Resource Analysis, Hyderabad *(response 3)*

The basis for estimating the water footprint of a region or nation lies in three important factors: 1) the level of consumption of various goods/agricultural commodities (cereals, vegetables, milk, meat, oil etc.) per capita; 2) the size of population; and 3) the place of production of these commodities, which actually determines the amount of water embedded in these commodities.

The water footprint for an agricultural community in a region = the amount of water used to produce a unit weight/volume of that commodity or the amount of water embedded in unit weight/volume of that commodity* total weight/volume of that commodity consumed per capita in a year* the population size.

If one takes the water footprint of milk consumed in a region, for instance, the amount of water used to produce a litre of milk (water embedded in a litre of milk) needs to be first estimated (see Singh, 2004; Kumar, 2007 for methodologies). This is a function of the water productivity of various inputs for dairying such as fodder (dry and green); feed and drinking water consumption by the livestock in the region where it was actually produced rather than where it was consumed; the quantum of these inputs used by the dairy animal and the amount of milk yield.

The first set of analysis involves estimation of water productivity (WP) of the dairy inputs (biomass) in kg/cu m of water. This is estimated by taking the crop yield and the amount of water actually consumed by the crop in evapo-transpiration (ET) (i.e., Y/ET)

So, WP for a given crop is a function of climate, soil fertility, etc., as they determine the yield, and the amount of water consumed by the crop till it matures.

If we assume that just 10 kg of green fodder is used by a dairy animal (hypothetical) on a average day in the entire animal life cycle, and the water productivity of green fodder is 2 kg/cu m, and the animal produces 4 litres of milk a day (on an average), then the water embedded in one litre of milk is 1.25 cu m (1/[4/(10/2)]). One animal will have a water footprint of 1.25 cu m for milk alone.

So, if a region has a population of 1 million people, and an average person in that region consumes 200 ml of milk per day, then the water footprint for that region from milk alone comes to 91.25 million cubic metres of water per year! You can work out the same for cereals, oil, vegetables, etc. For cereals etc., it will be easier as it involves estimating the total cereal consumption, the amount of water needed to grow the cereal and yields in the region where it is produced. So, for assessing the water footprint (WFP), tracing the place of production is very important. A person consuming wheat produced in Canada will have much lower WFP as compared to one who consumes wheat from Egypt or Punjab, even if both eat the same amount.

Similarly, if an Assamese consumes the milk produced in Gujarat, his/her water footprint would be much higher than if a Gujarati consumes the same quantum of milk produced in Assam. This is because of the climate advantage Assam has in producing milk using less water.

That said, Punjab might stand first in terms of virtual water export; but, its water footprint may not be as high as that of Kerala, which has to depend on rice produced in AP or Punjab. Those states have semi arid to arid climates, and therefore, low water productivity for rice consumed; and also consume a lot of meat.

There are quicker ways to estimate WFPs of a region by taking the net of water consumed in all production systems requiring water in the region (domestic use, agriculture, industry) and the net virtual water export (agricultural and industrial commodities). Here, water footprint estimation methodology become simpler if there is not virtual water import or export. Hoekstra and A. K. Chapagain have recently produced a paper (2007) which talks about broader methodologies titled "Water footprints of nations: Water use by people as a function of their consumption pattern". (http://www.waterfootprint.org/Reports/Hoekstra_and_Chapagain_2006.pdf, PDF, 80 KB).

Hope this is useful to the community. I will be writing about how to reduce the water footprint in another email using agricultural water management interventions. Another quick solution is "eat less meat (chicken) and drink less milk and beer!"

Hope this note is useful.

[Alice Lakra](), University of Edinburgh, United Kingdom

It is indeed an interesting and relevant concept even though it might still be in its nascent stage. The responses are thought provoking and diverse and show that to certain extent we all agree on the importance of tracing or at least keeping a tab on the H_2O footprints via traded consumables. There have been concerns in this forum with regard to the relevance of the concept of Virtual Water Footprint (VWF) to the common (wo)man a.k.a Mr. Layman.

I agree at this stage the concept may sound little theoretical and abstract just as carbon footprints were a couple of years ago. Who would have thought one day there would be such a thing called Clean Development Mechanism and Carbon Trading across countries? It was not meant for the common village person or the lay person then but today its benefits are being reaped by many even, though it may be tagged with its own nuances. But then what is a perfect solution for an imperfect problem?

We need to give things time before such profound concepts can be understood by laypersons like me but that doesn't mean we wait until some aliens from Mars drop us a manual on how to calculate water footprints on earth. Or perhaps we would be more receptive if that came from an XYZ University in the US or UK. If the world waited for the last layman in some village in Bastar to understand carbon footprints, it would not be trading in carbon and emission reduction now. Somewhere, things have to start. And we can have progressive and aware farmers like Mr. Ravi Singh who can be our local heroes and influence their neighbouring farmers!

I do not know much about VWF but I think it is about time when we do something that uses our knowledge and experience to simplify the issues. I guess the intellectuals, while finding ways to calculate carbon footprints, would have gone through a similar consultation process and have faced similar challenges.

It is true the rate of wastage is higher than actual utilization and yes, there may be threats to small farmers. Also, there may be cost implications for the products we middle class or lower class citizens in developing countries use. Considering that one kg of paddy consumes 3,000 litres of water, would I be made to pay 30 times more if the cost of water were to be accounted for? Are we on the brink of disturbing the pricing equilibrium at a time when food crises are hitting the headlines? Is it going to make it better or worse? Is it be wise to think of the interests of small farmers while the interests of millions of landless BPL people are at stake, on the pretext of how many gallons of water they might be consuming by eating one kg of rice. Will a time come soon when the <$1 a day bench mark be shifted to <1 kg of rice or <20 litres of H_2O a day?

My concern, however is while we are calculating water footprints, what is the value (price) of water the farmer pays for irrigating his acre of paddy field. If s/he is using water from free natural resources his/her expenses go towards cost of water or cost of energy incurred on procuring water. Does that become part of the energy-footprint or still remain in the domain of VW.

Do we consider run-off from the fields which may result in water wastage? Also, naive as it may sound, if we were to put an appropriate price tag and calculate water-footprints on other products, how much would a kilo of fish cost at the end of the day in the domestic and international market? Do we have a baseline of ground or surface water availability based on different agro-climatic zones to value the cost of water availability in that region. For example, would the cost of 1000 litres in Rajasthan be higher than in West Bengal?

What should be the role of various stakeholders in making this work:

- Scientists working out the cost of water utilization
- Industry to recycle and treat their waste water
- Governments to think of ways to safeguard the interests of large, medium and small farmers
- Farmers to take measures to reduce wastage.

However, this would come at a secondary stage after the methods have been established to calculate VWF.

How do we start? Perhaps, if I were to go about it, I'd start with industry as it would be easier to work out through a recorded production process and would be easier to monitor. Calculating VWF on agricultural products would have to keep in mind the following:

- Dynamics based on land-use patterns
- Agro-climatic zones (do crops in Rajasthan use same amount of water as in Goa or Jharkhand?)
- Product-specific water consumption levels
- Geological features of the given area
- Cost of energy involved (do farmers in Rajasthan incur same cost as farmers in Bihar, even after subsidies - and what are state-centric policies).

And what about possible conflicting scenarios in shared water resources between regions. Do we account for upstream and down-stream water quality while pricing water? What about rain-fed crops? What about when (hypothetically) rain-fed wheat is mixed in sack containing irrigated wheat – should the price of that sack be averaged? How do we determine its source? What would be cost of doing so? Is there a point in going to those levels of finer details in tracking the water-footprints?

If no, what is the point in the entire exercise? If yes, what should be the optimal level beyond which there are diminishing returns? Therefore, perhaps learning to take baby steps first before we start to run would help and I fully agree with Mr. James that 'adaptation to water scarcity' rather than 'mitigation of water scarcity' should be the governing factor at all times.

The questions are many but if it is decided to go about it, the solutions would also unfold as one goes about it with optimism and careful planning. We can't just debunk an idea simply because it may apparently seem difficult. I am sure there are lots of people in this forum itself who would be capable of finding solutions to at least some challenges if not all. I do wish good luck to The Ecological Foundation and humbly suggest that it should also honestly look into its own capacities (in terms of its preparedness and not undermining its capabilities) because I foresee this debate having an impact of high magnitude.

Ajay Rastogi, The Viveka Centre, Ranikhet

I think B. C. Choudhury has raised a very vital point about promoting rainfed crops. It is also important to note that many of these crops fall in the category of millets, coarse cereals, oil seeds and legumes which are also critical from nutritional security. At the same time, together with irrigation comes the package of agrochemicals that has socio-economic and ecological impacts. This is a very sensitive and highly debatable subject in agricultural circles and may call for a full fledged discussion in due course.

In the meantime, it would be good to take into account the past experience of Tarun Bharat Sangh with the Pani Panchayats. If, I recall correctly, from conversations with Rajendra Singh; they talked farmers into planning long term rotations and restricting the water intensive crops to certain acreages, making a more equitable system of sharing the benefits from available irrigation water. Another recent example is from the FAO led project in Andhra Pradesh and Karnataka where I learnt that farmers are planning crop rotations on a wider scale to match the water availability in the wells. The recharge of the well determines how much water can be utilised and accordingly the crops are selected. Further information can be had from Dr P S Rao of FAO New Delhi.

I am not sure if these experiences have been mentioned earlier as I have not followed the full discussion.

Abhishek Mendiratta, Consultant, New Delhi *(response 2)*

This concept of virtual water is actually similar to the International Economics theory of Absolute advantage. The theory of absolute advantage says, "Produce only goods where you are most efficient, trade for those where you are less efficient."

The theory of virtual water states if water-scarce areas import crops produced in water-rich areas, then it is as if water itself is 'virtually' imported into the water-scarce area. Such trade could allow residents in water scarce areas to enjoy products that require more water to produce than is available locally. But this critically presumes that water availability is the main determinant of price – with water-abundant areas having lower prices than water-scarce areas for the same products.

This need not be true, as the Heckscher (1919) - Olin (1933) Theory states, "Export goods that intensively use factor endowments which are locally abundant. Corollary: import goods made from locally scarce factors. Patterns of trade are determined by differences in factor endowments - not productivity. Remember, focus on relative advantage, not absolute advantage." Agriculture is dependent on Factor Endowments such as natural resources, climate, location, skilled labour, land and technology. Water is only one of the endowments. Hence, the virtual water concept is incomplete and impractical without taking into consideration other endowments.

Himanshu Thakkar, South Asia Network on Dams Rivers and People, New Delhi

I think Sudhirendar Sharma has taken up an important exercise. I do not have any clear answers to the questions he has raised, but some thoughts that may be relevant here.

I think the issue raised by Sunetra Lala about the water efficiency of methods like System of Rice Intensification (SRI) is very important and has huge water saving potential, larger than a few large dams or few river linking plans. There has been significant progress on that front, but a lot more can be done to reduce our water footprint for water-intensive crops like rice. In fact, we need to prioritize research on cultivating other crops using SRI techniques, for example, wheat and sugarcane where this has already been shown to be relevant.

We can possibly, as a first step, think of developing water footprints for food consumed in some cities. In this, an important factor would be the distance the products consumed travel before reaching consumers. I guess this won't be an easy exercise, and may involve some sweeping assumptions in the first place.

Here it is important to note all water used by the crop need not be assigned the same value. Thus, say if the water is coming from a big dam and has traveled a long distance to reach the farmer, the crop produced from that water cannot be said to have the same footprint as that produced either from harvested rainwater or water sourced locally. I know this adds to the complexity, but I think that if we do not keep this in the equation, we may reach some illogical conclusions.

Another issue is the use of various inputs for crops. Thus, a crop produced by SRI or organically would have lower footprint than one produced with a lot of chemical inputs. This is not only relevant for the carbon footprint for the crop, but also the water footprint, because those inputs that have gone into the production of the crop also have a water footprint. I guess this adds another level of complexity, but this may be required for reliable conclusions.

One way of approaching the issue would be to demand that crops produced from organic and SRI methods get a subsidy that is equal to, if not more than, those that use chemicals. Today, there are no such subsidies. This is relevant from both the carbon and water footprint points of view.

On similar lines, we recently asked Ministry of Agriculture (under the Right to Information Act) if it has done any assessment about the carbon footprint of various crops, and various methods like SRI, Organic or Chemical farming. Their answer was NO.

Similarly, while looking at the cost-benefits of augmenting water availability or water storage capacities, we need to keep in mind those methods that provide water with a lower carbon footprint. If these calculations are properly included in the cost-benefits and decision-making processes, my guess is that projects like river linking would get much lower priority or may even prove to be too expensive compared to other options.

These are some quick thoughts, I hope they make some sense and add value to this debate.

Devendra Sahai, Global Warming Reduction Centre, New Delhi

We are facing a water crisis, both in terms of quality and quantity. The water table is falling steadily while rivers, aquifers, lakes and ponds are getting polluted; floods and droughts are becoming common.

I feel this is due to the unchecked growth of population. Every country has finite natural resources that can support a given population. The eco-system remains healthy only as long as the population is within limits, as in New Zealand, Canada and the Scandinavian countries.

However, when rapid population growth outstrips its carrying capacity, the eco-system degrades as is happening in India and sub-Saharan Africa. Therefore, we must pay serious attention to stabilizing our population within the carrying capacity of the eco-system.

Kamala Krishnaswamy, Independent Consultant, Hyderabad

I am enclosing the details of a conference held in Bangalore, which might interest you. (The document can be downloaded at http://www.solutionexchange-un.net.in/environment/cr/res08100803.doc).

Satya Prakash Mehra, Rajputana Society of Natural History (RSNH), Rajasthan *(response 3)*

In my views circulated earlier, I took examples from Bharatpur that has had a drought for the last few years. The farmers there are not shifting to other crops even in times of drought. I too agree that people living in deserts know what to grow when they face dry conditions, but Bharatpur is just the reverse. It once had abundant rainfall and the crops were grown accordingly. However, the cropping patterns have not change even after the rainfall has decreased, because farmers have started extracting water from deep bores.

K. A. S. Mani, Andhra Pradesh Farmer Managed Groundwater System (APFMGS), Hyderabad

This discussion on Indian Virtual Water Footprint (VWF) continues to be very educative. The range of responses indicates that development of a comprehensive Indian Virtual Water Footprint should ideally consider multiplicity of parameters that fully embodies the ground level realities (social, political, environmental, and technical). Only then will the pricing mechanism worked out for the products and services be representative. Here it would be appropriate to mention some ground-level work that demonstrates the possibility of improving the water-use efficiency without sacrificing the economic returns. The question is, will such efforts by the farmers find a place in arriving at India's VW Footprint?

The APFAMGS project has been enabling farmers with skills, capacity and knowledge to reduce their water (groundwater) use in 650 villages in seven districts of Andhra Pradesh. Over a period of four years 30,000 groundwater users have reduced groundwater pumping from several thousand bore-wells by adoption of new practices and improving the water-use efficiency. It is fully acknowledged in government records that the farmers by themselves could halt severe decline in groundwater levels without any sacrifices, in fact recording improved returns from agriculture. While farmers shifted from high water demanding crops to low water demanding crops, yet they consciously continued to grow their family food requirements to ensure local food and nutrition security and thus cushion themselves from soaring food prices.

The farmers have been contributing in their own small way in reducing water footprints in the operational areas by striking a balance between the total water demand and available renewable water sources. Foot prints of high water consuming crops such as rice, sugarcane, mulberry, turmeric, and horticulture crops (banana, sweet orange, papaya) are substantially reduced without any losses in income. By adopting water efficient approaches that require less water per unit of crop, the farmers have reduced water use for irrigation ranging from 10 per cent to as high as 80 per cent.

Water productivity could be improved by a integrating number of approaches such as: System of Rice Intensification (SRI), crop diversification from 14 to 40 crops, adopting various combinations of intercrops, applying nutrient-rich organic fertilizer as vermicompost for improving the physical structure of soil while increasing its water holding capacity, adopting sprinkler and drip irrigation techniques, managing irrigation according to plant growth stage, adopting irrigation methods like border strip, check basin, double ring and furrow method.

Water conservation Method	**% of water Reduced**	**Crops**
SRI Paddy	40	Paddy
Sprinkler	30-50	Groundnut, Chillies, Vegetables, Bengal Gram
Drip	60-80	Sugar Cane, Sweet Orange, Banana, Papaya, Mango
Alternate Furrow Irrigation	25-30	Chillies, Sun Flower, vegetables
Check Basin for ground nut	15	Groundnut
Application of Mulch (Farm Yard manure, vermicompost, paddy straw, Paddy Husk, Crops stubbles)	10	Sweet orange, Groundnut, Chillies

Adopting Managed Aquifer Recharge techniques the farmers could conserve the flood waters within the aquifers for minimising the evaporation losses, thus improving the efficiency of rainwater. Given the experience of APFAMGS and many others it is clear that water use efficiency shows wide variation depending upon the source (surface irrigation/groundwater), agro-climatic situation, season (Kharif/Rabi). Since the amount of water used is a critical input for VWF computation, serious thoughts will have to be put in to arrive at the magic number or range. Experience also shows that farmers with independent water sources (wells, ponds, tanks) improve their water use efficiency over time, however in the case of major irrigation projects this is not necessarily the case. Thus in the computations of VWF a high level of caution needs to be exercised, keeping in mind the serious implications of a limited research on the lives of small farmers and the landless, in particular. While appreciating the efforts of The Ecological Foundation to get into this area of research it would be prudent for them not to go public with the results until there is a reasonable level of discussions for arriving at some unanimity.

Rajesh Shah, blog.peerwater.org, Bangalore

I have followed this rich, multi-dimensional discussion with interest since i have earlier been involved in working with and developing sustainability indicators (e.g., I worked at Redefining Progress developing extensions to the Ecological Footprint, carbon footprints, and using the Genuine Progress Indicator (GPI) as an alternative to the GDP).

Indicators make excellent choices for research, funding, conferences, awards, and graphics.

Indicators have been widely used, abused, and ignored. They get lives of their own and become goals (inflexible and unforgiving ones) rather than signposts. The inventor of the GDP did so under great pressure and quit his job and the then World Bank president later regretted creating such an indicator.

Another problem with indicators is some stocks are hard to measure and easier to ignore. For example in the water world, how would we figure out ground water stocks? And then how much should we consume out of it. How can we ascertain pollution levels? And what is acceptable?

Flows can be also pose problems for indicators. We have invented the concept of owning parts of rivers. What does that mean: We can use all the water in that section? Put anything we want? Control access? How can we assess the value of a flow, the value of the natural process?

The discussions have revealed the many dimensions that need to be considered. So far we have a very narrow Virtual Water Footprint (VWF) and certainly can keep adding parameters to broaden it.

Some thoughts regarding the use of such an indicator: If someone has a small water footprint, should we allow them to increase it? If someone has a high water footprint, can we pressure them to decrease it? Carbon footprints "work" because the impacts are not as localized as their creation. And there is a greater delay in time between generation and impact allowing trading of mitigation schemes. Also important to note is that only a small fraction of all the trading translate into projects on the ground.

We have experience, resources and intelligence to create indicators. Do we have the wisdom to realize when we need them and how to use them?

As the people of this forum know, our global civilization is facing threats involving resource scarcity, poverty and destitution, increasing disparity, climate change, sea-level increases, etc. We want more measurements to assess more accurately how serious the threats are. Our actions in responding to these threats are minuscule compared to our actions in continuing to run down the path that likely created these threats.

I have generalized my comments and not answered many comments specifically. For example, on issues such as inter-linking of rivers - it my observation that decisions are made to maximize economic impact. It is easy for the powerful stakeholders to ensure that the governments approve the most expensive scheme.

My intention is not to detract from the people and their work on indicators. With or without indicators it appears that we are paralyzed. So my comments are a reflection on a society unable to prevent problems, unable to act until it is too late, if at all. How do we mobilize? Maybe we need an indicator to measure how many indicators we need before we will act decisively, dramatically, with full intent to address issues related to our survival, to our humanity.

Nitya Jacob, United Nations Children's Fund (UNICEF), New Delhi

Let me try to address how to work on a Virtual Water Footprint (VWF) as it was extensively debated at this year's World Water Week in Stockholm, as well as the last World Water Forum in Mexico City. At both, it was seen as a new concept to ascertain the water-intensity of goods and services, and therefore, a means to potentially influence their movement from one place to another.

This seemingly new concept has been part of various theories of international trade and production for more than half a century. It was enunciated separately relatively recently but given the problems in working out the quantity of water used to produce and delivery any goods or service, has remained largely an academic topic. It is quite unlike its cousin, the Carbon Footprint, in this respect; countries and people now have well-established Carbon Footprints and there are clear norms for determining them.

A nation's VWF comprises an internal and an external footprint. The internal footprint is the quantity of domestic water used produce goods and services used by the inhabitants of the country. The following is one method of calculating a national VWF:

$IWFP = AWU + IWW + DWW - VWE_{\mathrm{dom}}$,

Where IWFP: Internal Water Foot Print; AWU: Agricultural Water Use; IWW: Industrial Water Withdrawals; DWW: Domestic Water Withdrawals and; VWE_{dom}: Virtual Water Exports in respect to domestically produced goods. (Please refer to Water Footprints of Nations: Water Use by people as a function of their consumption pattern, by A Y Hoekstra and A K Chapagain, http://www.waterfootprint.org/Reports/Hoekstra_and_Chapagain_2007.pdf, PDF, 50 KB).

This is one part of a country's VWF. The other is the external footprint, which comprises the water used in the production of imported goods and services. There are straightforward means to calculate the quantities of both used, and source the countries from where they originate. The External Water Foot Print (EWFP) is equal to the so-called virtual water import (VWI) into the country *minus* the volume of virtual water exported ($VWE_{\mathrm{re\text{-}export}}$) to other countries as a result of re-export of imported products:

$EWFP = VWI - VWE_{\mathrm{re-export}}$

Hoekstra has developed a VW calculator, available at http://www.waterfootprint.org/index.php?page=cal/waterfootprintcalculator_indv_ext that is one example of how to work out individual and national VWFs.

The Food and Agricultural Organization in 1998 developed the methodology of determining the water requirements of different crops grown in different countries (however, these vary widely). The Virtual Water content of crops, measured in m^3/tonne, is a function of product and value fractions. The first is the unit of crop product obtained per unit of primary crop and the second is the market value of a unit of crop product divided by the aggregated market value of all crop products derived from one primary crop.

The process for animal products is different. It is based on the VW content of their feed and volume, and physical water used during their lifetime, following the method above. The authors have worked out the VW content of eight major animal categories – beef cattle, dairy cows, swine, sheep, goats, fowl/poultry, laying hens and horses.

These methods have resulted in the following examples of VWFs for some commonly used products:

- It takes 140 litres of water to make 1 cup of coffee
- It takes 900 litres of water to grow 1 kg of maize
- It takes 1,000 litres of water to produce 1 litre of milk

- It takes 1,350 litres of water to grow 1 kg of wheat
- It takes 3,000 litres of water to grow 1 kg of rice
- It takes 16,000 kg of water to grow 1 kg of beef

Let me state, however, these are not India-specific figures. For example, the figure for milk assumes stall-fed animals, the water used in producing their feed and maintaining the diary. A large percentage of India's milk production comes from non-stall-fed animals, and the figure would be different; however, it will be harder to determine many of the buffaloes and cows eat crop leftovers or are left to graze on village commons. A crude method of determining and Indian VWF for milk could be to work out a weighted average of the production from the 'organised' and 'unorganised' dairy sectors.

Industrial products also similarly contain Virtual Water, used in their production process. For a car, it would be sum of the water used to produce steel (mining, refining and production of iron and subsequent conversion to steel), plastics (extraction of crude oil, refining and production of polymers), glass and rubber; it has been estimated at 400,000 litres for a 1.1 tonne passenger car. It takes about 900 litres to make a cotton shirt.

The same product has different VWFs when produced in different countries. For example, a tonne of cotton produced in China has a WVF of 5,404 m^3, but when produced in India, it is as high as 21,563 m^3. Even within India, there are variations in the water used to produce the same crop. A paper, Going Against the Flow (http://www.waterfootprint.org/Reports/Report31-India.pdf) concludes water-scarce regions like Punjab and Haryana export water to water-rich regions in eastern India.

By working out the total consumption of products and services, we can arrive at an Indian VWF. The point I want to reiterate is, we do not have the data for most of our products and services but have borrowed VWFs from other countries for our own products.

Virtual Water has limited use in helping price goods and services simply because it is next to impossible to put a true value on water. Farmers have never paid the true cost of water, but only the cost of extraction. City-dwellers also pay only a pay a fraction of the cost of processing and providing water; the large infrastructure costs are not factored in. Government policies of providing free power to farmers further complicate pricing and social costs are never taken into account. Therefore, while VW helps determine the total volume of water used, it is not a tool to help cost the product or service.

Similarly, VW has not been a determinant of international trade simply because water constitutes a negligible fraction of actual cost of a product or service (again, because it is not valued correctly without taking VW into account). Agriculture trade in the real world is determined largely by government subsidies to farmers and not by the competitive, or water advantage, or growing crops in a particular country. Trade in industrial products and services are governed partly by differences in technical abilities, demand, and economies of scale.

Agriculture, that uses nearly four-fifths of the world's fresh water, has been a favourite topic for VWF's advocates. Various studies indicate current farming practices waste 60 per cent of water as stated in an earlier reply; there is enormous scope for improvement. However, most improvement will have to do with crops used as cattle- or poultry-feed, the two most water-intensive farm outputs. This is not to argue that agriculture in countries where VWFs are large should be stopped, but to say it should be made more efficient given its implications for livelihood and food security.

VWF will gain importance, just as Carbon Footprints have, as water scarcity drives people to assess how much they are using, and how they can use less, water. It has the potential to impact livelihoods by influencing what farmers will grow, or industries will produce. The statement, it takes 3,000 litres of water to produce 1 kg of rice, can undermine the livelihoods and food security of a billion people, for whom rice is a staple; a large number of them live in India. If we can reduce the VWF of rice through the system of rice intensification or other similar process, we can counter such arguments, but first we need an Indian footprint. The basic tools are available; like I said earlier, we need reliable data to make them work.

Virendra Kumar, Indian Farm Forestry Development Cooperative, New Delhi

I read with interest the concern expressed by Mr. Pravakar Rath of Mizoram University in particular on the scarcity of water as a major issue affecting human beings, agriculture and industrial outputs. I had a first-hand experience of water scarcity in Mizoram 3-4 years ago while visiting the State as a Member of the Board of Central Agriculture University, Manipur. Mizoram receives maximum rainfall and we were surprised to notice that the State did not even have a single watershed management structure. The members of the board met the Chief Minister and apprised him about the absence of a model Watershed structure in the State. I along with Dr. A. M. Michel offered our services in association with Indian Farm Forestry Development Cooperative (IFFDC), New Delhi to establish a model for water harvesting. There was no positive response.

In fact, the problem can be solved by creating successful model structures so that they can be further replicated. IFFDC has the expertise of establishing large number of watershed structures in Rajasthan and Madhya Pradesh, which are sponsored by the Department of International Development (DFID), U.K. Even today, IFFDC can extend the expertise in this direction at a place where the need exists.

I urge the members to get in touch with us wherever our help is required in conserving this vital input of water.

Chris Morger, Intercooperation, Switzerland

Members have noted that nearly 60 per cent of water used in agriculture is wasted. I really wonder whether all agree with this. I would like to refer to a paper by V. Shikomanlow "Appraisal and Assessment of World Water Resources" (2000) that is frequently quoted in connection with water assessment worldwide and which you can download at http://www.ifu.ethz.ch/GWH/education/undergraduate/Wasserhaushalt_GZ/mat2.pdf.

In Table 5 of that paper, worldwide water withdrawals and water consumption are listed for the different uses such as agriculture, municipal and industrial. If we agree that water use efficiency is the ratio between water actually consumed and water withdrawn, then the water efficiency in agriculture is about 70 per cent and this means that only 30 per cent are "wasted". Taking into consideration that some operational losses are inevitable, I think that is not so bad at all considering only 800 trillion are wasted according to Shikomanlow (1834 km3 estimated consumed against 2605 km3 withdrawn in 2000).

In comparison the other sectors have water efficiencies as defined above of only 15 per cent (municipal) and 10 per cent (industrial). I would really be curious what the other members of this community think about the efficiency of irrigation and water wasted in agriculture.

Kalyan Paul, Pan Himalayan Grassroots Development Foundation, Uttarakhand

Water is for real and the problems associated with scarcity of water needs to focus on our depleting forests and its poor management. Water and forests are two sides of the same coin or rather an integral part of any ecosystem.

As field practitioners for three decades, we can only suggest that our attention needs to be on resolving the crisis, rather than focusing on some western concept called Virtual Water.

Vijayakumar V. Sarraju, National Institute of Hydrology, Deltaic Regional Centre, Andhra Pradesh

On a suitable pricing mechanism for products and services that reflects their 'virtual water footprint', I feel it is unjust to equally weigh the virtual water component of all 'Products' and 'Services' as so and so liters of water. Then, we dilute the value of products that use canal water or pumped groundwater compared to those that use water from nature. So, the weights for different components i.e., rainwater on forests, groundwater of wetland and marshes, rainfed, canal irrigated, lift irrigated, groundwater from overexploited and critical areas, harvested water, drainage water, return flows, waste water, etc., should be different based on their value.

Thus, the virtual value should be based on the characteristics or nature of water used and time and effort made to make such water available. Whether the product is naturally occurring or due to influence of man is also an important consideration.

As an example, compare the virtual water component of milk from a buffalo (which eats wild grass and swims in ponds and rivulets in the Indian context) and that of rice from irrigated paddy (dams, diversion works, canals, etc). Another example is virtual water for paper (made from forest produce and rainfed plantations) to microchips or IC's (that require huge water supply).

Dinesh Kumar, Institute for Resource Analysis and Policy, Hyderabad *(response 4)*

I understand that Mr. Chris Morger has raised a very valid and important question. I have been sharing similar thoughts in some of the earlier discussion with the same community. The concept of physical efficiency used in irrigation (as the ratio of the total water consumed by the crop and the total water applied) is very old and outdated. A more meaningful definition is the ratio of the amount of water consumed by the crop and the amount of water depleted in the entire process. The "depleted water" is the sum of ET (crop consumptive use), the non-beneficial consumptive use (evaporation from cultivated soil after harvest) and non-beneficial non-consumptive use (non-recoverable deep percolation from the field).

This means that the amount of wastage actually depends on the climate, soils, groundwater conditions and the crop type. For a detailed discussion on where one can make water application for crops more efficient, please refer to Water Use Definitions and Their Use for Assessing the Impacts of Water Conservation (Allen, R. G., L. S. Willardson, and H. Frederiksen, 1998), proceedings of the ICID Workshop on Sustainable Irrigation in Areas of Water Scarcity and Drought (J. M. de Jager, L.P. Vermes, R. Rageb (eds). Oxford, England, September 11-12, pp 72-82).

Our aim should be to reduce the non-recoverable deep percolation and non-beneficial evaporation for real water saving and to reduce the water footprint. Some technologies such as micro-irrigation would help only for certain crops (row crops and orchards). Zero tillage might help for certain other crops such as rice-wheat system. Plastic mulching would help in some row crops. However, in sub-humid and humid areas and shallow water table areas (good quality groundwater!), there would not be much savings.

Many feel that a lot of water is wasted for irrigation purposes, particularly in surface irrigation systems. Most of this water is actually recycled back through wells.

Arun Jindal, Society for Sustainable Development, Karauli

"The water footprint of a nation refers to the total amount of water that is used to produce the goods and services consumed by the inhabitants of the nation." This is a definition given at the site you mentioned.

Here I would like to say that water is a part of ecology and it should be seen as a precious resource gifted us by nature. In the water footprint use of water in producing goods and services should be included. Water used in by-produce, recreation, wild flora and fauna and other Bio-ecological products also need to be included. One can also include the services given to us by water in the form of oxygen and others.

Sunetra Lala, United Nations Children's Fund (UNICEF), New Delhi *(response 2)*

Please note that the World Business Council for Sustainable Development, University of Twente, WWF, UNESCO-IHE Institute of Water Education, Water Neutral Foundation, International Finance Corporation and the Netherlands Water Partnership have formed the Water Footprint Network to promote sustainable water management and help individuals and producers accurately measure water use. The formal launch of the network is scheduled for December 2008. Anyone working in water resources management is welcome to join the network, including academic institutions, government agencies, NGOs, businesses and public utilities.

The group plans to develop standards and tools for water footprint {the total water footprint of a country includes two components: the part of the footprint that falls inside the country (internal water footprint) and the part of the footprint that presses on other countries in the world (external water footprint)} accounting and impact assessment. For more information, please visit http://www.wbcsd.org/.

According to the publication titled, Globalization of Water: Sharing the Planet's Freshwater resources by A. Y. Hoekstra and A. K. Chapagain (2008), Blackwell Publishing, Oxford, UK, the water footprint of India is as follows:

- Average water footprint of the country - 980 m^3/capita/year
- Part of footprint falling outside of the country - 2 per cent
- Global average water footprint - 1243 m^3/capita/year

More details on India's Water Footprint, including virtual water imports and exports, is available at the website mentioned in the original query.

Arunabha Majumder, Presidency College, Kolkata

In India, we utilise 85 per cent of water in the agricultural sector. Around 10 per cent of water is utilised in industries and for power generation, and the rest (5 per cent) is utilised in public water supply.

The water availability is different in different parts of the country due to variations in rainfall. We have water-stressed areas as well as water-scarce areas. Water is essential for agriculture; however, the agricultural products grown at a place may be consumed at a distant place. Price of agricultural products includes, apart from others, the cost for watering (mainly pumping from aquifers or canals, etc). Cost of watering in agriculture differs from place to place.

However, there should not be any wastage of water in agriculture; rather we should ensure that there is minimum wastage. Again the cropping pattern must be according to the availability of water in that region. We must have a good assessment as well as estimation of Virtual Water, so that it is properly reflected in the price of products. I think we must do the needful to conserve water so that this can be utilised rationally for agriculture. We should ensure that there is no water reserve deficit in specific areas.

In industrial products the cost of water is included. Industries could be set up according to the availability of water in the region.

A country may import food from other countries and can take advantage of the concept of Virtual Water. In India we have to frame a policy to restrict export of products/ commodities which require a huge amount of water; or in other words we should export products/commodities which consume less water.

Manjula Menon, M. S. Swaminathan Research Foundation, Chennai

I was reading with great interest the various responses that were posted on the subject for the last few days. I do appreciate the fact that it is very essential every country should try to reduce its water footprints. However, I fear "Virtual Water" and the use of this concept in pricing of goods and services and as a determinant of international trade will have a lot of implications for a developing country like India.

Virtual Water (VW) is based on the assumption that water availability is the main determinant of price, which means a product will have lower price when produced in a water-abundant region than in a water-scarce region. (*This assumption itself is misleading, as has been rightly pointed out by Mr. Abhishek Mendiratta, one of the respondents, because water is only one of the factor endowments that goes into the production of goods and commodities)*. Any pricing mechanism should take into account all the other factors of production too.

But even if one goes by the above assumption (Virtual Water), and also by the estimation of average VW content of selected products for different products *("Water footprints of nations: Water use by people as a function of their consumption pattern" A. Y. Hoekstra and A. K. Chapagain*) it would mean that India should stop engaging in any kind of agricultural production activity, given the fact that India is estimated to have shockingly high average VW content for almost all the agricultural produce.

This in the long run, would mean the country surrendering her food and livelihood security in the name of free trade (based on the intrinsic value of water in products). Agriculture, despite a steady decline of its share in the GDP, is still the largest economic sector and plays a significant role in the overall socio-economic development of India, given that it supports almost 60 per cent of the total workforce of the country.

So, what we as a nation with a large population depending on agriculture as a livelihood means should do instead of "focusing on concepts like virtual water and water pricing which would push us into dependency" is to try to improve our water use efficiency by proper conservation and management measures, and also by using improved technologies for efficient water use. "More crop and income per drop of water" should be the mantra driving agricultural productivity in the country.

India enjoys diverse agro-climatic conditions, and a wide variety of temperate as well as tropical crops could be grown in these diverse agro-climatic regions. There should be regulations in place to restrict water intensive crops (wheat & rice) to those regions which is abundant in water (like Punjab) and incentives for taking up minor cereals and millets (ragi, sorghum, etc) in rain-fed and dry land regions. There should be concerted effort to popularise these minor cereals and millets as a means of achieving nutritional security.

Even in regions of water abundance, there should be regulations and subsidies for taking up water efficient technologies (SRI, drip irrigation, etc). Measures for in-situ moisture conservation like farm ponds and recharge pits in dry and rain-fed regions will help improve the water availability in these regions. Practice of mulching and cover cropping will help reduce the soil moisture loss through evapo-transpiration. The practice of application of farm yard manure and ploughing of crop residues in field will improve the soil texture and enhance the moisture holding capacity of the soils.

Reviving the traditional water users associations for conservation and management of water as a common pool resource is of great importance. Pani Panchayats in Orissa, and the traditional water users associations in Tamil Nadu in managing the tanks and regulating water use by the beneficiaries are two great successes. They regulate water use through planned cropping patterns and crop rotations and are great examples of how local level management of "Water - as a common resource" goes a long way in conserving and sustaining this resource.

Though agriculture is the sector which account for almost 87 per cent of water demand in our country, it is appalling to note the amount of water that is being consumed by the "bottled water Industry" in our country. The fact that India's mineral water bottling industry has tripled in the last few years is a clear indication of the excess of groundwater depletion that is happening in the country, thanks to this industry. The protests that soft drinks and bottled water giants like Coke and Pepsi faced in different parts of the country on account of ground water depletion, indicates the seriousness of the water scarcity threat faced by communities living in the vicinity of bottled water plants.

Access to clean and affordable drinking water is the right of every citizen in our country, but bottled water is neither the answer nor the solution to the problem of clean drinking water. The United Nations Millennium Development Goal for environmental sustainability calls for halving the proportion of people lacking sustainable access to safe drinking water by 2015. Concerted effort for ensuring clean drinking water through public taps would help reduce the demand for bottled water in public places and in reducing the strain on ground water depletion.

These are just a few of the "n" number of measures that we as a country could take to reduce our water footprint. None of the above listed measure is new, but on the contrary has been repeated to the point of being boring, but yet has found few takers be it among the policy makers, or the farming community.

K. K. Datta, National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi

The issue raised by Mr. A. Majumder relating to the concept of Virtual Water (VW) is no doubt an academic issue but I have doubts about its applicability. An intellectual discussion may help to get some new ideas, but I am doubtful about how far it will help for conservation purposes, since we need to be mature enough to focus on all issues with regard to market forces. We need to review and collect several opinions before we start working on it.

K. V. Peter, Kerala Agriculture University, Thrissur

Watermelon, muskmelon, ash gourd, bitter gourd, cucumber, snap melon, onion and amarath have water content of more than 95 per cent. Fruits such as papaya, juicy varieties of mango, passion fruit and oranges have more than 85 per cent of water. Plantation crops like coconut, cashew and rubber also have virtual water in plenty. In the discussion on Virtual Water we need to consider the water content of these vegetables and fruits as well, in order to arrive at the water footprint of our agricultural products.

Many thanks to all who contributed to this discussion!

If you have further information to share on this topic, please send it to Solution Exchange for the Water Community in India at se-wes@solutionexchange-un.net.in and/or Solution Exchange for the Food and Nutrition Security Community at se-food@solutionexchange-un.net.in with the subject heading "Re: [se-watr][se-food] Query: Developing an Indian Water Footprint - Discussion. Additional Reply."