

Need for proper water management for food security

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In India, for food security, the future agriculture faces the challenge of enhancing crop production under uncertain climatic extremes, in a limited (or degraded at many places) land area, with more and more requirement of water (in many places, poor quality water), complexities and rapid erosion of natural biodiversity and agricultural systems, and the socio-economic systems governing food supply and demand. Plant attributes conferring good yields, under fast-depleting/deteriorating natural resource base, are yet to be identified. Breeding for crop improvement, for higher quality, production, heat and water stress resistance, has met with limited success. It is well known that despite planting the improved genetic varieties, and application of the recommended doses of fertilizers and agronomic practices, the dormant seed gets its vigour only in the presence of water. But, reliable assessment of this important resource base and its protection from depletion and degradation has not received its due consideration in the management of agriculture. In this context, analyses of agricultural information reported in the literature, clearly suggest that proper water management can only help in enhancing future food production. Policy guidelines have also been suggested for ensuring food security.

Keywords: Food grains, food security, irrigation water, population growth, groundwater.

INDIA is a second most populous and largest democratic country in the world. A large percentage of the Indian population is dependent on agriculture for its sustenance. Agriculture is one of the major sectors of growth of the Indian economy. Since independence, considerable efforts were made towards attaining food security, to meet the ever-increasing demand of food for the ever-growing population, and there has been a remarkable improvement. Undoubtedly, the Green Revolution technologies of the 1960s addressed this challenge, promoted the production and distribution of seeds of high-yielding varieties, and successfully increased crop production. Since then, applications of the recommended fertilizer doses and agronomic practices have continued with a lot of expectation from the high-yielding varieties. But, during the last decade or so, the stagnation in yield and its recent decreasing trend of the most popular varieties of the two crops, wheat and rice, suggest that the genetic diversity of the farmer's limited fields with the current soil fertility conditions and agronomic practices has reached the limits of sustainability in food production, and that the food security of India seems to be at stake. Food security in the FAO terminology has been defined as follows: 'Food security exists when all people, at all

times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.' Now, ensuring food security for the fast-growing population is a major challenge, which ultimately exerts pressure on the available natural resources. While the significance of natural resources like water was felt as an important input, ensuring its availability in adequate quantity and good quality has been ignored by mismanagement. Indiscriminate exploitation of water resources and the inadequate protection measures have led to water depletion and deterioration at an alarming rate. Such exploiting practices of the available water resources could result to catastrophic situations. Thus, the future agriculture in India faces the challenge of increasing food-grain production in limited land area with limited water availability and in many areas poor water quality. To understand the severity of the problem, we provide a detailed insight.

Population growth: a concern

India's present population counts to 1.21 billion (Figure 1), according to the latest census release, and the growth is relatively slower than that in the past decades. In global scenario, India has 17.31% of the world's population and it occupies only 2.4% of the world's land area. China, the other most populous nation, accounts for 19.4% of the global population. But with population growth rate at

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1.58%, India is expected to have more than 1.53 billion people by the end of 2030 and would attain the first place in world population¹. Some of the reasons for India's rapidly growing population are poverty, illiteracy, high fertility rate, etc. The point of concern is that this fast-growing population causes stress on the available natural resources to meet the food requirement successfully.

Land utilization

India is endowed with a variety of soils, climate, biodiversity and ecological regions. According to the 2007–08 land-use statistics (Figure 2), out of the total 305 million hectare (m ha) area, 46% (140.86 m ha) is utilized for growing different crops². In some states like Haryana, Punjab and Uttar Pradesh, which lie in the fertile

Indo-Gangetic Plains of India, the net area sown is between 60% and 70% of the corresponding area of the states. Whereas 23% of the total area is occupied by the forests, 43.22 m ha is not available for cultivation. Fallow land and other uncultivated land, excluding fallow land are 8% and 9% respectively. In 1956–57, the net sown area of the country was 130.85 m ha, which increased to 140.86 m ha in 2007–08. This is an insignificant increase of 7.65% with respect to the likely exponential increase in demand for food by high population growth.

Role of water resources in food-grain production

In 2010–11, India achieved a target of 235.88 million tonnes food-grain production³, registering an increase of 364% during 1950–51 to 2010–11 (Figure 3). India's output of food grains comprises wheat, rice, pulses and coarse cereals. Among the cereals, rice and wheat have shown prominent rise in production since the 1980s. Overall global production trends are quite similar to that in India. Many factors like high-yielding hybrid seeds, availability of supplements in the form of nutrients like chemical fertilizers and water are responsible for increasing the food-grain production. However, the parallel trends of food-grain production and area under irrigation in Figure 3, clearly illustrate that the resource which has contributed the most to increase the food-grain production is irrigation water. This justifies the role played by water to make India self-sufficient in food-grain production. The net shown area increased marginally from 133.20 m ha in 1960–61 to 139.85 m ha in 2006–07. The contribution of water may also be reflected by the fact that since 1950–51 to 2007–08 the yield of food grains has improved from 522 to 1860 kg/ha, showing a similar trend as the increase in area under irrigation.

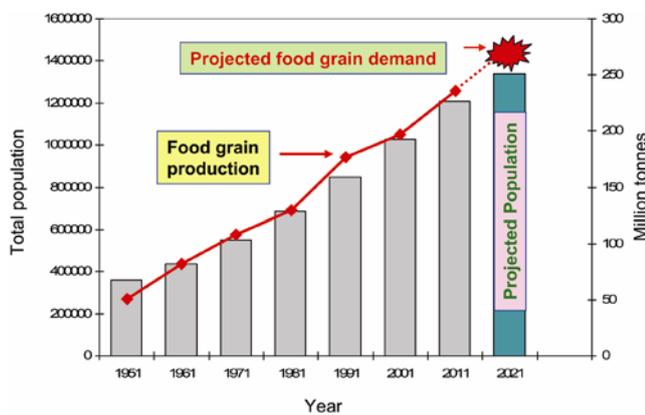


Figure 1. India's population and food production trend. (Source: Refs 2 and 3.)

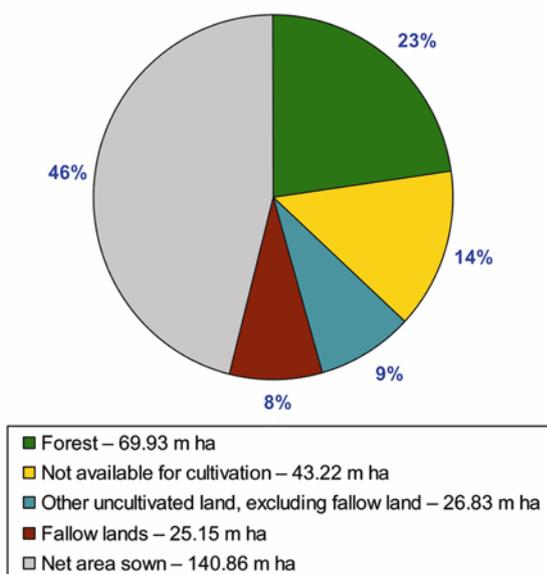


Figure 2. Land-use pattern for India (2007–08). (Source: Ref. 2.)

Irrigation water: a limiting factor

In the last 60 years, significant developments in water resources and in agriculture have been noticed in India. Improved hydraulic infrastructure has helped the farming community utilize the water resource for growing more food products. In India, canal water and groundwater are the major sources of irrigation. Figure 4 clearly shows that the canal-water availability for irrigation purpose has been limited, which varied from 8,295,000 ha in 1950–51 to 15,475,000 ha in 2005–06. During the last 2–3 decades, there has been practically no scope to further increase the canal water-irrigated area, and in the last 10 years or so, there has been a declining trend in the canal water-irrigated area. As opposed to this, the contribution from groundwater to the total irrigation area has increased substantially⁴ from 5,978,000 ha (29%) in 1950–51 to 35,372,000 ha (59%) in 2005–06. An abrupt rise in groundwater utilization is observed since 1980, which has

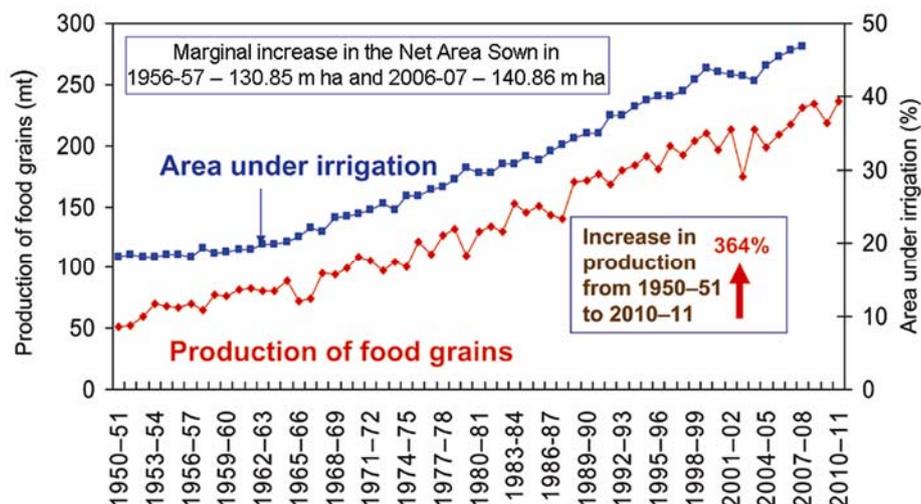


Figure 3. All-India production of food grains and percentage area under irrigation. (Source: Refs 2 and 3.)

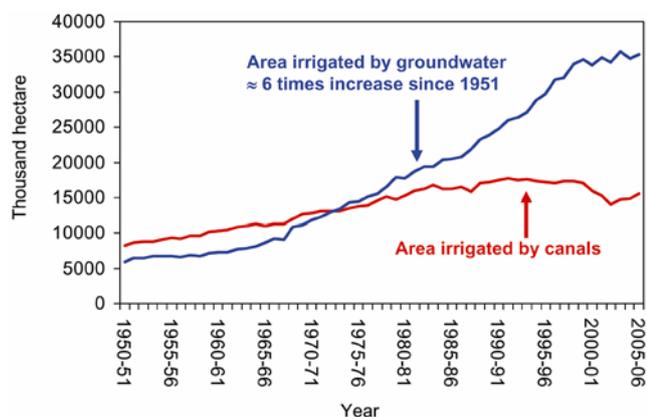


Figure 4. Irrigation trend by canals and groundwater. (Source: Ref. 4.)

doubled in 25 years. Groundwater irrigation, which expanded rapidly in the last few decades, forms a major part of the water withdrawals in many river basins. At present, more than 60% of the total irrigated area is groundwater-irrigated⁵. Nevertheless, during the last 10 years or so, even the groundwater-irrigated area shows relatively slower growth rate compared to the exponential expanding situation from 1950 to 2000. This may be due to possibly declining groundwater levels induced by indiscriminate withdrawal, thereby increasing the cost of pumping, and also due to pollution of groundwater in many areas.

Irrational water utilization

FAO Aquadata base suggests that globally the water utilization for agriculture is 70% of the total water usage, whereas water utilization for municipal and industrial purposes is 11% and 19% respectively. Figure 5 clearly

illustrates that water utilization for agricultural purposes in India is above the international usage trend, which was 87% in 1990 and 85% in 2000. For application of water as input, flood irrigation has predominantly been the adopted practice throughout the country. In India, with more than 60% of irrigated agriculture and 85% of drinking water supplies being dependent on groundwater, it is a vital resource for rural areas. Currently, India is the largest groundwater user in the world, with an estimated usage of around 230 km³/yr, more than a quarter of the global total water use. Reliance of urban and industrial water supplies on groundwater is also becoming increasingly significant in India⁶. To meet this tremendous requirement of water, millions of private tube wells have been constructed. Such phenomenal growth has been the reason for exploitation of groundwater in the previous decades. The overexploitation of groundwater and the existing vast canal network has, however, led to water-logging and soil salinity in many parts of the country. There are many reasons for high water usage, such as zero or negligible tariffs on farm power in some states of India; no additional costs for extracting extra water; inadequate canal water; cultivation of crops with high water requirement (e.g. rice and sugarcane), and assured markets.

In India, the annual replenishable groundwater resource is 433 billion cubic metre (bcm) and net annual groundwater availability⁶ is 399 bcm. The overall contribution of rainfall to the country's annual replenishable groundwater resource is 67%, and the share of other sources, including canal seepage, return flow from irrigation, seepage from water bodies and water conservation structures taken together is 33%. About 73% of the country's annual replenishable groundwater recharge takes place during the kharif period of cultivation. The available groundwater resource for irrigation is 361 bcm, 90%

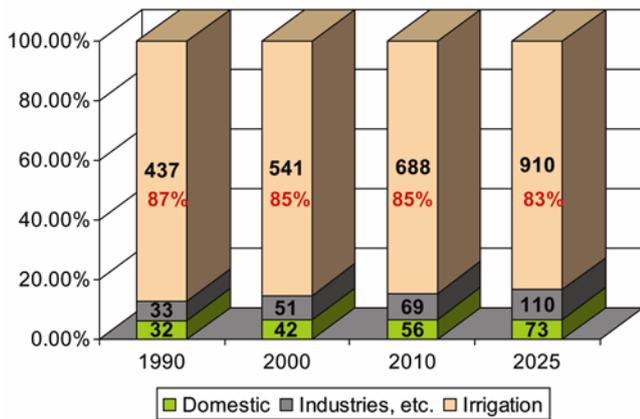


Figure 5. Annual water utilization pattern of India (bmc). (Source: Ref. 18.)

of which is utilizable quantity. The quantum of groundwater used for irrigation by the last century was of the order of 128 bcm (ref. 6). Groundwater draft is quite high in northwestern India, in Punjab, parts of Haryana and western Uttar Pradesh, as also in the eastern parts of West Bengal. In these areas, annual groundwater draft is mostly used for irrigation purposes. A rapid growth in the number of bore wells since 1980 has led to unplanned abstraction of groundwater and a steady decline in the water table, resulting in a large increase in the cost of pumping a given volume of water⁷.

Managing water resources for future food safety

Traditionally, India has been an agriculture-based economy. Hence, development of irrigation to increase agricultural production for making the country self-sustained and for poverty alleviation has been of crucial importance to the planners. Accordingly, the irrigation sector was assigned a high priority in the Five-year plans. It is projected that by 2030, demand of food grains in India will grow to almost 1.5 trillion m³, driven by domestic demand for rice, wheat and sugar for a growing population, a large proportion of which is moving toward a middle-class diet. Against this demand, India's current water supply is approximately 740 billion m³. As a result, most of India's river basins could face severe water deficit by 2030 unless concerted action is taken, with some of the most populous basins, including the Ganga, Krishna, and the Indian portion of the Indus facing the biggest absolute gap⁸. A 2004 nationwide assessment states that despite the valuable nature of the groundwater resource, 29% of groundwater blocks are semi-critical, critical or overexploited, and the situation is deteriorating rapidly. Moreover, aquifers are depleting in the most populated and economically productive areas⁷. Overall, up to a quarter of India's harvest has been estimated to be at risk due to groundwater depletion⁹.

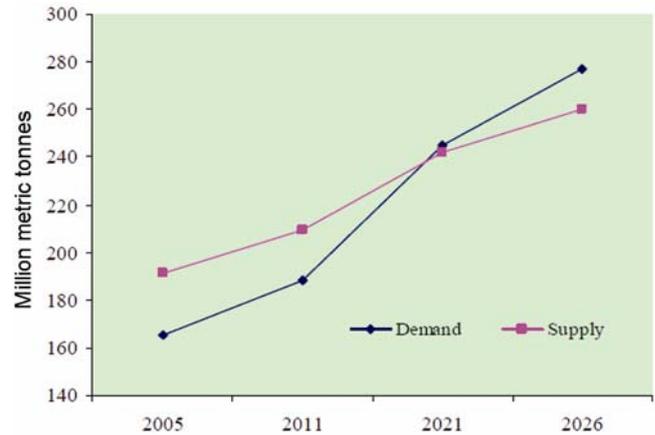


Figure 6. Future supply and demand balance for total cereals in India. (Source: Ref. 12.)

Since 1980, India has managed to maintain food-grain self-sufficiency at a national level even under adverse climatic conditions and high population growth. Continued irrigation expansion combined with better inputs have played a vital role in meeting India's national food security^{10,11}. But, with the increase in population and per capita income, the total demand of food grains is showing an uptrend, causing an imbalance in demand and supply. Figure 6 depicts the gap between supply and water demand of food grains in India¹². This clearly indicates that in the coming years more food grains need to be produced to fulfil the requirement of the population. The data also suggest that from 2021 onwards India may find it difficult to produce the required food to feed the people under limited or scarce water-availability conditions. Moreover, due to further decline in groundwater level and increasing cost of energy, the cost of withdrawal of groundwater for irrigation will be also increased.

Irrigation water cost

In some parts of India, the government provides electricity to farmers at a reasonable cost to enable agricultural use. This low-cost irrigation encourages the users to draw more water, resulting in lowering of groundwater and reducing the productivity of the wells. The groundwater level in many watersheds is declining due to unregulated over-exploitation even when the recharge conditions are good. It has cost more to the farmers in terms of increasing drilling and extraction costs. The situation is already critical in northern Gujarat, southern Rajasthan, coastal Tamil Nadu, parts of Haryana and Punjab¹³. One of the latest UN reports on water management issues describes that since 1960, throughout the world, as irrigation area expanded, food prices fell for the last 30 years¹⁴ (Figure 7). But, as the cost of energy started rising, the food price index also showed an abrupt increase since 2001 onwards. India also followed the same trend as far as cost

Table 1. Annual water use/requirement of India and China

Use of water (bcm)	India ¹⁸ (year)				China ²⁰ (year)				
	1990	2000	2010	2030 ⁸	1980	1993	1997	2005	2030 ⁸
Agriculture	437	541	688	1198	370	383	392	358	417
% use	87	85	85	80	83	74	70	64	51
Total	502	634	813	1498	444	519	557	563	818

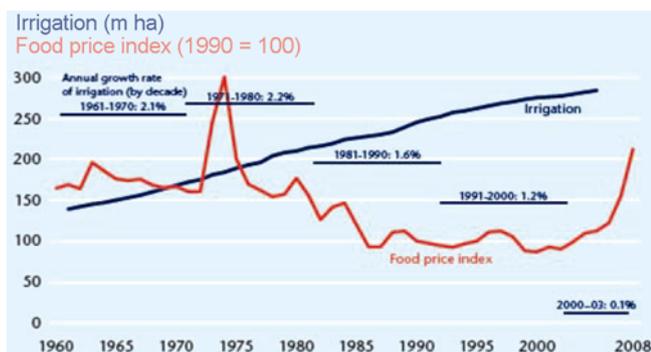


Figure 7. Globally, as irrigation area expanded, food price fell for 30 years before starting to rise again. (Source: Based on Comprehensive Assessment of Water Management in Agriculture 2007; FAO FAOSTAT¹⁴.)

of energy is concerned. The whole sale price index of food articles in India, base year 1993–94 (= 100) has risen to 301.5 in August 2010 (Ministry of Commerce and Industry, Government of India (GoI)). In the present situation, the Indian Government has taken strict measures to control inflation. One of the reasons for this increase in the cost of food items is growing expenditure cost for irrigation water. In many agriculturally productive regions of India, where a large number of small farmers exists, groundwater is pumped either by electricity or by dieselized pumps to serve the agricultural needs. In the recent past the price of diesel has increased tremendously, reflecting its effects on food price index. If we take an example of Uttar Pradesh, a part of the Indo-Gangetic Plains having extensive agriculture, where majority of the farmers hold >2 ha of land holding, the number of diesel pump sets in 1979–80 was 581,998, which increased to 2,965,357 in 1998–99, a four-fold increase¹⁵. From this trend, one can estimate the number of diesel pump sets now, i.e. 12 years later. The increased use of diesel pumps to run these sets would definitely be costing more under the depleting water-level conditions. One of the estimates of the Ministry of Water Resources, GoI under the Fresh Water Year 2003 project, is that in alluvium areas, energy saving for 1 m rise in groundwater level is around 0.40 kW/h or vice versa. Hence, if this is the case in only one state of India, one can imagine the rise in cost of the food items or energy requirement for proper irrigation of the food crops.

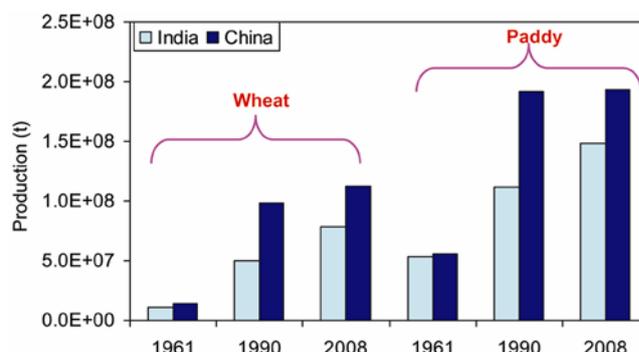


Figure 8. Comparison of production of wheat and paddy between India and China (Source: FAOSTAT | © FAO Statistics Division 2011.)

If China can do, why not we?

China is one of the world’s largest producers and consumers of agricultural products and so has the potential to have major impacts on global food markets. The threat of growing Chinese imports on world food prices has long been highlighted¹⁶, but despite such concerns, China continues to import only a small fraction of its food requirements. But over the past few decades, government policies and exponential increase in crop yields have made China self-sufficient in food production. Although the total amount of water used in agriculture has not increased in recent years, it remains the largest water user. The proportion of agricultural water use has decreased from 83% in 1980 to 65% in 2003 (ref. 17). Further estimation from 2030 Water Resources Group has predicted that in China the water requirement for agricultural purposes would decrease to 51% of the total water use. Whereas the water use in agriculture in India was 87% in 1990, 85% in 2000 and 2010, and would be 80% of the total water use/requirement in 2030 (refs 8, 18). Table 1 substantiates the above facts well. The reduction in water use for agriculture by China indicates the efforts for water management by their government agencies. While with respect to food-grain production, India is showing an increasing trend since 1961 (Figure 8) and in spite of more percentage of water used by the country, the food grains, e.g. wheat and paddy produced are all the time less.

Concluding remarks

The above analyses suggest that for enhancement in food production, besides the high-yielding genetic varieties

and usual agronomic practices, proper management of the limited available groundwater resource is important. In India, since the rural population density is large and most of the agricultural holdings are small (<2 ha) and highly fragmented, social equity must be ensured in terms of water availability. The water resources management practices may be based on increasing the water supply and managing the water demand under the scarce water availability conditions. Therefore, to develop planting strategies and selection of cropping pattern, systematic integration of time distribution of water requirements for various crops and various planting dates with water supply according to availability of water is of paramount importance. This will minimize the adverse impacts of water scarcity on potential water-consuming crops.

The availability of water is determined by water accessibility and utilizability in terms of quantity and quality. Enhancement in water availability and safe water supply is guided by the policies, plans and technologies at our disposal, in addition to political, socio-economic, biological and other factors¹⁹. As has been reported earlier, due to imbalance between demand and availability, groundwater management approaches are facing various ethical dilemmas¹⁹. For an effective, efficient and sustainable groundwater resources development and management, the future challenges are to assess the inextricable logical linkages between water policies and ethical consideration¹⁹. Water resources management and planning should be based on monitoring of hydrological parameters and dissemination. All development plans should be based on strict implementation of strategies for conservation of water, increasing irrigation efficiencies, minimizing the wastage of water, prevention of water pollution, more efficient protection of water quality, and restoration of landscapes and ecological systems.

Groundwater recharge should be estimated by reliable and accurate improved methods and revised time to time, and the exploitation of groundwater resources should be regulated so that it remains in commensurate with the recharge. Rational pricing of groundwater, energy-irrigation nexus and discouraging government support for the installation of tube wells and subsidies on electricity supplied to farmers could be the possible policies for groundwater withdrawal management. While such policy changes are likely to reduce excessive and injudicious use of groundwater, it may have different impacts on different sections of the society in different regions. This is the right time for the planners and managers from government and non-government organizations to come forward with efficient water-management plans and innovative ideas taking into consideration the aspects outlined

above, with involvement and active participation of the farming community to ensure India's self sufficiency in future food production.

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