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STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESIS (ES)

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RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–23

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SUSTAINABLE AGRICULTURAL PRACTICES AND USE OF IRRIGATION WATER IN INDIA

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ABSTRACT

Water is a major factor constraining agricultural development, especially in a developing country like India and there has been much discussion on how to use economic instruments to allocate irrigation water in an efficient, equitable and sustainable manner. In the policy domain, there has been a categorical shift from supply-side approach (dominated largely by government decisions) toward a demand-side approach (with more of user participation), in order to generate more crop per drop. Water scarcity has huge implications for health, hygiene, sanitation, drinking water, agriculture and industry. Therefore, equitable distribution of this scarce resource has been accorded prime consideration in form of sustainable irrigation, which serves as a springboard to provide food for public consumption as well as industrial raw materials. Drinking water enjoys second place in planning which in turn addresses legitimate needs of health, hygiene and sanitation. For this purpose, central, state, district and local (village level) governments have ensured voluntary public code of conduct to minimize the risk of over use of underground reservoirs and protect their water quality.

KEYWORDS

agriculture, sustainable, irrigation, water.

INTRODUCTION

Water is a major factor constraining agricultural development, especially in a developing country like India and there has been much discussion on how to use economic instruments to allocate irrigation water in an efficient, equitable and sustainable manner. In the policy domain, there has been a categorical shift from supply-side approach (dominated largely by government decisions) toward a demand-side approach (with more of user participation), in order to generate more crop per drop. However, imperfect markets or absence of markets for irrigation water in developing countries undermine its true opportunity cost. As a result, policy makers find it difficult to formulate suitable water pricing policies and design other institutional reforms to meet the increased water requirements of the farmers, and to recover the full cost. Thus, estimating the economic value that farmers place on incremental changes in irrigation water becomes vital in the process of deciding the economic viability of new irrigation projects.

BACKGROUND

The Tamil Nadu State in India is deficient in water resources. The annual available water resource per capita in Tamil Nadu is estimated at 600 M^3, which is quite small when compared to 4,000 M^3 of the national average. Hence, it becomes necessary to utilize the limited water resources efficiently in the State. Since total surface water sources in the State is estimated about 340 million M^3 and the developed surface water is 333 million M^3, it is difficult to develop new water resources for irrigation.

Wells are the major source of irrigation in the State accounting for 46.4 % of the net irrigated area followed by canals (29.1 %) and tanks (23.9 %). Over years, the area irrigated by tanks is decreasing while the area irrigated by wells is increasing. The current Water Policy of Tamil Nadu State stressed the importance of equitable use of scarce water resources, and in the planning and operation systems, water allocation priorities were given for drinking purposes followed by irrigation, hydropower, industrial and other uses. Hence, it is imperative that optimal and sustainable patterns of water use be established to meet the requirements of a growing population and need for basic agricultural foodstuffs (Joshi et al, 2003).

In many parts of the world both the free distribution and under pricing of water have led to inefficient allocation of the scarce resource. Both under pricing of water and lack of cost recovery mechanisms in government managed irrigation systems had resulted in poor O & M. Actions are necessary to use the water sustainably and manage the tank irrigation systems in South India. One strategy is to reduce water demand by adopting water conservation programs and improving water use efficiency, while another strategy involves a water pricing policy. This policy has the advantage that the income could be used to finance developments like the O & M of irrigation system. Pricing of water can also be considered as a pre-requisite for sustainable use of water resources. The underlying principle of irrigation water pricing in relation to sustainability concerns is that it should reflect the benefits forgone in the future from using a unit of water today which refers to the opportunity cost of irrigation water. The economic sustainability criteria or the socially optimal rule for water use can then be assessed by comparing farmer's WTP and the opportunity cost of water. From the stand point of economic efficiency, water prices should relate to the marginal value product or the opportunity costs. From the government's viewpoint, water price should at least cover capital costs as well as O & M expenses. From the standpoint of feasible revenue collection, tank irrigation water charges depend highly on farmer's WTP. The objective of this paper is to determine the value of tank irrigation water, which farmers would be willing to pay under dry and wet seasons and thereby draw policy implications for sustainable use and management of the tank irrigation systems (Rajapure and Kothari, 2016).

SUSTAINABLE WATER USE

MONSOON – A SUSTAINABLE SOURCE OF WATER

Presently, India cultivates annually 1-3 crops on its 125 million hectares of agricultural land, solely depending upon the availability of water for irrigation. Majority of the farmers undertake a single crop under rain-fed conditions using monsoon rain, generated by vast aerial circulations over the Bay of Bengal and Arabian Sea, facing east and west coast of India. These monsoon-generated rains, precipitated over 52-72 days from the last week of June until the last week of October, not only irrigate the crops, but they also replenish in a large measure sustainable source of surface and sub-surface water.

SURFACE SOURCES OF WATER

The surface source comprises thousands of small rivulets (locally known as *nullahs*), which merge in locally flowing minor rivers, turning into major rivers, which provide throughout yearly source of water for drinking, irrigation and industry. These major rivers are Sutlej, Ganga, Yamuna in north India, Teesta and Brahmaputra in N-E India, Narmada and Tapti in central India and Krishna, Godavari and Kaveri in peninsular India. The availability of water from these major rivers is guaranteed for the whole year for drinking, industry and hydroelectricity; for irrigation, it is available only to a section of farmers who have abundant resources to generate capital-intensive infrastructure for pumping water over 1-10 km distance.

Surplus water flowing through the above mentioned major rivers is diverted and collected in major dams like Bhakra-Nangal, Saradar Sarovar, Hirakud, Nagarjun Sagar, Koyna, Damodar Valley and several locally constructed minor dams for supply to urban settlements, local industry and canal irrigation for agriculture (Tyagi and Minhas, 2015).

HARVESTED SOURCES OF WATER

Rain water harvesting is not a new concept in India as historical excavations confirm the existence of village tanks, *bandharas*, bench terraces etc. to retard the flow rate of water and channelize it for storage. Water harvesting, which has been re-discovered and popularized, is borne out of sheer necessity. It is on record that millions of Rajasthani families migrated to different parts of India due to chronic hardships experienced by them as a result of continued water scarcity. The grandma used to tell us the story as to why there was no alternative to migration, leaving farms, homes and immovable hereditary property behind. Water was so scarce that a child used to get 2-3 liters water for bath, while the elders were getting about 5 lit. Turn-by-turn, all family members used to take bath in a shallow stone tub with a small outlet at the bottom for the collection of used water in an underlying drum for its subsequent use in washing the clothes. The effluent after clothe washing was once again used for wiping the floor in the home and after that it was finally used in the evening for either spraying on the terrace to render it cool for over-night sound sleep in the absence of electricity or surplus effluent used for deficit irrigation. Thus, each drop of water was recycled 4 times and when availability of rains and harvested little water was in question, a momentous decision was taken to migrate (Jain, 2013).

The success of watershed and irrigation depends largely on 2 factors: (i) to harvest water and store it by constructing economical earthen percolation reservoirs or dams and (ii) to use it effectively through micro-irrigation system (MIS) displayed on demonstration farms for the cost and benefits to the farmers, who have a faith in 'seeing is believing', rather than a faith in formal agriculture education in universities.

Water harvesting has been made successful at the foot of hillocks in a totally degraded land by creating a reliable, captive and sustainable water storage and recharge mechanism through open larger reservoirs, which came into existence on the basis of topography of land. Water transiently collected in them was gradually transferred in the dug-out open wells for recharge by virtue of slope and seepage. This system has enabled to harvest and store about 1200 million liters of water under the scheme Watershed Development. In simple terms, watershed development comprises of (i) allowing sufficient percolation of rain water in the catchment areas (recharge zone), (ii) permitting its further percolation in the command area (transition zone) and (iii) collecting flowing water at safe flow rate for judicious use in the delta area (discharge zone) (Goyal et al, 2014). This has been made possible by creating a network of terraces and trenches in the hilly region so that soil erosion is controlled, water percolation enhanced on the terraces for useful plantation to stabilize the soil strata and extra water harnessed through the network for the year-round use.

Watershed management in practice involved:

- Controlling, channelizing and collecting the surface run-off water
- Reducing the impact of more rainfall on soil erosion
- Decreasing the speed of flowing water by increasing its local infiltration
- Enhancing the moisture-holding capacity of soil
- Improving the soil texture and fertility
- Minimizing the chance of over-irrigation
- Arresting the ecological degradation and
- Increasing the productivity through crop intensity per unit area, per unit time and per unit of water utilized.

This success of watershed development has been put to use and practiced on a large-scale by banana growers in Jalgaon region of Maharashtra who initially thought that there is no alternative to flood irrigation. However, watershed development and its imaginative conveyance for drip irrigation and ultimate use for tissue-cultured banana has doubled the acreage as irrigation by Micro-irrigation systems (MIS) requires almost 50% less water and secondly, maturity (harvesting) period of banana crop reduced from 18 to 12 months (Gadgil, 2012).

RECYCLABLE SOURCES OF WATER

Vast stretches of land are irrigated to produce substantial amount of vegetables throughout the year in urban India, using unprocessed municipal waters, leaving the quality of vegetables doubtful in nutrition, due to contamination of pesticides and heavy metals. Precise quantum of this effluent, acreage under it and quantum of vegetables produced are not known as this work is being undertaken by the unorganized sector. Thus, through these four resources, Indian farmers undertake about 39-43% of cultivable area into irrigation to generate about 225 million tons of cereals, 15 million tons of pulses, 337 million tons of sugar, almost equal quantity of oilseeds, besides vegetables, spices, fruits and medicinal plants. Among the commercial water guzzling crops are rice, sugarcane, banana, jute, bamboo etc.

MICRO-IRRIGATION SYSTEMS (MIS)

This type of irrigation guarantees higher water use efficiency (WUE) at a greater benefit: cost ratio to the user (Zhang *et al*., 1998). In this system, water is directly applied at the root zone of the plants or plantlets and in controlled quantities through a low pressure network and at desired intervals as per the requirements of the crops (Vasane and Kothari, 2006). In case, the land is at different heights, irrigation could be beneficially provided by the construction of distribution tanks at strategic locations. This permits minimizing evaporational losses, seepage and therefore provides most efficient use of water. Computation of the cost of MIS per hectare is about USD 2000 per hectare. It includes the cost of construction of water distribution tanks, cost of installing MIS and cost of replacing old material from time to time. This cost may appear a bit on higher side for the poor farmers of India. However, upon implementation in a step-wise manner, neither the capital investment is beyond the reach, nor repentance occurs for the loss of crop. In fact, from the total cost and total income, the pay-back period is about 7.5 years, in the total lifespan of MIS for 12-15 years. During this period, the farmer is assured of adequate food grains, vegetables, fruits, spices for quality life, while preserving fertility of the land and hope for a prosperous future as it permits re-growth of local micro-flora and fauna changing the ecology for better, useful to the farmer, village and nearby region.

SOURCE-WISE IRRIGATION IN INDIA

The changing trends in the different sources of irrigation in an area explains the effort taken by the Government in augmenting the irrigation potential over the years and also the way in which the pattern has undergone changes. Table – 1 provides the data pertaining to the source-wise irrigation in India since 1950-51.

It is inferred from the table that the proportion of area under canal irrigation has increased from 39.78 per cent in 1950-51 to 42.05 per cent in 1960-61, but has declined continuously since then and came down to the level of 24.64 per cent in 2010-11. The total area under canal irrigation has however, increased initially from 8.30 mha in 1950-51 to 17.45 mha in 1990-91, then declined consistently and came down to 15.67 mha in 2010-11. The area under tank irrigation has declined in both absolute and proportion-wise over the period. The total area, though has increased initially from 3.61 mha in 1950-51 to 4.56 mha in 1960-61, it has declined since then and has come down to 2 mha in 2010-11. Its share in NIA has gone up from 17.33 per cent in 1950-51 to 18.49 per cent in 1960-61, but has decreased to 3.14 per cent in 2010-11. In the absence of any concerted efforts by the Government in enhancing the role of canal and tank irrigation in the country over the years, the structure of irrigation has shifted towards well irrigation and especially towards tube well irrigation. This also implies the fact that augmenting the extent of irrigation has been left to the poor farmers, as the state has been withdrawing from the same. In 1950-51, tube well irrigation was not known much in the country, as it has no share in the NIA. In 1960-61, tube well irrigation was practised to the extent of 0.55 per cent of the NIA, which has increased to 44.89 per cent in 2010-11. In the same way, the total area under tube well too has increased from 0.14 mha in 1960-61 to 28.55 mha in 2010-11.

There has been a similar trend in the expansion of irrigation by other wells which include open or surface wells. Its total area has gone up from 5.98 mha in 1950-51 to 10.51 mha in 2010-11. The proportion of area under the irrigation of other wells, however, has declined from 28.67 per cent in 1950-51 to 16.53 per cent in 2010-11. This indicates that though the pattern of irrigation has moved in favour of well irrigation, within well irrigation, open or surface wells cannot be sustained in the long run, since it should be dug deeper in every passing year. This forces the farmers, especially those who can afford, to shift towards tube well irrigation. This method of irrigation is not only highly expensive, but also highly unsustainable in the long run, as it should also be dug deeper and in that process, drives away the neighbouring small and marginal farmers, for whom the water table becomes 'unreachable'. The proportion of area under other sources like streams and other water ways has accounted for 14.23 per cent in 1950-51, which has declined sharply to 5.23 per cent in 2000-01, but has also increased equally sharply to 10.80 per cent in 2010-11. This suggests that the basic structure of irrigation in the country has undergone major shift over the years. The combined share of canal and tank irrigation which was more than 50 per cent until 1970-71, has given way to well irrigation (both tube well and surface well) in the later period, as it now accounts for more than half of the NIA in India.

TABLE 1: SOURCE-WISE IRRIGATION IN INDIA, 1950-51 TO 2010-11*

Year	Canals	Tanks	Tube Wells	Other Wells	Others	NIA
1950-51	8.30 (39.78)	3.61 (17.33)	Nil	5.98 (28.67)	2.97 (14.23)	**20.85 (100)**
1960-61	10.37 (42.05)	4.56 (18.49)	0.14 (0.55)	7.16 (29.01)	2.44 (9.89)	**24.66 (100)**
1970-71	12.84 (41.28)	4.11 (13.22)	4.46 (14.34)	7.43 (23.88)	2.27 (7.29)	**31.10 (100)**
1980-81	15.29 (39.49)	3.18 (8.22)	9.53 (24.62)	8.16 (21.08)	2.55 (6.59)	**38.72 (100)**
1990-91	17.45 (36.34)	2.94 (6.13)	14.26 (29.69)	10.44 (21.73)	2.93 (6.11)	**48.02 (100)**
2000-01	15.97 (28.96)	2.46 (4.45)	22.57 (40.94)	11.26 (20.42)	2.89 (5.23)	**55.08 (100)**
2001-02	15.27 (26.88)	2.19 (3.86)	23.24 (40.93)	11.73 (20.66)	4.36 (7.68)	**56.67 (100)**
2002-03	14.04 (26.17)	1.80 (3.36)	23.48 (43.76)	10.66 (19.87)	3.67 (6.83)	**53.78 (100)**
2003-04	14.45 (25.31)	1.96 (3.43)	26.69 (46.75)	9.69 (16.97)	4.30 (7.53)	**57.09 (100)**
2004-05	14.77 (24.94)	1.73 (2.92)	25.23 (42.60)	9.96 (16.82)	7.54 (12.73)	**59.23 (100)**
2005-06	16.72 (27.48)	2.08 (3.42)	26.03 (42.78)	10.04 (16.50)	5.97 (9.81)	**60.84 (100)**
2006-07	17.03 (26.84)	2.78 (4.38)	26.94 (42.46)	10.70 (16.86)	6.00 (9.46)	**63.45 (100)**
2007-08	16.75 (26.51)	1.97 (3.12)	28.50 (45.10)	9.86 (15.60)	6.11 (9.67)	**63.19 (100)**
2008-09	16.88 (26.52)	1.98 (3.11)	28.37 (44.58)	10.39 (16.33)	6.02 (6.46)	**63.64 (100)**
2009-10	14.98 (24.18)	1.58 (2.55)	28.38 (45.82)	9.99 (16.13)	7.01 (11.32)	**61.94 (100)**
2010-11	15.67 (24.64)	2.00 (3.14)	28.55 (44.89)	10.51 (16.53)	6.87 (10.80)	**63.60 (100)**

Source: Agricultural Statistics at a Glance, 2015, Govt. of India.
Note: Figures in Million Hectares and those in brackets are percentage to NIA. NA – Not Available.
* Irrigation data is available only upto 2010-11.

SUSTAINABLE WATER MANAGEMENT

It considers conservation of all water resources using appropriate technologies and their use with social acceptability, economic viability, and eco-friendliness. Under the head of social acceptability, cross subsidization of available water needs to be made into legitimate interregional (rural versus urban) and inter-sectoral (agricultural versus industrial) needs. Such considerations ahead of the scarcity will provide flexible practices in irrigation management. Otherwise, politically oriented and ill-considered decisions tend to aggravate human sufferings, cattle perishing, agricultural stagnation or decline and reduced industrial output, cumulatively affecting GDP adversely.

Under aridity, consideration of low moisture carrying capacity of the ecosystem in right perspective needs irrigation in small dosages and at higher frequency so that immediate hardships out of aridity are minimized (Sarwar and Bastiaanssen, 2001). This is a case of moderate contingency arising out of water scarcity.

Drought being a natural, but temporary imbalance in the availability of moisture caused by lower than the average rainfall over the years, its uncertain frequency, limited duration and severity of sunlight aggravate the rate of evapo-transpiration, resulting into diminished moisture availability for plants to sustain. Severity of such situation needs application of soil conditioner (Chaudhari and Kothari, 2009) and DI at night time so that due to water-holding capacity of the soil conditioner, crop is sustained at a minimal loss due to evapo-transpiration, providing the hope of livelihood, especially for rural and economically weaker population. This is a case of immediate contingency due to acute water scarcity (Pereira, 1999).

Desertification in a large measure is man-made problem over longer duration, carried forward from the past in the availability of water. While drought aggravates desertification, recycling of water for human and cattle consumption and recycling for irrigation provides a workable strategy to arrest the rate of desertification and thereby human hardships. This appears an extremely difficult contingency, being permanent in nature and scope, requiring irrigation scheduling (Teixiera *et al.,* 1995). This is a case of chronic contingency.

CONCLUSION

Water scarcity has huge implications for health, hygiene, sanitation, drinking water, agriculture and industry. Therefore, equitable distribution of this scarce resource has been accorded prime consideration in form of sustainable irrigation, which serves as a springboard to provide food for public consumption as well as industrial raw materials. Drinking water enjoys second place in planning which in turn addresses legitimate needs of health, hygiene and sanitation. For this purpose, central, state, district and local (village level) governments have ensured voluntary public code of conduct to minimize the risk of over use of underground reservoirs and protect their water quality. Therefore, water extraction, conveyance, storage and delivery infrastructure is being augmented, pricing of water considered to reflect its net cost and delivery made at reduced pressure and reduced frequency.

Agriculture being the major user of water, besides reliance on rain-fed irrigation, gradually surface or flood irrigation is being replaced by sub-surface (drip/sprinkler/mist) micro irrigation, which has inherent capacity to double the acreage under irrigation, without loss to agri-output. By experience, the farmers have also got educated that flood irrigation largely employed in sugarcane, rice and banana cultivation has rendered soil saline and less productive over the years. To reduce water use and transform saline soil into a productive matrix, sustainable water management is made through the enhanced use of farmyard manure, soil conditioner, press mud, fly ash/bio-fertilizers/plant growth regulators, which permit reduced use of water and at the same time soil fertility, is enhanced over 3-4 year duration. Similarly, crop planning is considered to restrict the cultivation of crops consuming "virtual water". For arid, semi-arid and desert landscapes, contingency irrigation/ deficit irrigation/ supplementary irrigation is considered to save the standing crops through recycling municipal effluents. Everything said and done, the ultimate success of irrigation practices depends on certain regulatory measures by the government and public participation through keen awareness.

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