Review

Water Pricing and Irrigation Economics: An Overall Assessment of Policy, Practice, and Sustainability in Indian Agriculture

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Water Pricing and Irrigation Economics: An Overall Assessment of Policy, Practice, and Sustainability in Indian Agriculture

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Abstract

Irrigation accounts for about 80 percent of India's freshwater withdrawals, making water pricing critical to ensure both efficient use and equitable access. Traditionally, tariffs for irrigation have been area-based and heavily subsidised, leading to poor cost recovery and weak incentives for conservation. In Maharashtra, the Maharashtra Water Resources Regulatory Authority (MWRRA) has introduced structured volumetric tariffs that provide greater transparency. However, challenges remain: collection rates are low and political pressures often keep charges below cost. Given the semi-arid climate and reliance on both canal and groundwater irrigation, a nuanced understanding of water pricing is essential to balance farmer livelihoods with sustainability. Water pricing mechanisms vary widely across Indian states, influenced by social, economic and political factors; although Kerala introduced irrigation water pricing in 1974, many states have only recently adopted policies. Low tariffs, infrequent revisions and weak revenue-collection mechanisms result in poor cost recovery, while groundwater depletion, climate variability, multiple water sources and socio-economic disparities make reform complex.

Keywords: volumetric pricing; quotas; tariffs; penalties; sustainability

Introduction

Water is the lifeblood of agriculture, and irrigation development has been pivotal in achieving food security, especially in water-scarce regions (Bar-Shira, Finkelshtain, & Simhon, 2006; Bazza & Ahmad, 2002; Briscoe & Malik, 2006). In India, agriculture accounts for approximately 80% of total freshwater withdrawals (Central Water Commission [CWC], 2017, 2022), underscoring the dominant share of water devoted to crop production. Major gains in crop yields during the Green Revolution era were facilitated by expanding canal networks and groundwater irrigation (Deshpande & Narayanamoorthy, 2001; Cornish, Bosworth, Perry, & Burke, 2004), often under heavy public subsidization and minimal direct cost to farmers. This legacy of low-cost or free irrigation water has, however, contributed to inefficient water use and acute resource stress (Dinar, 2000; Dinar & Subramanian, 1997). Groundwater levels are declining in many areas due to over-extraction, making India one of the world's hotspots of groundwater depletion (Shah, Scott, Kishore, & Sharma, 2004; Fishman, Lall, Modi, & Parekh, 2016). Surface water infrastructure, meanwhile, suffers from poor maintenance and diminishing returns, partly due to meager cost recovery from users (Johansson, 2000; Molle & Berkoff, 2007).

The concept of treating water as an economic good gained global prominence in the 1990s, emphasizing that pricing should reflect water's scarcity value to encourage conservation (Repetto, 1986; Thobani, 1997; Tsur & Dinar, 1997). In principle, charging farmers for irrigation water can provide incentives to avoid waste, shift to less water-intensive crops, and invest in water-saving

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technologies (Perry, 2001; Boland & Whittington, 2000; Hellegers & Perry, 2006). Pricing can also generate revenue for operation and maintenance of irrigation systems, improving financial sustainability (Dinar, Pochat, & Albiac-Murillo, 2015; Palanisami, Kakumanu, & Malik, 2015). Yet in practice, implementing effective irrigation water charges in developing countries like India has proven challenging (Chaudhuri & Roy, 2019; Mukherji et al., 2009; OECD, 2010).

Maharashtra provides a compelling context to examine these issues (Briscoe & Malik, 2006; Narayanamoorthy, 2001). As a leading agrarian state in western India, Maharashtra has faced recurrent droughts and growing water demand from agriculture, industry, and urban sectors (Rogers, Bhatia, & Huber, 1998; Ray, 2005). In response, it became one of the first states in India to experiment with institutional reforms in water management. Maharashtra established an independent water regulator in 2005 and has periodically revised its irrigation water tariffs to improve cost recovery and signal the value of water (Central Water Commission [CWC], 2022; Food and Agriculture Organization [FAO], 2017). The state's experience offers insights into how policy innovations in water pricing play out on the ground (Ward & Pulido-Velazquez, 2008; Grafton et al., 2018). This report provides a comprehensive review of agricultural water pricing with a focus on the Maharashtra context, integrating national policy evolution, institutional frameworks, current pricing practices, and case studies from recent research (Speelman et al., 2008; Hagos, Ahmed, Haileslassie, & Seid, 2022). The objective is to analyze how irrigation water pricing has developed, what methods are used, the outcomes and challenges observed, and what lessons can be drawn for sustainable water management and policy design (Li, Ma, Zhao, & Li, 2023; Mu, Tan, & Qu, 2023; Upadhyaya, Jeet, Singh, & Sundaram, 2023).

Irrigation water pricing in India must be understood against a backdrop of historically low tariffs and ingrained subsidies (Bazza & Ahmad, 2002; Cornish et al., 2004). For decades, canal irrigation charges have been kept nominal, often a flat fee per acre or per crop season as a matter of policy to support farmers (Johansson, Tsur, Roe, Doukkali, & Dinar, 2002; Palanisami et al., 2015). Each state set its own rates (usually via irrigation acts or government orders), leading to a patchwork of pricing practices across the country (Dinar & Subramanian, 1997). For example, in Uttar Pradesh and Bihar, canal water charges remained as low as ₹50 to ₹100 per acre for decades; Tamil Nadu outright waived its nominal water cess in 2004 (Shah et al., 2004), effectively making canal irrigation free; Punjab's abolition of charges from 1997–2002 followed by a minimal reinstated fee is another instance. Many northeastern states and smaller irrigation schemes simply do not charge farmers at all. This patchiness means farmers in one state might pay 10–20 times more per unit water than those in another, though in all cases the absolute amounts are low (Saleth, 2004).

Commonly, charges have been levied on an area basis—farmers pay a fixed amount per hectare of land irrigated, sometimes varying by crop type or season (Reddy, 2005; Rohith et al., 2015). For example, a state might charge more per hectare for sugarcane (a water-intensive cash crop) than for paddy or wheat, or have separate rates for dry vs wet season irrigation. However, many states opted for very minimal and uniform charges. In some cases, the fee was as low as a few tens of rupees per acre, effectively symbolic (Small & Adriano, 1989). States like Punjab even abolished irrigation fees for a period (in 1997) and later reinstated them at low levels, underlining the political populism surrounding the issue (Boland & Whittington, 2000).

Methods of Charging Irrigation Water Prices

Multiple approaches exist to charge farmers for irrigation water. Each method has its rationale, advantages, and drawbacks. The main pricing methods applied or discussed in the context of agriculture are:

- **Area-Based Charges (Flat Rate per Area):** This is the traditional method used in most of India. Farmers are charged a fixed amount based on the area irrigated (usually per acre or hectare) regardless of the actual volume of water used. The rate may vary by crop or season but does not require measuring water deliveries (Bazza & Ahmad, 2002; Speelman et al., 2008). *Advantages:* It is simple to administer and does not need costly metering infrastructure. Farmers know upfront

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how much they must pay per season. *Disadvantages:* It provides no incentive to save water since using more water does not incur additional cost.

- **Volumetric Pricing (Metered Use):** Under volumetric pricing, water is charged per unit volume delivered (e.g., per cubic meter or per million liters). This approach directly ties cost to the amount of water consumed, much like a utility bill. *Advantages:* It sends a clear conservation signal if you use more, you pay more which can encourage efficient use and cropping of less water-intensive crops (Dinar et al., 2015; Molle & Berkoff, 2007). It also allows for more fine-tuned management (for instance, different volumetric rates can be set for different times of year to reflect scarcity). *Disadvantages:* The practical challenge is measuring water accurately at the farm level. Installing and maintaining water meters or measuring devices in open canal systems is expensive and technically difficult.
- **Tiered or Block Pricing:** This is a variant of volumetric pricing where the unit price of water increases with higher usage blocks. For example, a certain basic volume might be charged at a low rate, but additional water above that threshold is charged at a higher rate. *Advantages:* Block rates can protect small users (ensuring affordable water for basic needs) while penalizing excessive use (Bar-Shira et al., 2006; Hellegers & Perry, 2006). It can also be structured to achieve partial cost recovery at low use and fuller cost recovery at high use. *Disadvantages:* It requires volumetric measurement and adds complexity to the billing. Determining the block thresholds and prices needs careful study of usage patterns
- **Output-Based or Crop-Based Pricing:** Instead of charging per volume or area, farmers could be charged per unit of crop output or based on the crop type grown. For instance, a fee could be levied per tonne of crop produced (effectively a form of cess) or higher rates could be charged for water if used on water-intensive cash crops like sugarcane compared to food grains. India has indirectly used this approach by setting different area rates for different crops, which is a simplified version of output-based pricing (assuming certain yields per crop). (Perry, 2001; Reddy, 2005)
- **Input-Based Charging (proxy methods):** In situations where measuring water directly is hard, sometimes other inputs are used as a proxy for water use. One example is charging based on the number of irrigations or hours of pumping (some irrigation schemes issue water on a turn basis and charge per irrigation turn). Another proxy is the capacity of the irrigation infrastructure for instance, a horsepower-based fee for pump irrigation, assuming a higher HP pump can draw more water. Electricity pricing for agricultural pump sets is a kind of input-based approach: farmers often pay a flat rate for power, ostensibly linked to their pump capacity rather than actual water pumped. (Shah et al., 2004; Fishman et al., 2016)
- **Water Markets and Tradable Water Rights:** This approach moves away from administratively set tariffs towards market-determined prices. In a water market, users have entitlements to a certain amount of water which they can use or trade. For example, if a farmer is allocated a fixed volume but can manage with less, they could sell the surplus to another farmer willing to pay the price is negotiated between them. Such systems exist in several countries: parts of the western USA, Australia, Chile, and Spain have tradable water rights frameworks. In South Asia, informal water markets are seen in groundwater: in Bangladesh, for instance, owners of private tube wells sell irrigation water to neighboring farms at rates set by local supply-demand (often per hour of pumping). *Advantages:* Markets can, in theory, allocate water to where it has the highest value (farmers who can profit more from the water will buy from those who value it less). Nonetheless, ideas like tradable groundwater permits or intra-WUA water trading have been floated as long-term possibilities to improve allocation efficiency.(Tsur & Dinar, 1997; Thobani, 1997).
- **Two-Part Tariffs:** This method combines a fixed charge and a variable charge. For instance, a farmer might pay a fixed annual fee per hectare (to cover fixed costs of the system) plus a volumetric fee for each unit of water used (to cover variable costs). *Advantages:* It provides revenue stability through the fixed component (ensuring basic maintenance costs can be met

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regardless of usage fluctuations) while still incentivizing conservation through the variable component. It can be seen as a compromise between pure flat and pure volumetric systems. *Disadvantages:* Farmers might view the fixed charge as an unfair burden if water delivery is unreliable.

Each pricing method above involves trade-offs between administrative feasibility, economic efficiency, equity, and political acceptability. In reality, many systems use a combination for example, Maharashtra's bulk water tariffs to WUAs are volumetric (per million cubic meters) but farmers within a WUA might still pay on a per-area basis to keep things simple, effectively creating a hybrid system. Policymakers must choose methods that align with local conditions: where measurement is possible, volumetric or block pricing can be pursued; where not, improving flat rates or exploring indirect pricing (like energy pricing reforms) might be the interim solution. The following section will discuss the current status of how these methods are actually applied in India, highlighting that despite the array of options, traditional flat pricing remains dominant, with gradual shifts toward volumetric principles only recently underway (Boland & Whittington, 2000; Dinar, 2000).

Current Status of Irrigation Water Pricing in India

Despite policy statements endorsing economic pricing, irrigation water remains very cheap or free for farmers (Chaudhuri & Roy, 2019; Narayanamoorthy, 2001). Area-based flat tariffs continue to dominate in most states (Central Water Commission [CWC], 2022; Food and Agriculture Organization [FAO], 2017). Volumetric pricing, as of 2022, is largely confined to pilot projects or bulk supply arrangements (Li et al., 2023; Mu et al., 2023). WUAs sometimes collect water charges directly (Veettil et al., 2011; Speelman et al., 2008).

A snapshot comparison reveals how disparate the pricing can be: For paddy cultivation under canal irrigation, some states charge as low as ₹50–₹100 per hectare per season (effectively almost nil), while others might charge ₹500–₹1000. Sugarcane, being a remunerative crop, often carries the highest water charge but in many states that simply means maybe ₹1000–₹2000 per hectare, which is still a minute fraction of sugarcane's gross revenue. Several states apply uniform flat charges regardless of crop: e.g., Punjab and Haryana historically had one flat rate per acre for all crops until Punjab's temporary fee abolition. A number of states have reported having no formal irrigation fee at all for certain categories (like minor lift irrigation schemes or tribal areas), treating it as a welfare measure.

Volumetric pricing, as of 2022, is largely confined to pilot projects or bulk supply arrangements. No state charges individual farmers strictly by volume at the headgate on a wide scale due to the practical challenges noted earlier. However, a few states have moved toward volumetric charges at the project or WUA level. Maharashtra's MWRRA sets bulk water tariffs on a volumetric basis e.g., an irrigation project might be charged a certain rupees per million cubic meters delivered. Gujarat's irrigation department, in its rules, has provisions for volumetric supply and even offers discounted rates if farmers adopt micro-irrigation (recognizing that drip irrigation can stretch water farther). In practice, such volumetric provisions often serve as guidelines; implementation depends on having measuring devices at canal outlets, which is still being developed (Briscoe & Malik, 2006; Grafton et al., 2018).

Another aspect of the current status is the role of **Water User Associations (WUAs)** in tariff collection and management. By 2020, many states claimed to have handed over part of the irrigation systems to WUAs. These WUAs sometimes collect water charges from farmers directly. In states like Maharashtra, an officially sanctioned arrangement is that WUAs retain a portion (often 20-50%) of the collected fees for local improvements and remit the rest to the government. This incentivizes WUAs to collect dues. Even so, collection rates vary some well-functioning WUAs in Maharashtra and Andhra Pradesh reported collections above 80% of assessed fees (especially when water supply was timely), whereas others are moribund and collect little. Nationally, data suggests that average collection efficiency remains low, with a considerable gap between what is billed (or should be billed) and what is actually recovered. This means that even the low tariffs that are on paper are not fully

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realized in revenue. (Rogers et al., 1998; OECD, 2010). Many systems use a combination for example, Maharashtra's bulk water tariffs to WUAs are volumetric (per million cubic meters) but farmers within a WUA might still pay on a per-area basis, effectively creating a hybrid system (Central Water Commission [CWC], 2022; FAO, 2012).

Tariff Structures in Maharashtra and Examples

Maharashtra's structured approach to water tariffs provides a useful case to examine how a tariff schedule can be designed for different irrigation contexts. Under the Maharashtra Water Resources Regulatory Authority's orders (notably the 2018 and 2022 tariff orders), the state has detailed schedules for bulk water charges. These schedules categorize tariffs by the mode of irrigation supply and whether volumetric measurement is available. The major categories include:

- **Flow Irrigation (Gravity Canals) Volumetric Bulk Tariff:** For water supplied from canals under gravity (flow irrigation), Maharashtra sets a volumetric charge per unit volume (e.g., per million cubic meters) delivered to an outlet or a Water User Association. In the 2022 tariff order, for instance, a base rate was specified for agricultural use through flow irrigation, applicable at the canal head or division point. These rates are to be uniformly applied across projects of similar type (with possible differentiation between say, major and minor schemes). The tariff order also built in annual escalations: from July 2022 to June 2023 a certain base rate applies, then from 2023–24 a 10% higher rate, and from 2024–25 a 20% higher rate, reflecting phased increases.
- **Lift Irrigation Volumetric Tariff:** Private and government lift irrigation schemes (where water is pumped from a source) have their own tariff category. Maharashtra recognizes that lift schemes involve additional costs and infrastructure, so historically these were sometimes charged differently. In the current tariff structure, bulk water supplied to a **Private Lift Irrigation Scheme (PLIS)** is charged volumetrically as well, often at a different rate table. The 2022 order, for example, provided a Table 2 for PLIS rates. These might be slightly higher or have different escalation because lift schemes often supply fewer farmers and involve pumping costs (which the farmers bear separately via electricity bills). By having a separate category, the tariff system can account for the different nature of service (pumped vs gravity) and perhaps encourage efficient use in lift systems too. Government-operated lift schemes are also covered, with some provisions if they don't fall neatly under WUA management.
- **Area-Based Tariff for Unmeasured Supply:** Recognizing that not all outlets have flow meters or other measurement in place, the MWRRA tariff order provides a fallback **area-based bulk tariff** (expressed in ₹ per hectare) for cases where volumetric measurement is not feasible. This acts as a default charge to individual farmers or WUAs per irrigated area when water cannot be quantified. The 2022 order's Annexure included a Table 3 specifying such rates. These are effectively calibrated with an assumed water duty (so that if a project can't measure, it at least charges farmers in line with typical volume they'd receive). For example, if the volumetric rate and typical allocation translate to, say, ₹1500 per hectare, that might be the area-based bulk charge. This ensures that lack of meters doesn't stall the ability to collect fees the system reverts to the traditional area charge but at levels consistent with the new pricing framework.(Johansson, 2000).
- **Crop Differentiation and Seasonal Variation:** Maharashtra's bulk tariffs are generally not crop-specific (they charge by volume or area regardless of crop), which is a shift from earlier times when sugarcane or other crops had separate rates. The idea is that volumetric charging itself accounts for crop water use (because water-intensive crops will simply use and pay for more volume). However, the tariff orders do consider seasonal differences for instance, some projects might have different rates for the Kharif (monsoon) season vs. Rabi (dry) season supply, reflecting availability and demand differences. Additionally, certain uses like orchards under drip irrigation might be promoted by offering a discounted rate per volume (since drip can irrigate more area with the same water, effectively encouraging efficiency by letting farmers benefit from the savings (Rohith et al., 2015).

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- **Escalation Over Time:** A notable feature in Maharashtra's structure is the automatic escalation of tariffs year-on-year as part of a multi-year tariff cycle. The 2018 order stipulated a 10% increase each year for three years. The 2022 order likewise set out incremented rates for subsequent years (e.g., base year, +10% next year, +20% the following year). This built-in increase, subject to review in the next tariff cycle, is meant to gradually close the gap between revenue and costs without a sudden jump. Few other states have such a forward-looking mechanism embedded in their pricing it reflects a regulatory approach akin to how utility tariffs are set, providing predictability and gradualism (Palanisami et al., 2015).

Table 1. below summarizes the land and irrigation statistics at global, national (India), and state (Maharashtra) levels.

Region	Net Cropped Area (Mha)	Net Irrigated Area (Mha)	Irrigation Coverage (%)	Ultimate Irrigation Potential (Mha)
World	~1724	~403	23.4%	–
India	140.7	79.3	~56%	139.5
Maharashtra	16.65	3.11	18.7%	12.6

(Sources: agriwelfare.gov.in, essd.copernicus.org, pib.gov.in, fao.org).

The data above illustrate the context in which irrigation costs and tariffs are discussed. Globally, only about a quarter of farmland is irrigated, but India has invested heavily in irrigation infrastructure, achieving over half coverage of its net sown area. Even so, a large gap remains between the existing irrigation extent and the potential for example, India's ultimate irrigation potential is about 139.5 Mha, well above the current ~79 Mha actually irrigated. Bridging this gap involves significant expenditures, which brings into focus the cost of irrigation and how it is recovered (or not) via irrigation tariffs.

Calculation of Irrigation Tariff: Tariff setting can follow different methods:

- *Area-based tariffs:* This is common in many Indian states. Farmers are charged a fixed rate per unit area (hectare or acre) irrigated, often differentiated by crop type and season. The formula can be as simple as Tariff = Rate (₹/ha) × Area irrigated (ha). Rates are typically set administratively. For instance, a state might set a rate of ₹300/ha for irrigating a rice crop in the wet season and ₹150/ha for a less water-intensive crop or for the dry season, etc. These rates usually consider crop water needs and economic returns; e.g. higher tariffs for sugarcane than for fodder crops. In Maharashtra's tariff system, as mentioned, the rates roughly aimed at a percentage of crop revenue effectively a formula tying tariff to the crop's profitability (so a high-value cash crop would be charged more per hectare than a staple crop).
- *Volumetric tariffs:* Here the formula is Tariff = Volume of water used × Price per unit volume. For example, if water is metered, a farmer might pay say ₹0.50 per cubic meter. If they use 1,000 m^3, the bill is ₹500. Volumetric pricing is considered more efficient (users pay for what they use), but it requires measurement infrastructure and is less commonly implemented in canal systems due to challenges in measuring water delivered to each farm. Some projects use proxy volumetric methods (like per irrigation turn or per hour of water flow).
- *Tiered or block tariffs:* A more complex formula can involve increasing rates for higher usage (to encourage conservation) or different slabs of area. For example, a base rate for the first 1 hectare and higher rate for additional area, etc. Some irrigation systems internationally use tiered pricing, though this is rare in Indian canal irrigation.

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Challenges in Implementing Effective Water Pricing

Challenges include low revenue collection (Speelman et al., 2008), political economy and populism (Boland & Whittington, 2000), resistance and equity concerns among farmers (Shah et al., 2004), inadequate measurement infrastructure (Johansson et al., 2002), poor irrigation service delivery (Molle & Berkoff, 2007), transparency deficits (Repetto, 1986), water theft (Fishman et al., 2016), concurrent subsidy policies (Reddy, 2005), and institutional capacity gaps (Briscoe & Malik, 2006; Rogers et al., 1998).

- **Low Revenue Collection and Enforcement Issues:** Even when water charges exist on paper, actually collecting them from farmers has been a chronic problem. Historical recovery rates for irrigation fees are very low (often well below 50% of the amount billed). Reasons include inadequate billing mechanisms, lack of manpower in the irrigation department to follow up, and deliberate non-payment by farmers when they know enforcement is lax. Penalties for non-payment are seldom enforced it's rare for a farmer to have water supply cut off for not paying a water bill, as might happen with electricity. In some instances, officials have been bribed or influenced to overlook arrears. This culture of poor compliance means that announced tariff hikes may not translate into proportionate revenue increase. Essentially, a cycle forms: because collection is low, irrigation agencies remain underfunded; underfunding leads to deteriorating service; poor service further discourages farmers from paying, or politicians from pushing collection, perpetuating the cycle.
- **Political Economy and Populism:** Agriculture is a politically sensitive sector in India, and farmers are an influential voting bloc. Any increase in water charges or strict enforcement of payments can become a flashpoint. Politicians often promise free or subsidized water (alongside free power, loan waivers, etc.) to win support.
- **Resistance and Equity Concerns Among Farmers:** From the farmers' perspective, irrigation water pricing can be perceived as an added financial burden with little immediate benefit. Many small and marginal farmers operate at subsistence or low profit margins; they fear that higher water costs will eat into their income, especially in the absence of guaranteed higher crop prices. There is also an ingrained sense that water is a public resource that should be provided by the state (a legacy of the welfare approach). Equity concerns are significant poorer farmers worry that pricing will favor rich farmers who can afford to pay for more water, potentially squeezing them out.
- **Inadequate Measurement and Infrastructure:** A practical barrier to volumetric pricing (and even to knowing how much area is irrigated) is the lack of measuring devices and modern infrastructure. Most canal systems were not built with flow meters at tertiary offtakes; installing them now is costly and logistically difficult. Even where meters exist, maintenance is a challenge silt, weeds, or tampering can cause meters to fail or give inaccurate readings. In groundwater, measuring individual well extraction is even more daunting. Because you can't manage or price what you don't measure, this becomes a fundamental hurdle. Many irrigation schemes also lack controlled outlets or any automated systems to monitor distribution.
- **Poor Irrigation Service Delivery:** One reason farmers are unwilling to pay is that the service quality of public irrigation can be quite poor. Water deliveries are often unreliable farmers might be promised water on a certain date but face delays or sudden cuts. Sometimes the quantity delivered is far less than the crop needs (especially in tail end areas of canals). In many canals,

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rotational water supply means some farmers get water at inconvenient times. If farmers are paying for a service, they expect that service to be reasonably reliable and timely.

- **Transparency and Trust Deficit:** Historically, irrigation departments did not always operate transparently. Farmers often don't know how water allocation decisions are made or where their fee payments go. There is suspicion that even if they pay, the money disappears into government coffers and doesn't directly improve their canal. Cases of fabricated water bills or inconsistent assessment of irrigated area have been reported, leading to grievances. This lack of transparency means farmers do not view water charges as a fair exchange. Building trust through participatory management and clear accounting is a challenge that must be met to get buy-in for any pricing regime.
- **Water Theft and Illegal Use:** Another ground reality is that water distribution in canals is not always strictly according to plan. Some farmers siphon extra water by breaching channels or pumping directly from canals, especially at night. If others are paying for water while some take it illicitly for free, the paying users become demotivated.
- **Concurrent Subsidy Policies (Power and Crop Pricing):** Irrigation water pricing does not operate in isolation. Other policies can counteract or undermine its impact. A prime example is electricity subsidies for pumping groundwater even if canal water had a price, a farmer might choose to over-extract groundwater if power is free, thus defeating the conservation goal. Similarly, if Minimum Support Prices (MSP) for water-intensive crops like rice and sugarcane remain high, farmers have incentive to grow them regardless of water cost. In fact, as one of the case studies will show, output price changes can have a bigger effect on water use than modest water price changes. This interplay means the challenge for water pricing is also about aligning broader agricultural policies. Without that alignment, water pricing alone faces an uphill battle to influence behavior.
- **Institutional Capacity and Coordination:** Implementing new pricing structures requires capable institutions from the state regulator (if one exists) to the irrigation department field staff and the water user associations. Training, data management, and coordination need improvement. In some areas, WUAs are lacking or inactive, so there is no intermediary to help implement pricing at the tail end. The irrigation bureaucracy in many states is oriented more towards engineering (building structures) than economic management; reorienting staff to handle tariff assessments, listen to farmer feedback, and resolve billing disputes is a major change management challenge. Additionally, coordination is needed between departments agriculture, water resources, power to ensure policies are working in concert. Such integrated functioning is still more an ideal than a reality in most places.

Recommendations for Improvement

Key recommendations include: gradual volumetric measurement and quotas (Dinar et al., 2015), transparent cost recovery (Central Water Commission [CWC], 2022), strengthening WUAs (Veettil et al., 2011), aligning crop pricing with sustainability goals (Perry, 2001; Li et al., 2023), differentiated tariffs (Rohith et al., 2015), investing in measurement technology (Mu et al., 2023), alternative pricing methods (Johansson et al., 2002), enhancing farmer awareness (Bazza & Ahmad, 2002), phased pilot projects (Speelman et al., 2008), and political engagement (Boland & Whittington, 2000; Grafton et al., 2018).

- **Gradual Introduction of Volumetric Measurement and Quotas:** Instead of abrupt price hikes, start by implementing volumetric allocation (even if not pricing every drop initially). For

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example, enforce a per-hectare water quota for each farmer or WUA (as suggested by Case Study 1) this rations water fairly and makes its scarcity explicit. Once users adapt to fixed allotments, volumetric pricing can be phased in on the excess usage beyond the basic quota. This combination ensures everyone gets a fair share (equity) but those wanting more must pay extra, which is more politically acceptable and highlights water's value.

- **Improve Cost Recovery with Transparent Reinvestment:** Aim to incrementally raise irrigation charges to at least cover basic Operation & Maintenance costs in the short term. This could mean, for instance, a 10% annual increase in tariffs until a target (say 50% of O&M) is reached, as Maharashtra has initiated. Crucially, be transparent about where the money goes establish a ring-fenced irrigation maintenance fund at the project or WUA level. Farmers should see that their payments result in canal repairs, better regulation, and timely water delivery. Publicize annual accounts of fee collection and expenditures to build trust that paying more directly leads to better service.
- **Strengthen and Empower Water User Associations:** WUAs need to be central actors in any pricing reform. They should be given clearly defined roles in water distribution and fee collection. Provide training to WUA leaders in basic financial management and conflict resolution. Incentivize WUAs by allowing them to retain a significant share of collected fees (e.g., 50%) for local improvements. Additionally, empower WUAs to enforce rules for example, give them authority to temporarily suspend water deliveries to members who persistently do not pay or violate allocation rules, backed by legal support from the state. A community-enforced approach can be more effective and locally legitimate than top-down enforcement.
- **Revise Crop Pricing and Subsidy Policies in Tandem:** Align agricultural pricing policies (like Minimum Support Prices for crops and input subsidies) with water sustainability goals. If water-intensive crops like sugarcane and rice have high support prices or free electricity, farmers will understandably grow them and pump water regardless of water charges. Therefore, gradually reduce incentives for such crops in over-stressed areas; encourage crop diversification by raising support prices or providing other incentives for less water-intensive cereals, pulses, or oilseeds. Consider incorporating the cost of irrigation water into the government's cost-of-cultivation calculations for MSP (echoing Case Study 2's implication) this would highlight crops where MSP is currently not covering irrigation costs and prompt policy adjustments. In parallel, ensure that any increase in water charges is timed with or preceded by support for alternative crops or value addition, so farmers have viable profitable options with lower water use.
- **Differentiated Tariffs and Targeted Relief:** One size may not fit all in water pricing. Develop a slab system or differential tariffs to protect vulnerable farmers while still charging larger users more. For example, smallholders could get a certain volume or area at a concessional rate (lifeline water), while large commercial farms pay higher rates for large volumes. Any such cross-subsidy should be transparent and ideally funded within the sector (so that it doesn't gut the irrigation agency's finances). In parallel, create a safety net e.g., an increased irrigation cost could be offset by direct income support or subsidy to small farmers during the transition period, so that no one is impoverished by water bills.
- **Invest in Measurement and Technology:** Prioritize investments in modernizing irrigation infrastructure to enable better measurement and control. Install flow meters or gauges at least at the canal minor or WUA level to get data on water deliveries. Use remote sensing and satellite imagery to estimate crop water use and irrigated area these can serve as proxies to validate what

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farmers should be paying under area-based systems or to detect if some farmers are using more water than accounted. Expand telemetry and perhaps pilot smart card systems where feasible (for instance, a WUA is given a water allocation on a smart card that is debited as gates are opened). On the farm side, continue promoting **micro-irrigation** with capital subsidies, but also consider coupling that with volumetric supply agreements so that farmers who save water through drip can potentially sell or bank their saved water (providing a real reward for efficiency).

- **Consider Alternative Pricing Methods:** As research (like Case Study 3) indicates, volumetric pricing, while logical, is not the only approach. In schemes or regions where metering is too costly, adopt second-best methods: e.g., area-based pricing with tiered cropping penalties (higher rates for water-heavy crops as a proxy for volume), or seasonal pricing (higher in dry season). Experiment with group incentives for example, if an entire WUA manages to reduce water use below a threshold, offer a rebate on their bulk bill.
- **Enhance Farmer Awareness and Capacity:** Conduct extensive outreach to shift perceptions about water. Extension services and WUAs can organize workshops on water productivity teaching farmers that sometimes "less water can grow the same crop yield" if managed well, and that net profit (₹ per cubic meter of water) is a metric to optimize, not just yield or acreage. Highlight success stories of farmers who, for instance, switched crops or adopted drip irrigation and maintained income with half the water use. When introducing any pricing change, accompany it with clear communication: explain why it's being done (link to drought experiences, drying wells, etc.), and how revenues will be used to benefit farmers. Building a sense of collective responsibility for the resource can make farmers more receptive to paying for its upkeep.
- **Phased Implementation and Pilot Projects:** Avoid a blanket roll-out of new pricing in one go. Instead, identify pilot command areas or projects (perhaps ones with active WUAs or relatively better infrastructure) to implement the new pricing regime fully. Monitor results for a couple of seasons see how water use, cropping patterns, and collections change. Use these pilots to learn and fine-tune the tariff design and implementation process. The pilots will also create demonstration effects success there can quiet some critics and provide practical proof to convince other areas. Then scale up gradually, region by region, incorporating lessons learned.
- **Political Engagement and Incentivizing Reforms:** Garnering political will is crucial. One approach is to tie water sector reforms to incentives from higher levels of government. For example, the central government could condition certain grants or program funds (like under PMKSY or the Accelerated Irrigation Benefits Programme) on states updating their water tariff schedule or achieving certain collection benchmarks. This creates a top-down push for what is otherwise politically hard at state level. Simultaneously, engage local political leaders by framing pricing reforms as pro-farmer in the long term emphasize that no water, not even free water, is what many farmers will face if resources continue to decline, so pricing is a tool to secure their future water supply.

In conclusion, the recommendations revolve around a strategy of gradual, participatory reform: combining improved rules (quotas, tariffs, penalties) with improved infrastructure and farmer support. By moving stepwise and demonstrating benefits (better service, maintained farm incomes, more resilient water supply), Maharashtra and other states can overcome the inertia and resistance to change. The case studies underscore that context matters measures must be tailored but they also show that creative policy mixes (pricing + quotas + education + complementary livelihood support)

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can yield positive outcomes. The case studies analyzed below provide concrete evidence supporting these recommendations and illustrate the consequences of various policy choices.

Conclusions

In conclusion, the journey to rationalize water pricing in agriculture, particularly in a state like Maharashtra, is a gradual and complex one. It requires balancing economic principles with social realities, and pairing policy reforms with on-ground capacity building. The evidence reviewed from policy history to case studies suggests that while challenges are formidable, they are not insurmountable. With a combination of regulatory innovation, stakeholder involvement, supportive measures, and persistence, Maharashtra can move toward a model where water's true value is recognized. Such a model would ensure that irrigation water the lifeblood of agriculture is used efficiently, shared equitably, and managed sustainably, securing the prosperity of farmers and the food security of the nation in the face of growing water scarcity.

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