Water Policy 23 (2021) 130–141

Irrigation water pricing policies and water resources management

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Abstract

As water is a state subject in India, an enormous variation of irrigation water pricing across the states is noticed. Revenue collection under irrigation water charges of the states is not encouraging. The present paper reviews the structures of water pricing mechanism in different states of India and suggests a way to achieve sustainable water resources management in India. Various reports, water policy documents, and major recommendations of the irrigation commission were reviewed and analyzed. It was observed that low revenue collection is mainly due to the low rate of water taxes, no periodic revision, and flaws in the current revenue collection mechanism across the states. The water regulatory authority should be made a statutory body to manage various water uses and their fair pricing. A volumetric pricing system can be implemented in wells and tube-well-irrigated areas and for surface irrigation, and this requires considerable investment in irrigation water supply infrastructure and development of operational plans. Until a well-developed volumetric system comes into practice, the current system of revenue assessment and collection must be rationalized and simplified. An appropriate power tariff policy for rural areas and inclusion of the irrigation sector in a ground water conservation fee is required.

Keywords: Groundwater; India; Irrigation water; National water policy; Revenue collection; Water pricing

Highlights

- Volumetric pricing can be implemented in wells and tube-wells irrigated areas.
- Until the volumetric system comes into practice, current system of assessment must be rationalized and simplified.
- A nationally coherent irrigation water policy is necessary for implementation of the volumetric system.
- Appropriate power tariff policy for rural areas and inclusion of the irrigation in Groundwater Conservation Fee is required.

doi: 10.2166/wp.2020.147

1. Introduction

Water is an important natural resource and essential for life on earth. Consistent efforts are being made to develop and manage precious water resources. The growing demand for water is expected to surpass supply, if not managed properly. Due to spatial and temporal variation of water resources availability, integrated efforts in each field of water such as development, distribution, consumption, and management are required. In recent times, there has been increasing interest in employing a water pricing system as a tool for managing the demand of water. The financing of irrigation projects was initiated and provisioned during the British era in India. Gradually, the financial aspect of the irrigation project deviated from its initial aim after World War II. For developing nations, proposing a new irrigation infrastructure plan and construction of dams and reservoirs became important investment options, especially in newly independent states. To be self-sufficient, states made a consistent effort to produce enough food grain to feed the common man, create income opportunities for rural people, balance the overall development of all the regions, and address the poverty issues (Molle & Berkoff, 2007).

Development was perceived largely in terms of creating infrastructures such as big dams, irrigation water supply schemes, and flood control measures. These water-based projects received huge funds. Free goods or non-economic goods such as air and sunshine do not have a price and are abundant in nature. Water was also included in the list of free goods but due to the exponential growth in population, increased food demand, changing lifestyles, and the surge of industries, water has been converted into an economic good from its earlier status of a free good. Although the World Bank recognized the reasonable share of payment from the beneficiaries of large irrigation projects, the fourth Dublin principle (1992) emphasized the importance of the economic value of water use in general and irrigation water in particular. This concept of the economic value of water was further strengthened in the Rio Declaration on Environment and Development of the United Nations in 1992 (EU, 2000) and its Agenda 21 (United Nations, 1992), mechanisms, and regulatory measures.

If water is termed as an economic good, this should have some price attached to it. Domestic water and water used by industries are charged reasonably but irrigation water can be termed as a non-merit good. In many countries, non-merit goods and services are provided by funding support of the government. The development of irrigation infrastructure is one of them. Irrigation, in terms of economic principles, is not non-divisible, or non-exclusive in use, nor does non-rivalry exist between its users. Therefore, an irrigation service, although an economic good in the theoretical sense, cannot be termed as a pure private good which can be bought, sold, and priced in the market based on demand and supply, but is a quasi-public, non-merit good which can neither be priced as per the free market mechanism nor can be provided exclusively as a subsidized or free service by the state. Thus, the pricing policy for irrigation water must take care of the appropriate balance before framing an economically justified irrigation water pricing policy. This is challenging, especially in democratic developing countries.

Several research papers have been published on water pricing mechanisms and many have tried to link water pricing with the performance of irrigation projects. Economists and water resources planners and managers differ in the adoption of approaches for an optimal water-pricing policy. Nagaraj (1999) studied the relevance and viability of approaches adopted for managing the institutional set up of France and advocated the accordance of financial autonomy to the water institutions and participatory approaches. It is worth mentioning here that not only the introduction of surface water pricing, but also a proper groundwater bill/act needs to be enacted for a country. Rajaraman (2005) evaluated the irrigation water pricing for Karnataka state of India and found local user groups as an option for adopting a flat rate and overseeing any informal water trading.

In another study done in China by Webber *et al*. (2008), it was suggested that farmers should pay not only the irrigation water charges but also the pumping cost of water. The feasibility of incentive-oriented policy instruments was also explored (Viaggi *et al*., 2010). Dono *et al*. (2010) applied a mathematical model to study the economic aspects and the impacts on usage of water under the volumetric pricing method and area-based pricing method for a farm sector in a Mediterranean area that relies on a dam for irrigation. Saleth & Amarasinghe (2010) discussed the status and effectiveness of various demand management options and opined that the direct returns from demand management investments can improve the efficiency of the irrigation sector and boost the water economy as a whole. Statistical tools were applied to study the behavior of farmers of the Krishna river basin, India when they choose options (Veettil *et al*., 2011). Shen & Reddy (2016) analyzed the water pricing reforms undertaken in China and India and opined that China has taken several steps farther in terms of implementation of policy reforms. Chaudhuri & Roy (2019) are of the opinion to introduce a volumetric water pricing system and suggested employing automatic metering devices to charge for the actual volume of water used. They were also cautious about the challenges to be encountered in installing metering devices in a vast country like India. Improved water rights and the presence of a Water Users Association reduces this preference for volumetric pricing. Many research works were carried out to study the impact of increased water pricing and other parameters on conservation of water and water demands by farmers at different scales (Chang *et al*., 2014; Aidam, 2015; Ziolkowska, 2015; Joshi *et al*., 2016; Loc *et al*., 2016).

The increased dependence on groundwater, especially for Rabi season crops, is a serious matter if sustainable water resources and power sector viability are kept in mind. The basic prevalent assumption is that at higher electricity charges, farmers will be encouraged to improve water-use efficiency and water conservation. In arid and semi-arid regions of India, extraction of groundwater is normally more than the average annual replenishment. Uncontrolled withdrawal of groundwater for crop production, along with subsidized electricity, has caused a drastic reduction in water level in many parts of the country (World Bank, 2010). In most of the states, electricity bills are charged on the basis of connected load, and consumption of units of power is not considered. Electricity supply to the agricultural sector in India is considerably subsidized under the existing power tariff systems (Scott & Sharma, 2009). This has caused decreasing and interrupted power supply, largely due to the poor financial condition of the State Electricity Boards (SEBs) and further provides incentives for unsustainable use of both electricity and groundwater. Power tariff changes influence groundwater use efficiency and productivity positively (Kumar, 2005). It is worth mentioning here that the number of groundwater wells in India increased from about 100,000 in 1960 to about 12 million in 2006 (Bassi, 2014). Since pumps on the deepest tube wells are predominantly electric, 85% of the groundwater pumping energy is provided by electricity (Dharmadhikary *et al*., 2018). Power pricing policies have a direct bearing on the rural sector and therefore tariff policy must be made in such a way that it influences the groundwater use and extraction decisions of the growers.

One way to achieve the reliance in the irrigation sector is to improve the supply side. Another way may be to manage the demand for water in the agriculture sector. Demand management and market mechanisms include options such as the implementation of appropriate irrigation water pricing, developing water markets, strengthening the water rights systems, revising the energy bills and supply regulations, and promotion and incentives for adoption of modern water-saving technologies such as micro-irrigation and sprinkler irrigation systems. This paper attempts to review the existing irrigation water pricing mechanism in India and various related provisions in the National Water Policy of the country so that a policy can be modified to enhance the sustainability of the water resources of India.

2. Methods of charging irrigation water prices in India

The water pricing system consists of many components. Based on the natural and economic conditions of the command area of any irrigation project, several methods have been developed for irrigation water pricing. These methods are broadly grouped into four categories: water market, quotas, non-volumetric pricing, and volumetric pricing (Johansson *et al.*, 2002). Developing water market mechanisms can deal with the inefficiencies of conventional irrigation water supply institutions. Water markets are found to be more flexible in fixing the irrigation water price. There should be a well-defined water right and the appropriate setting up of institutions to develop formal water markets (Thobani, 1997; Zilberman *et al.*, 1997). Quota allotments are used to address the fairness of water distribution and management issues that may arise due to the prevailing water market. A certain quota of water is allotted which can address equity concerns and can encourage efficient allocations (Dinar *et al.*, 1998).

The irrigation water pricing under non-volumetric methods normally depends upon the crop and area under cultivation or sometimes on land values. This method is convenient to implement and is suitable for surface irrigation systems. Due to the high costs of installation of a metered system, a non-volumetric system is found to be more efficient and easy to implement per unit area pricing than volumetric pricing (Smith & Tsur, 1997). Under volumetric irrigation water pricing system, charges for the quantities of water consumed are levied. The countries employing the volumetric pricing approach include Australia, England, France, Israel, Jordan, Mexico, Morocco, Spain, and the USA. In California, about 80% of the more than 100 irrigation districts have shifted to the volumetric charging system for the past 20 years (Burt, 2006). In India, although volumetric water pricing is recommended in the National Water Policy (Ministry of Water Resources, 2012), hitherto, this has not been practiced due to a lack of development of water metering infrastructure in the field. In general, water pricing mechanisms may not be very effective in generating income, but being a welfare government, it always attempted to manage the availability of water to certain sectors.

In India, the management and development of the water sector come under state control. Fixing the price of irrigation water in India is a sensitive issue and social, economic, and political considerations play a very important role. The water pricing mechanism differs from state to state. Farmers' opinions are very clear and they are more worried about the benefit of supply of irrigation water. The contribution of irrigation, which is only one of the basic inputs for agricultural production, is quite tedious, if not difficult, to be evaluated towards the gain in farmers' income. The Indian National Water Policy Statement of 1987 states,

> '*The water rates should be such as to convey the scarcity value of the resource to the users and to foster the motivation for the economy in water use. They should be adequate to cover the Annual Operation and Maintenance (O&M) Charges and a part of the fixed costs of irrigation works. Efforts should be made to reach this ideal over a while ensuring assured and timely supplies of irrigation water.*'

The water charges for surface and groundwater must be considered in the interests of small and marginal farmers. This was further emphasized by the Vaidyanathan Committee (Vaidyanathan, 1992) to cover the O&M costs and interest on the capital cost. Further, the National Water Policy (2002) reiterates the same, to cover O&M costs and a part of the capital costs later on. It was envisaged that the irrigation water pricing mechanism should encourage its efficient use, reward its conservation, and ensure equitable access for all. Volumetric water pricing was also proposed (MoWR, 2012). The 12th Finance Commission

(2005–2010) recommended an O&M cost norm of INR ₹ 600/ha for utilized water resources potential and ₹ 300/ha for unutilized potential. Half the rate of these norms was suggested for minor irrigation projects. For hill states, a 30% higher rate of operation and maintenance expenditure was suggested with a 5% annual rate of growth. The 13th Finance Commission recommended environment-related total grants of ₹ 10,000 crores with ₹ 5,000 crores each for forests and water sector management.

In India, all public irrigation systems are government-administered and there is no direct link between water charges and O&M cost. The water rates vary largely from state to state and are decided more as a political decision and are charged for the supply of water keeping in view of the fair and equal water distribution and management issues for efficient irrigation water supply systems. The water rates presently being charged are highly subsidized and are much less than even the recurring O&M expenses (CWC, 2010). In India, owing to its simplicity, charging of irrigation water on an area basis is the most widespread practice. Normally, the water charges on an area basis take into consideration the source of water, how the water is being supplied, season, crop type, duration, land type, and type of irrigation project (major, medium, and minor). The basic idea about the fixing of irrigation water price should be to generate sufficient revenue to at least cover O&M costs which are required for the maintenance of the system on a sustainable basis. Nevertheless, the paying capacity of the growers must be taken into account, especially in India, where small and marginal farmers are quite large in number. The Draft National Water Framework Bill (2016) advocated the full economic pricing for water used for commercial agriculture and industry and a graded pricing system may be implemented for domestic use.

In many states of India, where agricultural crop production is higher, groundwater is the main source of irrigation, especially during Rabi season (November–March). The farmers do not have to pay for the water from tube wells dug on their own land. The electricity is supplied free or at subsidized rates for agriculture in many states. This has resulted in drastic depletion of groundwater storage in many districts of India. Groundwater pumping can be controlled if an appropriate power tariff policy is implemented for rural areas. Zekri (2005) used three criteria, including water quotas, electricity quotas, and electricity pricing to analyze the best option for controlling the pumping of groundwater. Enforcing an electricity quota along with gradual taking away of the subsidy on the electricity price was found to be the most equitable solution. Kumar *et al.* (2011) demonstrated that an increase in power tariffs in the agricultural sector may be a socially and economically viable option to bring efficiency and achieve sustainable groundwater extraction.

3. Pricing of irrigation water in India – current status

The current pricing system, as mentioned above, in a state varies with seasons, crops, and irrigated areas. Although the first water policy was adopted in 1987, Kerala, a southern state, imposed irrigation water pricing for the first time in 1974. The seven States/UTs of Arunachal Pradesh, Andaman and Nicobar Islands, Nagaland, Meghalaya, Mizoram, Puducherry, and Lakshadweep have recently formulated their state water policy (Tables 1 and 2). Much variation of water pricing across the states is observed. Maharashtra is charging the maximum rate for flow irrigation as ₹ 6,297/ha and the minimum as ₹ 238/ha. Himachal Pradesh collects ₹ 28.17/ha for all irrigation uses. The states also follow inconsistent water policies and do not consider irrigation water charges as a source to generate revenue. Punjab had a specified water pricing for irrigation water but abolished it in February 1997. This was again continued from 12th November 2002 and the charge of a flat rate of ₹ 375.00/ha has been levied since 28 January 2010. On the other hand, Tripura has been charging ₹ 312.50/ha since 1 October

Table 1. Water rates for wheat crop under flow irrigation by state (CWC, 2013).

S. No.	States/UTs	Rate (Rs/ha)	Date since on applicable	Status as on
1	Andhra Pradesh	148.20 to 1,235.00	01.07.1996	12.01.2010
2	Arunachal Pradesh	No water rates	–	29.12.2008
3	Assam	150.00 to 751.00	30.03.2000	07.03.2009
4	Bihar	74.10 to 370.50	17.11.95/26.11.01	08.02.2010
5	Chhattisgarh	123.50 to 741.00	15.06.1999	05.02.2010
6	Delhi	34.03 to 1,067.04	6 N.A.	14.01.2009
7	Goa	60.00 to 300.00	01.02.1988	09.03.2010
8	Gujarat	160.00 to 300.00	01.01.2007	04.02.2010
9	Haryana	24.70 to 197.60	27.07.2000	02.02.2010
10	Himachal Pradesh	28.17	01.04.2009	03.02.2010
11	Jammu and Kashmir	29.65 to 74.13	01.04.2005	04.02.2010
12	Jharkhand	74.10 to 370.50	26.11.2001 and 14.11.1995	13.01.2009
13	Karnataka	37.05 to 988.45	13.07.2000	30.01.2009
14	Kerala	37.00 to 99.00	18.09.1974	06.02.2009
15	Madhya Pradesh	50.00 to 960.00	01.11.2005	05.01.2010
16	Maharashtra	238.00 to 6,297.00	01.07.2003	02.04.2009
17	Manipur	45.00 to 150.00	August 2003	27.12.2008
18	Meghalaya	No water rates	–	09.03.2010
19	Mizoram	No water rates	–	06.02.2009
20	Nagaland	No water rates	–	15.01.2009
21	Orissa	28.00 to 930.00	05.04.2002	05.01.2010
22	Punjab	375.00	28.01.2010	01.02.2010
23	Rajasthan	29.64 to 607.62	24.05.1999	21.1.2010
24	Sikkim	10.00 to 250.00	2002	19.01.2010
25	Tamil Nadu	2.77 to 61.78	06.11.1987	04.03.2002
26	Tripura	312.50	01.10.2003	01.04.2009
27	Uttarakhand	35.00 to 474.00	18.09.1995	18.12.2006
28	Uttar Pradesh	30.00 to 474.00	18.09.1995	11.09.2007
29	West Bengal	37.06 to 123.50	06.04.1977	03.02.2010
30	Andaman and Nicobar Islands	No water rates	–	01.01.2009
31	Chandigarh	No water rates		01.02.2010
32	Dadra and Nagar Haveli	110.00 to 830.00	29.01.1996	31.08.2005
33	Daman and Diu	200.00	1980	28.08.2008
34	Lakshadweep	No water rates	–	12.06.2008
35	Puducherry	No water rates	01.01.2005	12.12.2008

2003 for water used in agriculture. The multiplicity of factors contributes to the process of fixing water rates in states/Uts, and their common as well as diverging considerations form the basis of fixing overall water rates. As there is still no independent water regulatory authority in the majority of states, the mechanism of fixing water charges for various uses is ad hoc, non-consultative, and non-transparent.

No water rates are levied from the farmers when they lift water from rivers or in the downstream of a reservoir or barrage in Gujarat. As drip and sprinkler irrigation systems involve a continuous process of watering fields, the rate of drip and sprinkler irrigated crops is considered as 35 and 65% of the rate of flow irrigation, respectively. This is a kind of incentive which must be followed by other states also. The capacity and assuredness of irrigation are kept in view while fixing water rates in Haryana. Maharashtra has fixed water rates by considering the volume of water supplied, paying capacity of the farmer,

Table 2. Water rates for lift irrigation by state (CWC, 2013).

S. No.	States/UTs	Rate(Rs/ha)	Date since on applicable	Status as on
1	Andhra Pradesh	148.20 to 1,235.00	07.01.1996	12.01.2010
2	Arunachal Pradesh	No specific water rates		29.12.2008
3	Assam	150.00 to 751.00	30.03.2000	07.03.2009
4	Bihar	333.45 to 1970.75	06.05.1998	08.02.2010
5	Chhattisgarh	123.50 to 741.00	15.06.1999	05.02.2010
6	Delhi	34.03 to 1,067.04	N.A.	14.01.2009
7	Goa	120.00 to 600.00	01.02.1988	09.03.2010
8	Gujarat	160.00 to 300.00	01.01.2007	04.02.2010
9	Haryana	43.23 to 98.80	27.07.2000	02.02.2010
10	Himachal Pradesh	56.34	01.04.2009	03.02.2010
11	Jammu and Kashmir	74.13 to 741.30	01.04.2005	04.02.2010
12	Jharkhand	No separate rate for lift irrigation	–	13.01.2009
13	Karnataka	No separate rate for lift irrigation	–	30.01.2009
14	Kerala	17.00 to 148.50	18.09.1974	09.03.2010
15	Madhya Pradesh	50.00 to 960.00	01.11.2005	15.03.2010
16	Maharashtra	297.00 to 5,405.00	01.07.2003	13.04.2010
17	Manipur	45.00 to 150.00	01.08.2003	27.12.2008
18	Meghalaya	No water rates	–	09.03.2010
19	Mizoram	No water rates	–	06.02.2009
20	Nagaland	No water rates	–	15.01.2009
21	Orissa	No separate rate for lift irrigation	05.04.2000	30.03.2010
22	Punjab	375.00	28.01.2010	01.02.2010
23	Rajasthan	14.80 to 1,215.24	24.05.1999	21.01.2010
24	Sikkim	No separate rate for lift irrigation	–	19.01.2010
25	Tamil Nadu	No separate rate for lift irrigation	–	02.01.2009
26	Tripura	312.50	01.10.2003	01.04.2009
27	Uttarakhand	15.00 to 237.00	18.09.1995	06.01.2009
28	Uttar Pradesh	15.00 to 237.00	18.09.1995	30.12.2008
29	West Bengal	251.94 to 2,015.52	01.07.2003	03.02.2010
30	A and N Islands	No water rates	–	01.01.2009
31	Chandigarh	23.00 per hour	01.01.2010	01.02.2010
32	Dadra and Nagar Haveli	75.00 to 275.00	29.01.1996	31.08.2005
33	Daman and Diu	200.00	1980	28.08.2008
34	Lakshadweep	No water rates	–	12.06.2008
35	Puducherry	No water rates	01.01.2005	12.12.2008

sufficient recoveries to be at least equal to the annual cost incurred in providing services, tapping of full potential, and the level of the average gross income. The rates for flow irrigation in respect of non-cash crops are fixed roughly at 6% of the gross income from these crops and about 12% of the gross income in the case of cash crops, as recommended by the Maharashtra State Irrigation Commission. Also, the water rates are so fixed as to meet the expenditure on maintenance and repairs of irrigation projects and ensure a 1% return on capital cost. The water rate, as suggested by Maharashtra Irrigation Commission as 6 to 12% of the gross income, in fact, may be brought to 3 to 12% of the gross income to be implemented in other states. This 3% will take care of the paying capacity of the small and marginal farmers. Again, the question will arise on how to determine the farmers' income. In many states, farmers sell their produce to the local middle man, and most of the transaction is carried out in cash. It may be

difficult to ascertain the true income. Crop produce sold at government cooperatives is well recorded and the total amount is transferred to the farmers' bank account. Government cooperatives or the mode of transactions must be strengthened and flawless.

The rationalized irrigation water pricing mechanism alone is not sufficient if the revenue collection mechanism is not streamlined and strengthened. In most states, there is a wide gap between the revenue assessed and the revenue realized by the government agency. The average revenue realized as a percentage of revenue assessed during 2000–01 to 2007–08 for some of the states varied between 0.86% and 92.14%, including Andhra Pradesh (24.15%), Assam (0.86%), Bihar (7.73%), Chhattisgarh (31.72%), Gujarat (63.45%), Haryana (92.14%), Himachal Pradesh (71.25%), Jammu and Kashmir (56.46%), Kerala (83.58%), Madhya Pradesh (84.02%), Maharashtra (81.21%), and Orissa (61.66%) (Indian Environmental Portal, 2019). It is evident that some of the states are collecting revenues to the tune of 60–90% but it is not clear how close the collection is to the O&M cost, nor whether this collected revenue is entered into the accounts of the irrigation department or not. There is considerable deviation in the norms and practices followed for the collection of irrigation water revenue among the different states in India. In some states, assessments, as well as collection of the irrigation water revenue, are managed by the State Water Resources Department. In other states, revenue assessment is carried out by the Irrigation Department and revenue collection is the domain of the Revenue Department of State Government. In some other states, both responsibilities are carried out by the Revenue Department. There are also states where there is no mechanism for raising the bill and collection of revenue for irrigation water. Thus, poor revenue receipt leads to inappropriate operation and maintenance of irrigation water supply infrastructure and lack of new initiatives and investment in irrigation projects. This further reduces the opportunities for implementation of effective irrigation water pricing policy, and if not enacted through act or law, this will always be relaxed for political benefit.

The water regulatory authority should be made a statutory body and be given the mandate to regulate various water uses and their fair pricing. Irrigation water, although subsidized for farmers, must be priced reasonably. Therefore, the states should constitute an autonomous board which may be named 'State Water Pricing Board' to formulate the state water policy, set the norms for O&M costs, estimate the actual expenditure, assess the requirement of manpower, and develop the criteria for revising water rates to be applicable for drinking purpose (rural/urban), irrigation water (flow/lift/groundwater), and industrial water use. Delay in raising billing demands causes an accumulation of arrears which finally tend to be written-off or sometimes waived. Coordination among different government agencies involved in assessment and collection needs to be streamlined. The same department may be entrusted with the responsibility of raising demand and collection of revenues. The revenue collected should be reflected in the account where the cost of O&M is entered.

4. Volumetric pricing system – impediments

A volumetric water pricing system may be easy to implement and can provide a stable cash flow once commissioned. It ensures economic efficiency if processes are kept at the marginal cost of water. This system encourages the idea of water resources management because irrigation water charges increase with the use of water. The system ensures the volume of water, timing, and reliability of supply, and thus charging based on a volume basis is appropriate and will be appreciated by farmers, if supply is ensured in a crucial time. In the case of domestic, industrial, and commercial use of water, uniform

volumetric charges are levied with the same rate per 1,000 m^3. This type of pricing mechanism is the most prevalent in the Organisation for Economic Co-Operation and Development (OECD) countries, and also throughout the world (Whittington, 2002). Agricultural water use is metered in only a few countries. There is no single best practice that can be recommended to one country or sector. Water-using sectors in various locations face different situations and needs for pricing approaches (Dinar, 2015). The variations in irrigation water rates are observed across countries (Table 3). For irrigation water charges, most countries follow a two-part pricing system (fixed and volumetric components), with the volumetric component up to at least 75% of the total water charges. Some eastern European countries like Hungary, Poland, and the Czech Republic only use volumetric pricing systems (OECD, 1999). Pricing of irrigation water also depends upon the source of water. For example, in Jordan and Turkey, irrigation water supply is charged from groundwater sources. Although the volumetric and other irrigation pricing systems are followed, water is still subsidized in most countries (Tsur & Dinar, 1997). In the United States, some growers who have agreements with the federal government pay a very nominal cost (USD 5 to 10 per 1,000 m^3). Those who buy the water from state-level irrigation water agencies normally pay a higher cost (USD 20 to100 per 1,000 m^3). It was noticed that irrigation water prices increased considerably if the source of water was groundwater in Ogallala aquifer (Seo *et al.*, 2008). The Government of India made provision for levying a ground water conservation fee (GWCF) to be paid with effect from June 1, 2019 by industry and domestic users for consumption beyond a certain limit. The irrigation sector, which accounts for the largest share of groundwater consumed, is exempted. Obviously, the indiscriminate use of groundwater by the irrigation sector would not be avoided. This must include the irrigation water in order to avoid the over-exploitation of groundwater by the irrigation sector.

How will the volumetric pricing mechanism for irrigation water be developed in India? This is not clearly elaborated in any policy documents. In order to develop a fully fledged volumetric pricing system in India, considerable investment is required to make the necessary changes in irrigation water supply infrastructure and develop operational plans which make a good balance between efficiency and equity objectives. This will need the installation of an extensive network of water metering systems, which is expensive. Setting up appropriate institutions will be required for monitoring

Table 3. Pricing mechanisms adopted and irrigation water charges in selected countries (Tsur & Dinar, 1997; CWC, 2010; FAO, 2014).

Country	Pricing mechanism	Water price
USA (California)	Volumetric	US$ 5 on average per acre-foot (Range: US$2–US$200 per acre-foot); and US$19.32 per acre-foot in some cases
Jordan	Volumetric	US$0.04 per cubic meter for the 1.5 meters of irrigation depth and US $0.08 for any additional amounts
United Kingdom (Wales and Northumbria)		13–28/1,000 m^3
Jordan		21.13
Bulgaria	Volumetric	45.54 per ha (maize) for two irrigations
India	Area/crop-based	Flat rates, betterment levy, etc. Varies across states. Ranges from US$0 in Punjab to US$100 in Maharashtra per hectare of flow irrigation
Australia	Volume	4.36/1,000 m^3, Nearly all O&M is recovered
France (Adour-Garonne W.A.)	Volume	5.26/1,000 m^3, 100% O&M

and maintenance. Irrigation authorities must be willing to take on greater responsibility for irrigation system management, and stakeholders, i.e., farmers, may be included to share their experiences for better management of irrigation water allocations. When the phone and electricity bill of each customer can be raised and collected, there is no question of not implementing the volumetric system. This must be initiated in a phase-wise manner and long-term plans must be announced. Automation in the canal system will increase accuracy and billing efficiency. The volumetric system may allow flexibility in different crops. A phase-wise effort may be made to take up the system and there will always be a challenge as far as automation and security are concerned. The availability of mobile phones and online payment systems can facilitate billing and payment issues. The only issue is to meter the irrigation water. This has to be done one day in India, why not today?

Until a well-developed volumetric system comes into practice, the existing system of assessment based on crop-wise irrigated areas must be rationalized and simplified, especially the revenue collection mechanism. The concept of water as a free good needs to be replaced, and revenue collection must be strict, which will inculcate a habit of paying water taxes among farmers. Assessments can be made to improve the quality of irrigation, the level of cost recovery at least, the O&M costs, and 1% interest on capital employed as recommended by the Planning Commission from time to time.

5. Conclusions

In the present paper, an effort was made to review and analyze surface as well as groundwater irrigation water pricing in order to enhance water resources sustainability. Irrigation water pricing mechanisms differ from state to state. Even with the existing pricing mechanism, the revenue collection of states varies from 60 to 90% of revenue assessed. Revenue collection is very poor in many states and, therefore, unable to provide adequate funds for O&M costs of the irrigation projects. The low revenue collection is primarily due to the low rate of water taxes levied by states and flaws in the existing mechanism to ensure full and timely collection of the assessed revenue. A water regulatory authority, as mentioned in the consecutive three National Water Policies of India, is missing from many states. This should be made a statutory body and be given the mandate to regulate various water uses and their fair pricing. A rational water pricing mechanism, periodic review of water rates, and system for timely recovery of water charges are key to providing reliable services. Cost increase due to inflation must be taken into account during the periodic review. The water rate, as suggested by Maharashtra Irrigation Commission as 6 to 12% of the gross income, in fact, may be brought to 3 to 12% of the gross income to be implemented in other states. This will enable each category of farmer to pay water tax. Groundwater pumping may be controlled by implementing an appropriate power tariff policy for rural areas. The policy must be formed after wider consultation with farmers. A volumetric pricing system can be implemented in the case of wells and tube-wells where the timing is controllable and measurable, and the volume supplied can be determined with the help of hours of supply. A GWCF should address the over-exploitation of groundwater by the irrigation sector.

An efficient volumetric pricing system in India can be developed if considerable investment is made in irrigation water supply infrastructure and the development of an operational plan which has a good balance between efficiency and equity objectives. Irrigation authorities must be willing to take on greater responsibility for irrigation system management. This must be initiated in a phase-wise manner and long-term plans must be announced. Until a well-developed volumetric system comes

into practice, the existing system of assessment based on crop-wise irrigated areas must be rationalized and simplified, especially the revenue collection mechanism. The concept of water as a free good needs to be replaced and revenue collection must be strict, which will inculcate a habit of paying water taxes among the farmers. The time has come when we need to move from the vision envisaged in our national water policy to focus more on the action and make water everybody's business. Nationally coherent water policy and proper plans for infrastructure development are required when resorting to any type of irrigation water pricing mechanism in India.

Data availability statement

All relevant data are included in the paper or its Supplementary Information.

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Received 11 July 2020; accepted in revised form 20 October 2020. Available online 25 November 2020