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Sustainable Management of the Water Resources of India for the Development of the Indian Agriculture

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Abstract—‘*Water is at the foundation of sustainable development as it is the common denominator of all global challenges: energy, food, health, peace and security, and poverty eradication’. [1] Water is the most important input for the overall success of the Indian Agriculture. Sustainable Water Management (SWM) is a composite area in the Indian Economy with its linkages to the other sectors of the economy, namely, agriculture, industry, environment, fisheries, power, domestic and the household sector. SWM requires allocating of the water resources between the competing sector demands, balancing the financial and social resources required to support the necessary water systems. This paper attempts to examine the demand, availability and the need for sustainable management of the water resources of India for the development of the Indian Agriculture. It briefly deals with the water sources in Indian Agriculture, a profile of Indian Agriculture, the challenges faced by the water sector, the need for sustainable management of the water resources in the Indian Agriculture, the hydrology, water use and the economics of water resource management in the Indian Agriculture. It focuses on understanding the economics of water resources, the value and cost of water with regard to water supply in the Indian Agriculture. Finally, the paper concludes with policy measures for water planning, water management, research and development, education to farmers for sustainable management of the water resources in the context of water availability, water demand and the water use for the development of the Indian Agriculture.*

Keywords*: Sustainable Water Management (SWM), Cost, Valuation, Agriculture Development, Food Security, India*

1. INTRODUCTION

Despite India’s relative wealth of fresh water, there are two persistent issues facing India’s water supply- water scarcity and water quality. Water scarcity occurs because seasonal pattern of water demand does not synchronize with natural weather and ground water renewal patterns. Further, water scarcity is exacerbated by low water prices, which provide little incentive to use water efficiently. This calls for immediate attention by the stakeholders to make sustainable use of the available water resources. Agriculture is the central sinew to the Indian Economy. It provides food surplus to the expanding population, occupies a major share in national income, provides raw materials to the industries, and has an important role in international trade and overall poverty reduction of the population of India. Agricultural water resource management in India covers a wide range of agricultural systems and climatic conditions, drawing on varying water sources, including surface water; groundwater; rainwater harvesting; recycled wastewater; and desalinated water. ‘Water is bulky and expensive to transport relative to its value per unit of weight. This makes the water supplier to be a monopoly supplier in any given area, requiring a high degree of managerial and social control’. [2]Sustainable Development is defined by the Brundtland Commission Report as ‘meeting the needs of the present generation without compromising the ability of the future generation to meet their own needs’. [3] “Needs” refers to economic, environmental and ecosystem service delivery and cultural goals including identity and subjectively defined values. These are all together defined as the sustainability triple bottom line. Sustainable Water Management (SWM) is a critical component of sustainable development and it accounts for similar issues as that of sustainability. Mays defines SWM as ‘meeting current water demand for all water users without impairing future supply’.[4] SWM in India poses a numerous challenges: bridging the wide gap between demand for and supply of water, providing enough water for the production of food, balancing the uses between competing demands, meeting the demands of the big cities. ‘India has only 4 percent of the world water resources and 16 percent share in population’. [5] Therefore the pressure on India’s water resources is increasing with the rising population and the trend of urbanization, industrial growth, expanding agriculture and the rising standard of living.

2. AIMS AND OBJECTIVES

(i) To study the economics of Sustainable Water Management in Indian Agriculture.
(ii) To study the valuation and cost of water.

(iii) To study the benefits of sustainable management of the water resources of India for the development of the Indian Agriculture
(iv) To implement a policy for sustainable management of the water resources of India for the development of the Indian Agriculture.

Research Questions.(i)What are the sources of water supply in the Indian Agriculture?(ii) What is the present state of the water availability and water demand in the Indian Agriculture? (iii) What are the challenges in the water supply to Indian agriculture? (iv)How to implement a policy for sustainable management of the water resources of India for the development of the Indian Agriculture?

Methodology: The entire study will be based on the use of secondary data. Data on water resources of India and the data on agricultural productivity of India will be taken from websites of the Ministry of Water Resources, Government of India and the Ministry of Agriculture, Government of India. Books, Journals will be used to make the study an effective one.

Review of the Literature: Hedge. G Narayan (2006) in his study of 'Water Scarcity and Security in India' dealt with the causes for rising demand for water in India and suggested some measures for sustainable management of the water resources of India to meet food security for the growing population of India.

Rainfall is the main source of fresh water in India. Surface water and ground water are the main sources of water available in Indian Agriculture. 'The Ministry of Water Resources have put the overall water resources of the country at 1869 $km^{3,}$ total utilizable water resource is accessed as 1,122km^3 out of which 690 km^3 is surface water and 432 km^3 ground water'. [6] 'When the annual per capita of renewable fresh water in a country or a region falls below 1,700 cubic meters, it is held to be a situation of water stress. If the availability is held to be below 1000 cubic meters, it is a situation of water scarcity. When per capita water availability falls below 500 cubic meters, it is a situation of absolute scarcity. In 1947, the per capita water availability in India was 6008 cubic meters a year. It is expected to be 1140 cubic meters in 2050'. [7]Table 1 and Fig. 1, shows the trends in per capita water availability for hundred years from 1947 to 2047.

Table 1: Per capita water availability in India

Year	Population (Million)	Per capita water availability (m3/year)
1951	361	5177
1955	395	4732
1991	846	2209
2001	1027	1820
2025	1394	1341
2050	1640	1140

Source: Ministry of Water Resources, Government of India

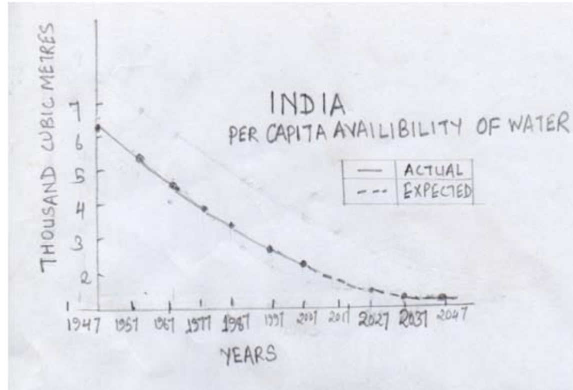

Fig. 1: Declining per capita water availability in India from 1947 to 2047

The diversity of water resource management in Indian agriculture can be summarized in terms of hydrology, water sources, uses, and institutional structures. Hydrology is the mobility of water − it flows, evaporates, and has the opportunity to be reused. Water resources has a heterogeneous use in terms of space, quality and variability over time (seasonal and annual) present challenges in matching supply and demand for water. A given quantity of water is not the same as another available at a different location, point in time, quality and probability of occurrence. The heterogeneity extends to structuring legal and institutional arrangements.

Economics in Sustainable Water Management stresses on the growing inter sectoral competition for water and increasing emphasis on environmental externalities associated with agriculture. The Dublin International Conference on Water in 1992, stated that 'managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources'. [8] There are some distinctive economic features that make the supply and demand for water more complex than other economic goods and services This include the private (extraction) and public good (stewardship) characteristics of water. When water is used on a farm it is a private good, but when left in situ, such as a lake or wetland, it is a public good for which private market is generally absent. Moreover, water is largely used by the private sector (farms, households, industry) but its ownership and delivery is normally in the public domain. Food production is fundamental to sustainable human development. 'Sustainable agricultural water management objectives include attaining food security and maximizing the food water productivity in rainfed and irrigated agriculture'. [9] There are primarily three methods for SWM: (i) indicators and indices (ii) product related assessment (iii) integrated assessment.

'Value of water, is the sum of the economic and intrinsic value'. [10] The economic value includes the value to users of water for productive activities, such as irrigated farming, net benefits of return flows of water diverted for agriculture and other users, which may also include groundwater recharge, net benefits from indirect use, such as drinking water for domestic purposes and providing habitat for flora and fauna, although these benefits can be offset by various negative environmental externalities, such as salinisation of soils and pollution of water from farm chemicals used in irrigation. The intrinsic value includes the value of water linked to the attributes of water (that are the most difficult to assign values), for example, the aesthetics of waterscapes and recreational attributes. The cost of water consists of three elements- full supply cost, full economic cost, and the full cost. The full supply costs are the costs associated with supplying water to consumers without considering either the externalities of water consumption (positive or negative) or alternate uses of water (opportunity costs). These costs further consist of two elements- operation and maintenance costs, associated with daily running of the water supply system, such as electricity for pumping, labour and repair costs. Capital costs, covering both capital for renewal investment of existing infrastructure and new capital investment costs, such as building a new dam and canal network. The full economic costs are the sum of the supply costs, plus the opportunity (or resource) costs and, the economic cost of externalities.

The demand for water in India is steeply increasing because of the following reasons –'India's population which was 1.3 billion in 2005 is expected to rise to 1.66 billion in 2050. The per capita income of Indians will increase from $468 in 2007 to $6735 in 2050. Increased industrialization will demand more water as its contribution to GDP will increase from 29.1% in 2000 to 40% by 2050. Thus, the demand for water will increase from 30 billion m^3 in 2000 to 161 billion m^3 in 2050.The agriculture development will be more on water intensive cash crops and there will be 80% increase in the demand for water by 2050'. [11] The prosperity of the entire nation depends upon the prosperity of the agricultural sector. Agricultural sector contributes a lot to the export trade of India. Indian Agriculture is seasonal in nature. The major agricultural crops are Kharif (sown- June / July, harvested- September/October) includes rice, maize, jowar, bajra, cotton, sesamum, groundnut, pulses-moong, urad. Rabi (sown- October/ December, harvested April/May) includes wheat, barley, gram, oilseeds. Zaid (a summer crop) includes rice, maize, groundnut, vegetables and fruits. Plantation Crops (tea, coffee, coconut, oil palm, cashewnut, cocoa, rubber) constitutes a large portion of the crops and provides great opportunities to the investors. India has maintained the leadership in the production of mango, banana, acid lime, ginger, turmeric, blackpeeper. It occupies prime position in production of cauliflower, second in onion, third in cabbage in the world, the largest producer, consumer, exporter of species (cardamom, black pepper, ginger, garlic, turmeric and chilli), the third largest producer of coconut and a premier coir manufacturing country in the world. Products like soft drinks, edible and inedible oil from coconut are manufactured and exported from India. It is the original homeland to Sugarcane. It produces 90 percent of the World's Rice, 8.7 percent of the World's Wheat. Indian agriculture heavily depends on the south-west monsoon rains. There is large variation in the spatial distribution of rainfall. 'The areas of Meghalaya receive more than 1000 cm of rainfall annually while the area of the Thar Desert receives less than 10 cm of rainfall annually. Only 30.2 percent of the cultivated area in India receives sufficient rainfall where the annual rainfall exceeds 100 cm. About 35.7 percent of the cultivated area receives 75-100 percent of annual rainfall and 34.1 percent of the cultivated area receives less than 75 percent of the annual rainfall'. [12] Even in areas of high rainfall, irrigation is necessary to further increase the farm productivity. The crops like rice, sugarcane, cotton, jute requires more water that has to be provided through irrigation apart from rainfall. It is estimated that the production of irrigated crops is 50 to 100 percent higher than the unirrigated crops under similar geographical conditions. The ever increasing population of India leads to more intensive agriculture which require more irrigation facilities along with other inputs The Indian Council for Agricultural Research (ICAR) divides the Agricultural Regions of India as:

Rice- Jute-Tea- Region**:** This includes the lowlands, valleys and river deltas in the states of Assam, Arunachal Pradesh, Tripura, Meghalaya, West Bengal, Orissa, northern and eastern Bihar, parts of Jharkhand, Chhattisgarh and Tarai Region of Uttar Pradesh. The rainfall varies between 180-250 cm. Rice is grown under varying conditions between 8 degree to 25 degree north latitude and from sea levels of about 2500 metre altitude.

Wheat and Sugarcane Region: Wheat belt of India is Punjab, Haryana, Ganga-Yamuna doab of Uttar Pradesh and North Eastern Rajasthan. Sugarcane is grown in Uttar Pradesh and parts of Bihar. Rainfall here is moderate most of which is caused by south west monsoon in summer.

Cotton Region: It spreads over the Deccan plateau with rainfall varying between 75-100 cms.

Maize and Coarse Crops Region: Western Rajasthan and Northern Gujarat are included in this region. The rainfall is scanty and below 50 cm. Agriculture is possible only with irrigation. Maize is produced in Mewar plateau and Ragi, Bajra; Pulses are grown throughout the region.

Millets and Oilseeds Region: This region includes areas of Karnataka, Tamil Nadu, Andhra Pradesh, and Kerala. Rainfall varies between75-125 cm. The millets include bajra, ragi, jowar, while oilseed include groundnuts and caster. Mangoes and bananas are the important fruit crops.

Fruits and Vegetable Region: This region extends from Kashmir Valley in the west to Assam in the east. The rainfall varies between 60 cms in the west to 200 cms in the east. Apple, peach, cherries, apricot are grown in the west while potatoes, chillies, vegetables, oranges are grown in east.

Challenges in the Water Sector**:** ‘The most serious concern in the water sector is the growing population which is likely to increase to 1.66 billion by 2050. With the increasing population, the annual food requirement in the country will exceed 250 million tons. The total demand for grains will increase to 375 million tons including grain for feeding livestock. With the growth in the National GDP, at 6.8% per annum, during the period from 2000 to 2025 and 6.0% per annum, during the years 2025 to 2050, the per capita income is bound to increase by 5.5% per annum. This will further increase the demand for food. While the per capita consumption of cereals will decrease by 9%, 47% and 60%, with respect to rice, coarse cereals and maize, the per capita consumption of sugar, fruits and vegetables will increase by 32%, 65% and 78% respectively, during the period from 2000 to 2050. This will create an additional demand for water’. [13] Over-exploitation of ground water is another concern.

Findings and Conclusions: As there is an open access to ground water resources, the tragedy of commons is inevitable. One of the pressing needs is the requirement to increase irrigation and the difficulty of creating water storage facilities. ‘Of the 140 million hectares (mh) of the net cultivated irrigated area in India, only 60 mh are irrigated.’ [14] In order for Indian Agriculture to grow at the rate of 4percent per year, it needs to increase the area irrigated, introduce new high-yield technology, or expand cultivable area. There is no scope to increase the cultivable area, which has remained 140 mh since the last two decades. Since rainfall in India is concentrated in few months and unevenly distributed across the country, it is imperative for India to develop the capacity to store and transport water for irrigation. In this regard, the first step is to increase local storage and recharge through watershed development. The Twelfth Five Year Plan (2012-17) stressed on the need for watershed development, involvement of NGOs, aquifer mapping and efficiency in the development of irrigation facility. Water supply can match the demand only if there is a big improvement in the efficiency of irrigation. In the light of the above scenario, the NAP, 2000 announces that “rational utilization and conservation of the country’s abundant water resources will be promoted”.[15] This policy aims to take concrete measures for conservation of the water resources through measures like rain water harvesting and ground water recharging and ensure the judicious use of water. For these, addressing property rights in water, appropriate pricing policy of water would be its priorities. To obtain more agricultural productivity with less water use, policy makers need to establish a structure of incentives, regulations, permits, restrictions and penalties that will encourage people’s innovation in water saving technologies.

Suggestions: Water scarcity will affect the future food production. Sustainable Management of Water Resources for the development of Indian Agriculture can be done in the following ways: (i) construction of water reservoirs and small and medium size dams and rivers can retain more surface water, while increasing the ground water recharge. (ii)Interlinking of rivers will help in preventing floods while improving water distribution in the country. (iii) Establishing a long-term plan for the sustainable management of water resources in agriculture taking into account climate change, including the increased need for protection of water resources from flood and drought risks. (iv) Policies addressing water resource management need to be tailored and targeted to situations specific to both countries and regions within countries. This reflects the great variety across different water basins from the local to international levels in terms of the: heterogeneity of-water sources (*e.g.* surface, groundwater, recycled wastewater, desalinated water); linkages between water resource (quantity) and water pollution (quality) issues.(v) Allocation of water between consumptive uses (*e.g.* agriculture, domestic, industrial, power generation), to meet environmental needs and the management of the complex institutional and property right arrangements associated with water should be addressed. (vi) Water tariffs should be sufficient to cover the full supply costs of water (including the operation and maintenance costs and the capital costs for renewing and extending the water system), opportunity costs (scarcity value) and externality costs (economic and environmental) (vii) The costs and benefits of agriculture’s use of water (*e.g.* groundwater depletion, flood mitigation) need to be more precisely defined to better inform policy decision making. Farmers also need more technical advice and education on best practices to adopt themselves to flood, drought and climate change. (viii)There is a need for investing in research related to ground water monitoring, weather forecasting, breeding water efficient and drought resistant crops and varieties which can cope up with the changing climatic conditions that arises due to global warming.

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