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Drivers of India's Water Turbulence

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Abstract:

Recurrent floods and droughts in the country are the challenges that India is facing. These are indicators that India is heading towards a turbulent water future. The most significant primary drivers of India's water future in the short to medium term. Many river basins will have relentless water stress conditions under business as usual water-supply and use patterns. To cater the growing demand in the coming decades, India strongly requires substantial additional water supply provisions. India should have to think seriously on important policy options for meeting the increasing demand like- recharging groundwater to increase the groundwater stocks. This, along with a reliable water supply for diversifying high value cropping patt[1]erns, may involve large surface water transfers. The interbasin water transfers could raise the recharge groundwater in much overexploited area. While artificial groundwater recharge, rainwater harvesting, and interbasin water transfers are answers for meeting the water requirement in the near-term, they are also solutions for rising the latent serviceable water supply in many water scarce river basins.

Key words: drivers, cropping pattern, turbulent, rural, agriculture

Introduction

The water availability of India differs significantly across different provinces and river basins. Though abundance of water is easy to get in the north-eastern province, very few people live and food production, too, is very low there. On the contrary, the north-western region supplies food to insufficiency regions of the country. In the southern and western provinces of the country, water is in short supply. Today, recurrent floods and droughts in various parts of the country are the challenges that India is facing. These are indicators that India is heading towards a turbulent water future (World Bank 2005). It is predicted that India withdrew about 680 BCM for meeting the demand in the irrigation, domestic and industrial sectors in 2000 and the future demand is projected to increase by 22 % and 32 % by 2025 and 2050, correspondingly (Amarasinghe et al. 2009 and 2007).

Drivers of Turbulent Water Supply and Demand:

More than one quarter of India's population is active in agro-economic activities and their livelihoods directly depend on agriculture. India has world's biggest cropped area under arid to semi-arid climatic conditions. India is the world's major consumer and producer of cereals and pulses, and most of that, produced under irrigated conditions. Water has shown to play gradually more integral role in the countryside livelihoods and economic growth.

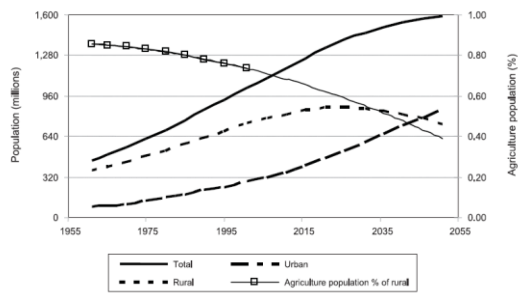
Many drivers, either endogenous or exogenous to water system influence India's turbulent water futures (IWMI 2005). The exogenous drivers are mainly the key drivers that set the direction of water futures. Some of the key drivers that are exogenous to water system are primary drivers, such as: Changing Demographic Patterns, Rural Livelihood Security, Changing Consumption Patterns, National Self-sufficiency, Realizing the Potential in Rain-fed Agriculture, Increasing Crop Productivity, Growth in Irrigated Area, Increasing Efficiency, Domestic and Industrial Water Needs and so on.

The endogenous drivers to water system of a country are secondary drivers. They over and over again responses to the guidelines set by the primary drivers. Some of the key secondary drivers of the turbulent water futures of India are: Total Renewable Water Resources, Potentially Utilizable Water Resources (PUWR), Rainwater Harvesting, Artificial Groundwater Recharge (AGWR), Intra-basin or Interbasin Water Transfers (IBWT), Ecosystem Water Demand, Environmental Water Demand and so on. The magnitude of the changes depends on vital turning points of primary drivers and the responses to them thereafter.

Primary Drivers of Turbulent Water Future of India:

1. Changing Demographic Patterns:

The varying provincial demographic patterns is important for a large country like India with a major spatial distinction of water availability, and also when irrigation is the biggest consumptive water use zone in many regions. Irrigation has played a crucial role in the past in many states where a major part of the countryside population depended on agriculture for their livelihoods. Regional demographic patterns are varying with speedy urbanization. Study by Mahmood and Kundu (2006) projects India's total population to reach about 1.6 billion by 2050 and become constant thereafter (Fig. 1). It has been expected that about 53% of the population will live in urban areas by 2050. In either scenario, demographic trends of many states will transform drastically by the second quarter of this century. Many states will have further cities with major urban centers, and more urban than rural population.



Source: FAO 2005, Mahmood and Kundu 2006

Fig 1. Urban, rural and agriculture depended population in India.

2. Rural Livelihood Security:

Security of rural lives, for which crop growing is the focal source, was a crucial factor of the overall underlying principle for agriculture water demand projections in the past. Still, current trends imply that the agriculture demography is rapidly changing with growing employment in the nonagricultural sectors. In last four decades, the agriculture- reliant population has turn down from 86 to 74 %. This proportion is likely to diminish further, and could arrive at even below 40 % by 2050 (Mahmood and Kundu 2006). Perhaps it could speed up in the future as the National Sample Survey show that majority (40 %) of farmers speak that they would like to way out agricultural for enhanced prospects in the nonfarm sector. In coming

50 years, India will have even less populace that depends on agriculture than it is nowadays.

3. Changing Consumption Patterns:

Generally, the food consumption patterns of a country for the most part establish what its people produce in the agriculture fields. More than two-thirds of the food consumed in India at present is produced under irrigated environment. And due to large marginal to small land holders, the producers are also the main consumers of the crops they produce. In the past, grain crops dominated the agriculture production model, as food grains endowed with a major part of the daily dietary intake. Yet, a delicate alteration in food consumption model has been evolving in the recent past in both rural and urban India. While, the insistence for food grains, in particular for rice and coarse grains in both rural and urban areas are on its last legs in the 1990s, the requirement for non-grain food crops such as vegetables, fruits and oil crops, and animal products such as milk, chicken, eggs and fish is mounting. The study by Amarasinghe et al. (2007) in fact shows that non-grain crops (oil crops and vegetable oils, roots and tubers, fruits, vegetables and sugar), and animal products (mainly milk, chicken, eggs) are predictable to offer a key part of the nutritional intake by 2050. Food grains give more than two-thirds of the nutritional supply today, and this will decrease to less than half by 2050. As an outcome of declining per capita grain consumption in both the urban and rural areas, and the rate of urbanization, total food grain requirement will boost slowly. On the other hand, due to rising consumption of animal products, the food grain demand will enlarge a number of folds. The demand for non-grain crops will also rise substantially. Therefore, non-food grain crops will consist of a major part of the supplementary irrigation geography in the future.

4. National Self-sufficiency:

Nationwide self-sufficiency of food grains is another key driver that subjugated the choice of cropping prototypes of agriculture in general, and irrigation in particular. This hypothesis was for the most part based on the three concerns,

a. India has a huge population and the food grains are the main food of its populace with mostly a vegetarian diet, because of which large production shortfalls.

b. Agriculture was the major driver of financially viable development and has added to extensive part of the gross domestic product; and
c. India's foreign exchange capital is too low to introduce bulky amount of food from the world market.

With varying using up patterns, there will be additional occasions for Indian farmers to augment income from rising high-value non-grain foodstuffs. In addition, India's agriculture oversea sell and trade in patterns are also shifting. Even if the split of total agriculture exports is falling, which is normal and acceptable with fast mounting industrial and service areas, the total quantum of exports has been escalating in current years. Moreover, India has been importing a noteworthy part of the necessities of vegetable oil, and also some pulses, fruits and nuts etc. On the other hand, the cost of agriculture exports here go beyond that of imports, and the distinction is amplifying steadily.

Nonetheless, the India should have to concentrate with great emphasis on quantity of food imports is its effect on prices. Latent price boosts due to large food import from countries such as China can harm the very consumers that the imports would look forward to help, and also can boost the explosive nature of global grain markets in the years of momentous grain production deficits. As a result, a logical degree of food self-sufficiency, solely because of the precariousness in the grain prices in the markets, can still be a fine assumption for analytical future food and water demand.

5. Realizing the Potential in Rain-fed Agriculture:

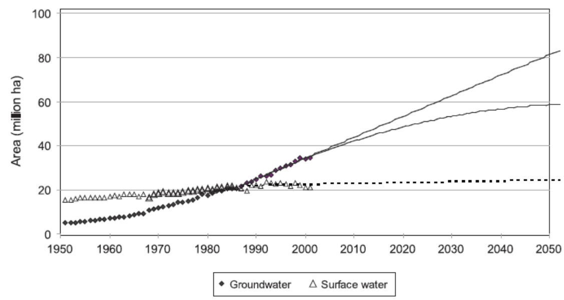
Though India boasts as the highest in rank amid the countries with rain-fed agriculture area, it ranks one of the lowest in rain-fed yield (IWMI 2000). The full amount of food grain production from the existing land can be enlarged 30% by elevating the rain-fed yield by just one ton, which is still to a great extent lower than the rain-fed yields of many other fat rain-fed food grain producers. Recurrent incidences of mid-season and fatal famines were the focal grounds for near to the ground yield of crop in a most important part of the rain-fed cropped vicinity. Small supplemental irrigation during the water stressed periods of mid-season and terminal droughts can notably add to the rain-fed yields. As long as supplemental irrigation through decentralized, more evenhanded and beleaguered rainwater harvesting structures can lend a hand to millions of resource poor farmers in rain-fed faming. They shall also trim down the necessity for large-scale irrigation projects, which in the present states of water scarcities need large inter or intra-basin water transfers.

6. Increasing Crop Productivity:

The one of the major drivers in formative the constraint of supplementary agriculture area and irrigation is postulation of the growth in crop yields. For example, India can be self-sufficient in food grains devoid of any supplementary irrigation if it doubles the crop yield in 50 years. In 2000, India was self-sufficient in food grains with a production of about 205 Mmt. The land and water efficiency of food grains in 2000 was 1.67 ton/ha and 0.48 kg/m^3. With two-fold increase in land and water productivity, India can increase food grain production over 400 Mmt without any additional consumptive water use. This level of production is more than sufficient to meet the consumption demand of 377 Mmt projected by Amarasinghe et al. (2007).

7. Growth in Irrigated Area:

Irrigation extension was the one and only supplier to the development in gross cropped area, during the last few decades and groundwater was the core driver behind this area extension. In fact, the groundwater irrigation has put in to all of the net irrigated area growth in the 1980s and 1990s (Fig. 2). Today it accounts for 60% of the gross irrigated area of India. Actuality, the groundwater irrigation outburst in the last few decades was driven primarily by the population heaviness and not essentially by the water availability through return flows of surface water irrigation. The trends in the 1990s show a barren divergence from this assumption. Such assumptions without a doubt have most important inferences on the financial cost and also on the total water demand. As regards the cost, intensifying surface irrigation under the existing water scarcity conditions in many river basins will almost certainly necessitate expensive interbasin water transfers. In this view, the water demand, surface irrigation may have need of radically higher water withdrawals, as project competence of surface irrigation is much lower than groundwater irrigation.



Source: GOI 2005; Amarasinghe et al. 2007.
Fig. 2 Net surface and groundwater irrigated area growth

8. Increasing Efficiency:

The next most important driver affecting irrigation demand projections is the project efficiencies of surface and groundwater irrigation systems. There is a significant scope for increasing project efficiency, especially in surface irrigation systems. Still, the efficiencies of major systems are on the edge around 30-40% and no foremost addition of efficiency was observed in the last few decades. Certainly, ever-increasing irrigation efficiency in one location of river basins that are approaching closure may not yield the preferred outcome of gains in on the whole efficiency, as it influences another user in the downstream of the closing basins. Thus, rising surface irrigation competence will have limited effect within the water stressed basins.

Several water economy technologies, in particular micro-irrigation systems, can considerably increase water use-efficiency.

9. Domestic and Industrial Water Needs:

The requirements for water for the domestic and industrial purpose can be constrained by the economic development, growing income and lifestyle changes. Water demand in domestic and industrial sectors swelling in haste with rising income in the low to middle-income categories. In India, the service and industrial sectors stretched out speedily in the 1990s and added to a GDP growth of more than 5.1 % annually between 1991 and 2002. During this period, per capita GDP has increased at 3.9 % annually, and it is growing 5.3% annually in this decade. Such escalation patterns in the economy will put forth a considerable force for water demand in the domestic and industrial parts in the future. In fact, according to the current drift of economic development and urbanization, most of the additional water demand between 2000 and 2050 could well come from the domestic and industrial sectors (Amarasinghe et al., 2007).

Secondary Water Demand Drivers:

1. **Total Renewable Water Resources:**

The water resources created by endogenous rainfall within the borders, the internally renewable water resources (IRWR), and the net inflow from other countries through natural processes or allocated by treaties, the externally renewable water resources (ERWR) forms the total renewable water resource (TRWR). With 1,896 billion cubic meters (BCM) of surface runoff, 636 and 1260 BCM of ERWR (ERWR is the net inflow to India. Inflows to India are from Nepal and Burma and outflows from India are to Pakistan and Bangladesh.) and IRWR, India has the seventh largest, and about 4% of the total renewable water resources (TRWR) of the world (CWC 2004). On the other hand, due to un-even rainfall, TRWR vary drastically across river basins (Table 1).

The current research shows that with climate change, Mahanadi, Brahmani, Ganga and Godavari will experience advanced rainfall and larger surface runoff, while a lot of peninsular basins will experience lower rainfall and lower surface runoff. Although, the aggregate of TRWR at the national level show no major alteration, regional differences are likely to boost further.

Table 1. Water resources of India.

River basins	Total water resources (TRWR)	Utilizable surface water resources	Total ground-water resources	Potentially utilizable water resources (PUWR)	PUWR - % of TRWR
	km3	km3	km3	km3	%
Indus (Up to border)	73.3	46.0	27	72.5	99
Ganga	525.0	250.0	172	422	80
Brahmaputra and Meghna	585.6	24.0	36	60	10
Subernarekha	12.4	6.8	2	9	70
Brahmani-Baitarani	28.5	18.3	4	21	74
Mahanadi	66.9	50.0	17	66	99
Godavari	110.5	76.3	41	117	106
Krishna	78.1	58.0	26	84	108
Pennar	6.3	6.9	5	12	187
Cauvery	21.4	19.0	12	31	147
Tapi	14.9	14.5	8	23	153
Narmada	45.6	34.5	11	45	99
Mahi	11.0	3.1	4	7	64
Sabarmati	3.8	1.9	3	5	135
WFR1[1]	15.1	15.0	11	26	173
WFR2[2]	200.9	36.2	18	54	27
EFR1[3]	22.5	13.1	19	32	142
EFR2[4]	16.5	16.7	18	35	212

Source: GOI 1999, CWC 2004

Notes:
WFR1 includes west flowing rivers of Kutch, Saurashtra including Luni;
WFR2 includes west flowing rivers between Tapi and Kanayakumari;
EFR1 includes east flowing rivers between Mahanadi and Pennar;
EFR2 includes east flowing rivers between Pennar and Kanayakumari;

2. Potentially Utilizable Water Resources (PUWR):

The PUWR which is the part of the TRWR can be detained for human use within a river basin. This depends on the deviation of rainfall and the prospective of storage space and distraction facilities. This is estimated to be only 58% of the TRWR for India. In the midst of the river basins, Brahmaputra and Meghna have the largest TRWR, but with inadequate storage opportunities, only 10% of TRWR can be captured as PUWR (Table 1). The PUWR per person in India in the middle of this century is projected to be 701m^3, which is only 22% of the PUWR per person in the middle of last century, representing more than four-fold swell of population over this period.

The frequency of flash floods increases along with growing incidence of soaring amount and short duration rainfall events. As a result, the ability to capture or divert water will reduce and as a consequence PUWR will trim down.

Yet, different reactions are offered for augmenting PUWR in water stress regions. The three popular methods practiced for augmenting PUWR are- Rainwater harvesting (RWH), artificial groundwater recharges (AGWR) and intra-basin or interbasin water transfers (IBWT). The RWH and AGWR are largely local level intrusions and they will cause immediate impacts in a neighborhood of the location where water is captured. However, the IBWT, which generally have need of large infrastructure development, including storage reservoirs, barrages, river links, and distributaries canals etc., can add to water availability in far away locations from where water is originally stored or diverted.

3. Rainwater Harvesting:

The amount that RWH can supplement the PUWR depends on the competence of RWH structures to store part of the unutilizable water resources. The study by using a district level analysis demonstrates that 99km^3 of surface runoff are accessible for rainwater harvesting in 25 Mha of rain-fed lands. These lands eliminate the extreme arid and intense wet rain-fed areas. Bharat et al. study also illustrates that it requires only about 20km^3 of the above runoff to be captured to bring relief to about 25Mha of rain-fed lands suffering from mid-seasonal droughts.

4. Artificial Groundwater Recharge (AGWR);

The total 432 BCM renewable groundwater resource is estimated in India. In whole country, simply about 37% of the renewable groundwater resource is withdrawn at present. But, with thorough withdrawals for irrigation, groundwater resources of some regions are relentlessly over-stressed. The numbers of overexploited bocks are rising, where groundwater notion well exceeds the replenishable recharge (CGWB 2008). Sustaining the groundwater supply for various services, especially in the severely water stressed blocks and in areas approaching overexploitation, and retaining the base flow in rivers in the dry season is indeed a major challenge.

AGWR have the ability to alleviate the stress in groundwater overexploited areas. According to the master plan prepared by the Central Groundwater Board, 36 BCM of unutilizable surface runoff can be captured through AGWR (CGWB 2008). This augments India's PUWR by 3.4%.

5. Intra-basin or Interbasin Water Transfers (IBWT):

The IBWTs may have the latent for large net augmentation of PUWR. The NRLP visualize transferring 178 BCM from water leftover Brahmaputra, Maghanadi and Godavari basins to water scarce basins such as Krishna, Cauvery, Pennar, and Sabramati, in the southern and western regions (NWDA 2006). If all that diverted water in the NRLP is from unutilizable surface runoff, then it augments PUWR of India by 18%. The NRLP anticipates mitigating the damage caused by floods which damages the eastern parts of the country every year, temporarily dislocating many people, wiping out crops and livestock, and disrupting the livelihood of numerous, especially the rural poor people. In fact, it can improve water scarcities in many river basins, which in some regions are flattering a serious check on further economic development.

Lakhs of people are displacing and large areas of forest and productive agriculture land is submerging due to the IBWTs. The hardest hit by such displacements are obviously the weaker sections of society, including tribal communities, landless laborers and so on. The immigration and rehabilitation issues, if not properly carried out, it becomes a major bottlenecks for implementing large IBWTs. Political solidity and relations between states and neighboring countries are also major drivers of planning and implementing IBWTs. Often, IBWTs cut across several states and at times, several countries. As a result, the existing level and the future scenario of trans-boundary or inter- state cooperation are most important influential factors determining the practicability of such IBWTs.

6. Ecosystem Water Needs:

Ecosystem water needs is another most important key driver, which is over and over again overlooked in IBWT planning. According to Bandyopadhyaya and Praveen 2003, there is no free surplus of water available to be transferred from one river basin to another basin. All water in the unutilizable water resources, including floods, acts upon an imperative ecosystem service. Such suppositions, indeed, are an intense view point in-terms of ecosystem water needs. A compromised method can resolve the extent of surplus that can be transferred from the water surplus river basins. On the other hand, this condition can change if eco-system water needs are well thought-out as a primary driver of water availability. The premise here is that parts of the floods in the rainy season and a minimum river flow in the dry season play a major role in servicing the needs of the riverine ecosystems. Thus, a key part of the unutilizable water resources cannot be captured and transferred for water use in other basins.

7. **Environmental Water Demand:**

As a prime driver, a good starting point is to suppose that at least a minimum environmental flow (EF) requirement is to be sustained for providing ecosystem services of a river basin. Aspects influencing the EF are the natural hydrological inconsistency of the river flow, an endogenous driver to the water system, and the environmental management class that the river ought to be maintained.

Conclusion

To cater to growing demand in the coming decades, India strongly requires substantial additional water supply provisions. The most significant primary drivers of India's water future in the short to medium term includes- the population and economic growth, increasing world trade, the changes in lifestyles and food consumption patterns, technological advances in water saving technologies etc. The climate change will become an influencing factor in the long-term.

Over the last two decades, groundwater has been the most important source for meeting ever-increasing demand in all parts. Even though, many river basins will have relentless water stress conditions under business as usual water-supply and use patterns. With escalating dependence on groundwater, mainly for irrigation, many river basins will have severe groundwater overexploitation-related harms. Indeed, meeting India's short to medium term water demand itself will be a testing task.

India should have to think seriously on important policy options for meeting the increasing demand like- recharging groundwater to increase the groundwater stocks; harvesting rainwater for providing the life-saving supplemental irrigation; promoting water saving technologies for increasing water use efficiency; formal or informal water markets and providing reliable rural electricity supply for reducing uncontrolled groundwater pumping; increasing research and extension for enhancing agriculture water productivity; and carefully crafted virtual water trade between basins etc. This, along with a reliable water supply for diversifying high value cropping patterns, may involve large surface water transfers. The interbasin water transfers could raise the recharge groundwater in much overexploited area.

While artificial groundwater recharge, rainwater harvesting, and interbasin water transfers are answers for meeting the water requirement in the near-term, they are also solutions for rising the latent serviceable water supply in many water scarce river basins. They will without a doubt have most important benefits when complete influence of the climate change starts to impact the serviceable supply in many water scarce river basins.

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