Assessing Global Water and Food Security Challenges:

Rethinking on Methods

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Rationale

- Globally, there is too little appreciation of the fact that having plenty of water in some regions does not help improve the agricultural situation beyond a point unless sufficient arable land is available there to make use of that water for biomass production.

- Conversely, having vast tracts of arable land also does not help in boosting agricultural production unless a critical amount of moisture is available in the soil profile to support plant growth.

- When the second criterion is fulfilled, it is quite likely that a country may not face any shortage of water for meeting demands, including that from agriculture, even when very little **blue water** is available from rivers and aquifers.

- The study looks at these issues very critically at the global scale. It analysed the food security and water management challenges facing the world, at the level of individual nations, but does so by **<u>delinking</u>** the food security challenges from that of supplying water to meet the needs of various sectors including the environment.

Approach and Methodology

- The study first examined how the positioning of a country vis-à-vis per capita **RWA** and per capita arable land, determined the extent of water utilization for various uses and the extent to which arable land is put to crop cultivation, respectively. It then tries to simulate the complex interaction between arable land availability and **RWRs** that decides the agricultural production potential of a country.

- A composite **water-land ind**ex, which evaluates the adequacy of water resources to bring the entire cultivated land under irrigation, and the amount of cultivated land per capita, was derived to simulate the agricultural production potential of different countries.

- The robustness of this index was tested by using it as an independent variable in a statistical model that uses per capita virtual water trade as dependent variable. Then, a composite index, which adds up the value of water-land index and the **pasture land index** was also derived to simulate the milk production capability of different countries.

- It was used in an independent variable in a statistical model that uses per capita milk production as dependent variable.

Approach and Methodology

- The index called '**water adequacy index**' (WAI) indicates as to what extent the current water availability is sufficient to meet the maximum CWR of the available cultivable land for an assumed crop-growing period of 300 days. Its value is estimated by dividing the total renewable water availability by the multiple of the total cultivable land and average annual ET_0. However, the maximum value for **WAI** is 1.0. These values indicate the water adequacy for likely future needs also when the cultivated area increases and becomes equal to the cultivable area.

- $WAI = (AWR/(CA\ X\ ET_0\ X\ 300)$ ……… (1)

- If the value of WAI is less than 1.0, it is modified by dividing it by the fraction of the cultivable land that is actually under cultivation to reflect on the current water needs. If the original water adequacy index is 0.50, and if only 2/3rd of the arable land is under cultivation currently, the modified WAI becomes 0.75. If the value of the 'modified WAI' for any country exceeds 1.0, it has to be adjusted to 1.0 (one).

- The Modified WAI is multiplied by the 'per capita cultivated area (ha)' to derive a new index called '**water-land index**'

- The pasture land index was derived by multiplying the amount of pasture land per capita (ha) and a 'coefficient', which reflects the primary productivity or richness of the pasture land.

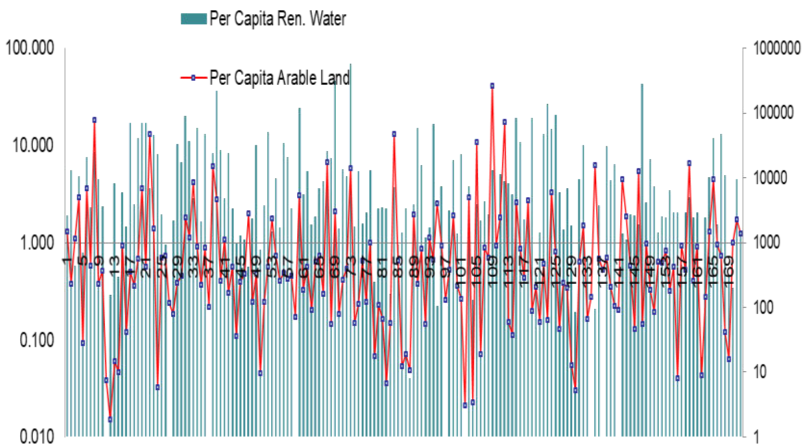
Tenuous link between renewable water resources and cultivated land

- The nexus between land and water, which define the food security and water management challenges, operates in two ways. First: even if a region doesn't have sufficient amount of renewable water, the availability of certain amount of crop land ensures the use of water in the soil profile, which can be used by the crop for production. Second: even if a region is highly water-rich, the absence of sufficient amount of cultivable land can render it un-utilizable for crop production making it food insecure.

- We have analysed the data on per capita renewable water availability and per capita cropped land in 150 countries. The values for the former ranges from **8 m³ per annum to 5,82,190m³ per annum**. For the latter, the values range from **0.0028 ha to 2.094 ha.**

- Analysis shows that there is no relationship between renewable water resources and agricultural land.

Two sample paired T test showed no relationship between per capita renewable water resources and per capita arable land.



Which Countries have Plenty of Water for Future Crop Production?

- Kumar and Singh (2005) found that net virtual water export through agricultural commodities is a direct function of gross cropped area, and explained this phenomenon using the concept of 'effective agricultural water withdrawal', which increased linearly with per capita **GCA**

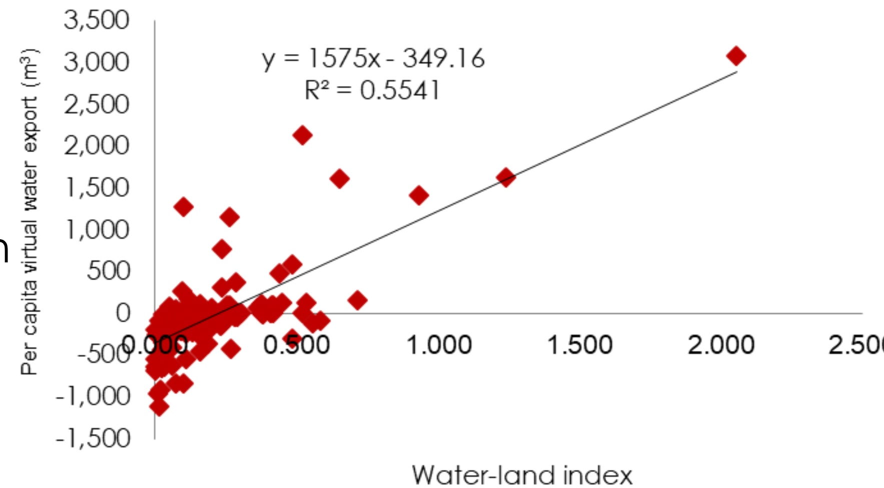
- They also developed a framework, according to which **a country which has large amount of agricultural land and with sufficient amount of water to bring in under crop production would have the highest advantage in terms of producing agricultural surplus for export**. However, another country which has the same amount of water as the first one, but with very little agricultural land, will not have that advantage.

- A third country **with less amount of renewable (blue) water**, but with the same amount of agricultural land as that of the first country, with be relatively better off than the second one in terms of agricultural production potential.

- Beyond a point, having large amount of water disproportionately higher than the amount that is required to bring the entire cultivated land under intensive production does not help in securing food self-sufficiency

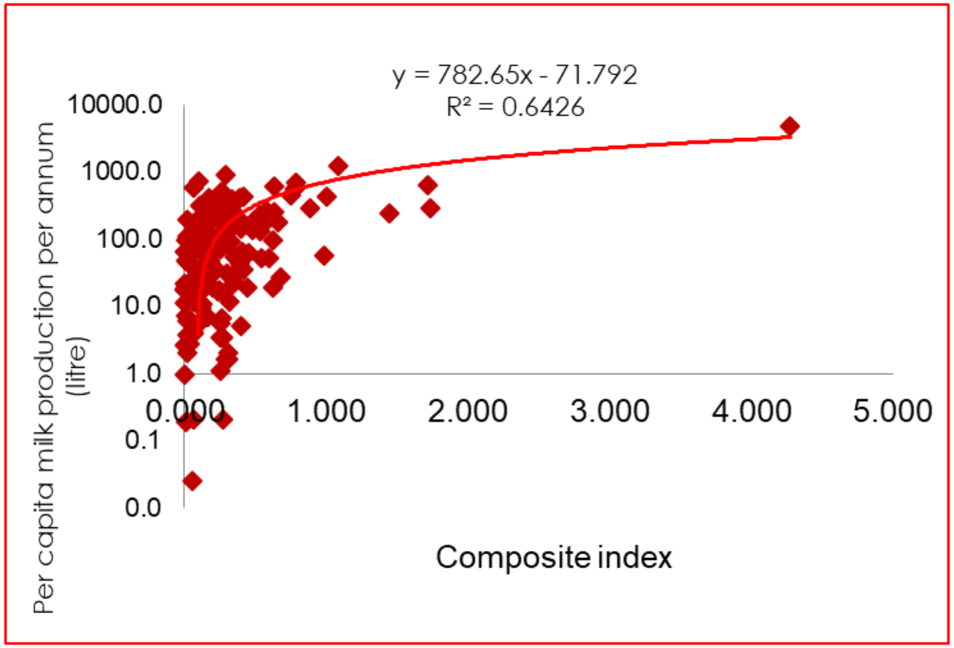
Which Countries have Plenty of Water for Future Crop Production?

- The **water-land index** captures two important dimensions of agricultural production potential of a country, viz., adequacy of water to bring the available cultivated land under intensive irrigation for 300 days in a year, and the total amount of cultivated land per capita.
- The regression run between water-land index and the per capita virtual water export showed a linear relationship with an R^2 value of 0.55.
- Increase in value of water-land index meant greater agricultural surplus after domestic consumption, and reduced value of the index meant production deficit to meet the domestic consumption needs.
- This strong relation means that water-land index is robust enough to capture the agricultural production potential



Linkage between Agricultural Land, Cultivated Land and Milk Production

- The composite index reflecting the adequacy of water for intensifying irrigated cultivation, amount of cultivated land and pasture land availability explained the level of per capita milk production in these countries to the extent of 64%.
- When the value of the index increased, milk production per capita increased. New Zealand, which produces around 4836 litres per capita of milk per annually, also has a composite '**land-water-pasture land' index of 4.28**.
- Here again, the achievement of India's dairy farmers is nothing short of a miracle.



Findings

- We can infer that the criteria for assessing the magnitude of food security and water management challenges have to change to factor in the role of the cultivated land. When this is done, we have four different categories of countries emerging:

  1] Countries with large amount of renewable water and cultivated land, which have both water and food self-sufficiency (**Canada, Argentina**)

  2) Countries having large amount of renewable WRs, but also having disproportionately larger amount of cultivated land, resulting in low 'water-adequacy', but 'food-surplus' situation, though with occasional water scarcity (**Australia**);

  3) Countries having sufficient amount of cultivated land, but low water availability, and facing different degrees of water shortages (with some experiencing groundwater mining problems) and food insufficiency, depending on the actual per capita cultivated land, water availability and extent of its utilization for irrigation; and

  4) Countries having **high values of 'water adequacy**' mostly because of **large amount of renewable water and low per capita cultivated land**, and sometimes because of disproportionately lower amount of cultivated land even with low water availability, but mostly dependent on food imports.

Conclusions

- Historically, analysis of water scarcity and food security challenges facing nations were assessed as a single challenge, using simplistic considerations of RWA and extent of withdrawal of renewable water.
- Problems of domestic food shortage facing certain countries were largely viewed as a water management challenge, meaning if more water is made available for irrigation, the agricultural situation would improve.
- It ignores the fact that limited availability of cultivable land renders most of the blue water un-usable for crop production. Similarly, water management challenges of countries were largely viewed from the perspective of **RWA**, suggesting that those having low renewable water availability in per capita terms would imminently face water scarcity.
- Conversely, moderately high **RWA** in per capita terms was considered as an indication of 'water richness', without considering the **per capita land under cultivation**, which determines the demand for water for that sector.

Conclusions

- Such skewed analyses ignore the role of access to agricultural land, which increases the access to **water in the soil profile** for crop production thereby reducing the demand for **blue water** in agriculture, in determining agricultural production potential of a country, while increasing the overall agricultural production potential itself.

- Our analysis suggests that countries having high **water-land index**, and large amount of rich pasture land per capita would be able to produce surplus milk.

- The countries having large amount of cultivated land per capita and sufficient water to cover the entire land under intensive production will have the comparative advantage for producing agricultural surplus for export. This is followed by countries having high 'per capita cultivated land', but relatively low 'water adequacy index' (40 nos.).

- Countries that are very water-rich, but having very little cultivated land in per capita terms (69 nos.) will not face problems related to water supply, but might have to depend on food imports. Nevertheless, there are many countries under the second and third category (21 out of the 40 nos. and 60 out of the 69 nos., respectively), which can increase their production through increasing the utilization of irrigation water

Policy Inferences

- Overall, there is a need to develop quantitative indicators for assessing water availability and food security situations of individual countries separately using the parameters that were found to have significant impact on water supply and overall water demand, and crop and dairy production potential.

- These parameters are: water adequacy ratio (which considers renewable water resources, cultivated land, climate and crop growing period); per capita cultivated land; and, pasture land index (including per capita pasture land and pasture land coefficient).