International Journal of Social Science and Economic Research

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Irrigation Subsidies in India: Balancing Farmer Welfare and Environmental Sustainability

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DOI: 10.46609/IJSSER.2025.v10i09.026 URL: https://doi.org/10.46609/IJSSER.2025.v10i09.026

Received: 7 September 2025 / Accepted: 19 September 2025 / Published: 25 September 2025

ABSTRACT

This research paper explores the impact of irrigation subsidies on water use efficiency, groundwater depletion, and farmer welfare in Indian agriculture. By analyzing regional variations in subsidy structures across Punjab, Maharashtra, and Gujarat, the study highlights how such policies affect both agricultural productivity and environmental sustainability. While subsidies have lowered input costs, supported food security, and enabled technological adoption, they have also encouraged inefficient water use and contributed to critical aquifer depletion. Importantly, the benefits of these subsidies have been unevenly distributed: larger and wealthier landholders capture a disproportionate share of support, while marginal and small-scale farmers often struggle to access or benefit from the schemes. This has exacerbated rural wealth inequality even as the overall productivity of the respective states has risen. The findings indicate that blanket subsidies without governance mechanisms have numerous long-term environmental and social effects, whereas adaptive, conditional, and performance-based approaches can improve efficiency and equity. As a result, policymakers must develop region-specific incentives that are regularly audited and connected to measurable outcomes like groundwater recharge, agricultural diversification, and the use of water-saving technologies. The study also underlines the need for policy that strikes a balance between short-term productivity gains and long-term environmental stewardship and social justice.

Keywords: Irrigation, Subsidies, India, Agriculture, Groundwater, Equity, Productivity, Policy

I. Introduction

Water scarcity is a critical challenge faced around India, but a primary cause is the Indian agriculture sector, which consumes nearly 80 percent of the country’s freshwater resources. To support the agricultural economy as well as the livelihoods of farmers, the government has

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

introduced various state-wide irrigation subsidies primarily aimed at making water more affordable and accessible. However, concerns have been raised regarding the role of these subsidies in promoting groundwater depletion and inefficient irrigation practices. At the same time, government irrigation subsidies have been crucial in expanding irrigated land, reducing per-unit production expenses, promoting the utilization of modern inputs and technology, and supporting rural incomes across the nation. One such technology is micro irrigation, which is defined as a water-efficient method that delivers water directly to plant roots using drip or sprinkler systems, reducing waste and improving crop yields.

The agricultural sector accounts for nearly 20 percent of India's GDP and 59 percent of the rural workforce. Irrigation subsidies began in the 1970s to support farmers' productivity. Yet access to and benefits from these subsidies have not been uniform: better-resourced and larger landholders often capture a disproportionate share of support, while marginal and smallholders face administrative, capital, and information barriers. Nevertheless, these policies involve trade-offs: many farmers gain economically even as aggregate extraction and local aquifer stress can increase, creating tensions between short-term welfare gains and long-term resource sustainability. Moreover, the impact of irrigation subsidies varies across regions due to differences in climate, crop choices, and water availability. Understanding these differences is crucial for formulating sustainable policies that balance agricultural productivity with environmental conservation.

Specifically, this paper hypothesizes that while irrigation subsidies were intended to enhance agricultural productivity and support small-scale farmers, they have unintentionally led to inefficient water use and groundwater depletion. Targeted reforms, such as the promotion of micro-irrigation systems and crop diversification, could potentially improve water efficiency without significantly reducing farmer incomes or yields. It is critical to ensure that resources are used sustainably in order to maintain the long-term contributions of the agricultural sector.

This research contributes to existing literature on the common pool problem by filling gaps in the analysis of regional variations in subsidy impacts, as opposed to broader national trends. It also considers both agricultural productivity and environmental sustainability, providing a more holistic understanding of the issue and offering opposing viewpoints.

This study examines how India's irrigation subsidy policies affect water-use efficiency and groundwater depletion, and how they frequently favor larger landholders over marginal and small-scale farmers, hence widening the wealth gap in rural areas even while overall agricultural output increases. The analysis then links these outcomes to specific mechanisms, notably rebound effects and distributional capture, which together explain shifts in irrigation practice, crop choices, and income distribution over the long-term. The study will focus on comparing the role and effect of these subsidies, particularly in the states of Punjab, Maharashtra, and Gujarat. Additionally, this contribution will explore the policy question: What policy reforms could mitigate their negative effects?

II. Background

Since the independence of India, the government has placed great importance on the agricultural sector, as evidenced by the early implementation of irrigation subsidies. These subsidies were essential in addressing widespread overpopulation and food insecurity. Currently, 88 percent of Indian crops are used for domestic consumption, while exports remain significant, as agricultural exports make up 11.9 percent of total exports. The Indian agricultural sector is heavily reliant on irrigation, largely because much of the country experiences uncertain rainfall patterns. Therefore, to ensure stable agricultural output, the government has introduced a range of region-specific irrigation subsidies. For example, the state of Punjab has implemented a policy of free electricity for agricultural pump sets, under which farmers receive unlimited, unmetered power for groundwater extraction.

The cumulative cost of this subsidy exceeds ₹1.2 lakh crore ($13.8 billion), with annual expenditures in recent years surpassing ₹10,000 crore ($1.15 billion) (Tribune India, 2023). Put in context, ₹1.2 lakh crore could fund a ₹10,000 transfer to 120 million households which is about one month’s income for an average farming household. While this has reduced irrigation costs and sustained high-yielding cropping patterns, particularly rice and wheat, the environmental consequences have been severe. With no cost associated with electricity usage, farmers are incentivized to extract groundwater with little regard for sustainability. As per the Central Groundwater Board (2022), over 80 percent of the state’s blocks are now categorized as “over-exploited,” meaning annual groundwater extraction exceeds the annual recharge, indicating a critical level of groundwater depletion (Central Groundwater Board, 2022). Although socially and politically popular, this subsidy model has directly contributed to the region’s water crisis by removing any price signal that could otherwise curb excessive usage.

In 2019, the Indian government replaced electric pumps with solar-powered irrigation systems through schemes such as the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) aim to reduce reliance on grid electricity (Government of India, Ministry of New & Renewable Energy, 2021). However, across various states, other, more tailored initiatives were launched in order to benefit the local farmers further.

Maharashtra offers a slightly different model through its implementation of micro-irrigation subsidies under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY). The scheme offers subsidies of up to 80 percent for small and marginal farmers (with 55 percent from the

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

central government and 25 percent from the state) and 75 percent for other farmers, encouraging the adoption of drip and sprinkler irrigation systems (Government of Maharashtra, 2022). Specifically, drip irrigation delivers water slowly at the plant base to reduce evaporation, while sprinkler irrigation sprays water over a wider area like rainfall, but with more water loss. While drip irrigation has the potential to conserve water, it has also enabled the proliferation of water-intensive crops like sugarcane and bananas in ecologically sensitive regions. Thus, the environmental efficacy of these subsidies is undermined when they are not coupled with restrictions on crop choices or borewell regulation (Panda, Kanungo, & Rout, 2023). Furthermore, evidence from the Economic Survey of Maharashtra (2022–23) shows that despite the expansion of drip irrigation over 1.5 million hectares, the state continues to rank among the top users of groundwater per unit of irrigated land, raising concerns about the actual outcomes of these subsidy programs (Economic Survey of Maharashtra, 2023). In practice, Maharashtra's micro-irrigation subsidies produce strong field-level gains, but these gains are frequently offset at the landscape level by a rebound effect: lower irrigation costs and higher returns induce expansion of irrigated area and shifts into water-intensive high-value crops. Consequently, Maharashtra's model tends to deliver moderate environmental benefits at best and can exacerbate distributional capture unless targeting and complementary regulations are tightened.

In Gujarat, the state's irrigation subsidy policies are implemented through the Gujarat Green Revolution Company (GGRC), which provides financial assistance for the adoption of micro-irrigation systems. The base subsidy covers up to 50 percent of the cost, with additional support from the Gujarat Mineral Development Corporation and targeted increases in tribal or "dark zone" areas–those with critically low groundwater availability. In some cases, the subsidy reaches up to ₹70,000 ($800) per hectare or 70 percent of the total cost (Gujarat Green Revolution Company, 2023). The policy clearly targets areas with little water, but it doesn't have any enforceable protections like limits on how much groundwater can be taken out, guidelines for what crops to grow, or zoning rules for how land can be used. This means that there are no clear rules to stop people from taking too much water or expanding farming in areas that are already fragile. This has led to the expansion of high-input agriculture in dryland areas, placing further stress on already fragile water reserves.

In Punjab, the Punjab Energy Development Agency (PEDA) subsidizes up to 80 percent of the cost of solar pumps for certain eligible farmers. However, these systems, while promoting renewable energy, do not address the root issue of over-extraction. On the contrary, as solar pumps have near-zero operational costs once installed, they may intensify groundwater usage in the absence of regulatory controls (Punjab Energy Development Agency, 2023). The broader problem persists: irrigation subsidies are structured in ways that fail to incentivize efficient or sustainable water use.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Despite agriculture growing steadily over the past six years at an average rate of 4.4 percent (Commission for Agricultural Costs and Prices, 2020), this expansion has been driven by heavily subsidized irrigation practices that prioritize equity and productivity over environmental sustainability. Even though initiatives like PM-KUSUM and the National Water Policy place a strong emphasis on resource efficiency and climate resilience, input-focused subsidies like free electricity, subsidised solar pumps, and micro-irrigation grants have inadvertently promoted excessive water use and environmentally inappropriate cropping. Moreover, the distribution of these subsidies has been skewed in favor of relatively wealthier farmers who can afford to invest in borewells or capital-intensive drip systems. According to a 2020 report by the Commission for Agricultural Costs and Prices (CACP), less than 25 percent of small and marginal farms. As a result, groundwater levels are declining in many areas, jeopardising rural lives and agriculture's long-term sustainability. Although previous studies have shown these nationwide trends, little is known about the effects that are region-specific. Therefore, this study closes that gap by examining the effects of various subsidy regimes on groundwater depletion, water-use efficiency, and income inequality among farmers in various agroclimatic situations.

This study targets the three states of Maharashtra, Gujarat, and Punjab for their unique characteristics in terms of irrigation practices, climate conditions, and water dependency. Maharashtra's climate is temperamental, as some regions are prone to seasonal droughts, whereas others experience excess water. Lots of micro-irrigation schemes to improve water efficiency have also been tested in this state. The agricultural sector here employs around 50 percent of the workforce, and its overall population and general development are quite high compared to the rest of the country. The most commonly grown crops here include sugarcane, jowar, cotton, and pearl millet. Specifically, crops including cotton and sugarcane are extremely water-intensive. Gujarat has been chosen due to some of its successful policy interventions, including the Jyotigram Yojana, which regulates electricity supply for irrigation to prevent overuse. Its climate is also moderate, sitting in between the other two. Agriculture employs roughly 50 percent of the workforce here, and the major crops grown include cotton, groundnut, and wheat. Finally, Punjab is highly dependent on groundwater due to free electricity subsidies, which encourage excessive water extraction for irrigation. Moreover, it has a semi-arid climate, which inherently means less rainfall and a higher dependence on groundwater. The state is also significantly reliant on agriculture, as 75 percent of the population does so. It is one of the most irrigated states, with around 87 percent of its land being cultivated. In its land, the most common crops seen are wheat, rice, maize, and cotton, all of which are relatively water-demanding. Among the three models considered in this paper, Punjab's free-and-unmetered electricity model is the most directly linked to severe groundwater depletion and the largest equity distortions because it removes the marginal cost of pumping and therefore disproportionately rewards farmers who can afford multiple borewells and pump-sets.

ISSN: 2455-8834
Volume:10, Issue:09 "September 2025"

Comparing the three models highlights why they must be analysed together rather than as isolated cases. Punjab’s free-power regime is the most environmentally damaging and inequitable, eroding price signals and rewarding those with capital to pump. Maharashtra’s subsidy-driven micro-irrigation model can raise efficiency at the field level but suffers from rebound effects and elite capture. Gujarat’s rationed-supply approach curbs over-pumping relative to free power, yet depends heavily on feeder segregation, metering, and supporting rules. Seen in combination, these contrasts illustrate how different policy levers create distinct trade-offs in sustainability and equity—making a joint analysis essential to understand the full spectrum of outcomes.

Figure 1: Map of India with highlighted regions being the ones targeted in this study

(*West India Map, West Zone Map of India, 2013*)
Source: MapsofIndia

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Table 1. Comparison of irrigation subsidy models (Maharashtra, Gujarat, Punjab)

State	Type of Subsidy	Intention (to solve…)	Impact	Outcomes
Maharashtra	PMKSY - micro irrigation subsidy	Encourage efficient drip/sprinkler use to conserve water in drought-prone regions.	Rapid uptake on 8.86 L ha (~5.3 % area), ₹532 cr disbursed (FY 21–22); streamlined via MahaDBT with lottery to curb leakages.	+20–25% yield gains and 25–40% lower input costs for adopters, but 8% net water savings due to rebound, reduced aquifer recharge, only 17% land covered, and continued groundwater stress.
Gujarat	Jyotigram Yojana -	Ration farm power (8–12 h/day) while ensuring 24×7 household supply to curb indiscriminate pumping.	Farm electricity use fell by ~50%; AT&C losses halved; USD 260 M rewiring of 18,000 villages; feeder segregation improved reliability.	Stabilized aquifers; spurred cash-crop intensification (onion, banana) in dry zones; reduced return flows; localized aquifer drawdown persists.
Punjab	Free electricity for tube wells	Eliminate irrigation energy costs to lower farmer input costs and boost staple output.	Agri power use doubled to ~12,000 MU/yr; pump-set numbers rose from 2.8 L to 14.5 L; unmetered tariff drove indiscriminate pumping.	Sustained rice-wheat monoculture and higher incomes; 86% of blocks over-exploited, water tables falling ~1 m/yr; ₹9–10 k cr/yr fiscal burden; severe groundwater depletion.

Notes: MU = million units; L = lakh (100,000)

Sources: State budgets, PSPCL, GGRC, Economic Surveys

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

III. Literature Review

Although irrigation subsidies in India aim to lower farmer input costs, expand irrigated land, and secure rural livelihoods, there is growing evidence highlighting their unintended environmental and equity costs, raising doubts about their net benefit to society ("Agricultural subsidies: Curse or boon?", 2021). Shah et al. (2008) provide one of the most rigorous early examinations of this dynamic, using panel data from Gujarat and Punjab between 1995 and 2005. Through fixed-effects regressions on state utility records and Central Ground Water Board assessments, they demonstrate that heavily subsidized electricity drove a 150 percent increase in pump-set installations and a 70–80 percent rise in groundwater withdrawals, even as irrigation coverage expanded by 30–40 percent and rural incomes rose by up to 20 percent in some districts. Crucially, they link these gains to water-table declines exceeding one meter per year in over-exploited blocks–defined as those where annual extraction surpasses 100 percent of recharge–thereby coining the term "unsustainable extraction" in the Indian context. Shah and colleagues further underscore the role of political economy in perpetuating subsidies, documenting how electoral pressures deterred state governments from metering or charging for farm power despite mounting environmental costs.

Building on this foundation, Singh et al. (2019) employ a spatial econometric approach to quantify the national significance of electricity subsidies. By pairing Gravity Recovery and Climate Experiment (GRACE) satellite-derived groundwater anomalies (2003–2016) with district-level power-use data, they estimate that high-subsidy districts experienced 10–15 cm greater annual aquifer declines compared to low-subsidy areas, with free or nearly free electricity accounting for roughly 60 percent of the overall depletion. Although this study powerfully illustrates subsidy-driven groundwater loss at scale, it lacks household-level data to assess distributional outcomes or the potential mitigating effects of modern irrigation technologies. Moreover, it does not counter these negative externalities with positive impacts, especially on farmers and rural economies. Taken together, these early electricity-subsidy studies converge on the conclusion that cheap or free power drives rapid groundwater depletion, but they differ on whether the associated income gains outweigh the environmental costs (Jessoe & Badiani-Magnusson, 2019). What is largely missing is a consistent assessment of how these trade-offs vary by region or by farmer size.

In contrast, research on micro-irrigation subsidies has focused on field-level efficiencies and farmer benefits. Viswanathan et al. (2022) combine propensity-score-matched surveys of 650 farmers in Gujarat with qualitative interviews to show that nearly 90 percent of adopters reported yield increases of around 25 percent , and 61 percent achieved groundwater savings of 20–30 percent per hectare following drip or sprinkler installation. Mukherji et al. (2010) extend this analysis through cost-benefit accounting at the macro level, finding that state and central grants

ISSN: 2455-8834
Volume:10, Issue:09 "September 2025"

of approximately ₹27,700 ($316) per hectare yielded net income gains of around ₹18,000 ($205) per hectare and average water savings of 500 m³ per hectare per season. Yet both studies stop short of evaluating "rebound effects" or the opportunity cost of directing large subsidies toward individual farm systems rather than communal recharge infrastructure. Thus, the micro-irrigation literature generally agrees that field-level efficiency and income gains are real, but it disagrees on their durability once cropping choices and rebound effects are considered (Jessoe & Rapson, 2021). Very few studies test whether such gains translate into basin-level water savings or whether they accentuate inequality when wealthier farmers adopt first ("Groundwater-sourced irrigation and agro-power subsidies", 2019).

The political economy and equity dimensions of irrigation subsidies are equally well documented. Baird (2015) uses interviews with Punjab legislators, farmer union leaders, and utility officials to reveal the electoral imperatives that keep free-power policies in place, despite repeated attempts to reintroduce modest bulk charges. In Maharashtra, Ramachandran and Rao (2018) apply difference-in-differences methods to labor-force survey data (2016–2018), showing that while marginal farmers saw median income increases of 12 percent following PMKSY implementation, larger farmers experienced an 18 percent gain, underscoring pro-rich capture of subsidies. Across this body of work, the broad consensus is that subsidies, while politically resilient, often exacerbate inequities by disproportionately rewarding larger landholders. Where scholars disagree is on the magnitude of these inequities and whether design tweaks—such as targeted micro-irrigation grants or feeder segregation—can offset them.

Placing the Indian evidence in comparative perspective helps clarify whether these dynamics are unique to India's subsidy regime or part of a broader global pattern. In northeastern Brazil, Carvalho et al. (2012) document a 90 percent surge in well drilling and a 50 percent rise in withdrawals under subsidized irrigation power (2000–2010), while Australia's Howell and Duke (2019) attribute 20 percent of boreholes drilled post-subsidy to redundancy, as existing bores sufficed. Conversely, performance-based subsidies in Israel (Droppers et al. 2017) and Spain (Fernández et al. 2020) demonstrate that payments tied to measured water savings (via drip retrofits) can achieve 35 percent field-level water cuts and 12 percent yield gains, albeit with limited uptake due to administrative hurdles.

Despite this extensive scholarship, notable gaps persist in this field of research. Specifically, few studies systematically compare subsidy designs, governance mechanisms, and outcomes across multiple Indian states, and most treat water efficiency and equity in isolation (Devineni et al., 2022). Research also rarely proposes actionable, integrated policy alternatives that blend conditional power supply, performance payments, and recharge investments. Finally, there is a dearth of long-term analysis of how subsidies perform under climate stress or how they shape

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

cropping diversification and resilience ("Evaluating the role of subsidies in sustainable agriculture", 2023).

Hence, this paper addresses these gaps by conducting a comparative analysis of Punjab, Maharashtra, and Gujarat–each with distinct subsidy regimes (free electricity, micro-irrigation grants, and feeder segregation, respectively). By synthesizing state-level financial data, technology-uptake metrics, groundwater trends, and equity indicators, the paper assesses the relative effectiveness of each approach. Our framework integrates environmental outcomes with stakeholder impacts and governance variables (metering, abstraction limits, digital transparency), thereby identifying context-specific reform pathways. In doing so, we contribute the first cross-state comparison that links subsidy design to both hydrological and socio-economic outcomes, offering evidence-based outcomes and lessons for aligning India's irrigation policy with sustainable water management and social equity.

IV. Case 1: Maharashtra

a. Policy Framework & Subsidy Structure

Since 2015–16, the Union government's (Indian National Government's) Pradhan Mantri Krishi Sinchayee Yojana – Per Drop More Crop (PMKSY-PDMC) scheme has subsidised field-level micro-irrigation (drip and sprinkler) to enhance on-farm water-use efficiency. Under central guidelines, small and marginal farmers receive 55 percent of equipment costs and other farmers 45 percent; the 60:40 cost-share means the Centre funds 60 percent of the subsidy and the state 40 percent.

Five years later, the Maharashtra state government has further topped up these subsidies as it adds 25 percentage points for small/marginal farmers and 30 points for others, so that beneficiaries effectively receive 80 percent (small) or 75 percent (others) of the system cost. Thus, a farmer installing a drip or sprinkler system on up to 5 hectares pays only about 20–25 percent of the cost. The high subsidy reflects a policy priority to modernize irrigation in drought-prone regions. Specifically, the subsidy was topped up to accelerate the adoption of efficient irrigation technologies in response to recurring droughts, water scarcity, and growing stress on groundwater resources across Maharashtra.

In tandem, Maharashtra moved subsidy disbursal onto its MahaDBT digital portal (the agriculture department's e-governance platform) to improve transparency and speed. It also helps to allocate funds more fairly and transparently in the case that the cost required to allocate funds to the eligible participants that year exceeds the available budget. In principle, this direct-benefit-transfer approach should reduce leakage. Specifically, before the new solution's implementation, studies found that up to 30–40 percent of allocated micro-irrigation subsidies were either delayed or diverted due to middlemen and manual processing, with many small farmers excluded entirely due to opaque eligibility criteria and corruption at the local level.

b. Benefits to Agricultural Productivity

In practice, farmers frequently face delays and bureaucratic challenges when accessing their subsidies through the direct-benefit-transfer system. Despite being approved, many must wait an uncertain amount of time before receiving the funds, which creates financial strain–especially for those who have already made out-of-pocket investments. As a result, some farmers are forced to take out loans to bridge the gap, highlighting a critical disconnect between policy design and on-ground execution. For example, field reports from Jalna describe a smallholder who had already borrowed ₹25,000 to install drip on two hectares, only to wait more than six months for his subsidy reimbursement. During this time, he paid interest on the loan, effectively erasing much of the intended support from the scheme. This unpredictability undermines the intended efficiency of the system and discourages participation, particularly among smallholders who cannot afford to wait indefinitely for reimbursement.

Maharashtra's focus on micro-irrigation is evident in the numbers. State government data reports that by the end of 2021–22, about 886 thousand hectares of farmland were under drip/sprinkler systems (Economic Survey of Maharashtra 2022–23). That area represents only about 5.3 percent of the state's net sown area (approximately 16.6 million hectares), but it was a rapid rise from almost zero a decade earlier. Cumulatively, official figures suggest that over one million hectares have been brought under micro-irrigation in the 2015–24 period. Significant policy momentum is reflected in this quick expansion, but it also highlights ongoing access gaps because many small and marginal farmers are still unable to put these systems into place even with hefty subsidies. Moreover, penetration–defined as the proportion of total cultivated land where a specific technology or practice has been adopted–remains low relative to total agriculture: one news analysis pointed out that only about 17 percent of cultivated land (approximately 25.7 lakh hectares) is under any micro-irrigation, highlighting a huge scope for expansion. This is because many small and marginal farmers struggle to afford even subsidized systems upfront, face delays in reimbursements through schemes like MahaDBT, and often lack adequate technical guidance or awareness about long-term water and yield benefits (Mohan & Sinha, 2024).

In practice, adopters in Maharashtra have reported significant farm-level gains, especially through higher yields and reduced input costs. Supporting this, an ICAR study found that adopters saved substantially on seed, fertilizers, and manure (fertilizer costs fell by 13–52 percent) while generating higher incomes than non-adopters. The subsidy lowers the upfront cost of installing micro-irrigation systems, enabling precise delivery of water and nutrients to plant

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

roots. This reduces input wastage and boosts efficiency–so farmers need less seed, fertilizer, and manure. As a result, input costs dropped significantly; for example, ICAR found fertilizer expenditure fell by 13–52 percent among adopters. In essence, the subsidy enables technology, and the technology reduces costs (Shroff & Miglani, 2024).

c. Environmental Impacts & Groundwater Depletion

However, these field-level gains do not always translate into broader environmental benefits.

Government subsidies, while well-intentioned, can unintentionally encourage over-adoption and inefficient usage. By making drip systems financially accessible, subsidies lower the cost of irrigation, often triggering a "rebound" effect: farmers expand their irrigated area or switch to more water-intensive crops. Under flood irrigation, excess water seeps back into the earth, indirectly benefiting neighboring farms and sustaining regional water tables. With drip, that shared benefit disappears. As a result, drip systems may deplete the commons–reducing groundwater levels and increasing long-term water stress. In essence, while micro-irrigation raises the productivity of water for individual farmers, it risks undermining basin-wide sustainability. The widespread subsidization of such technologies, without adequate regulation or planning, may thus lead to environmental externalities that offset many of the initial efficiency gains.

d. Equity Implications for Marginalized Farmers

In contrast, marginal or tenant farmers–many of whom belong to Dalit or tribal communities–face persistent challenges in accessing Maharashtra's irrigation subsidies. These farmers make up a significant share of the rural population, yet have disproportionately lower incomes. According to the Periodic Labour Force Survey (2022–23), the average monthly income of a rural regular worker in Maharashtra was around ₹10,016 ($121), whereas for SC/ST workers, it was notably lower at ₹8,000 ($96), depending on employment type. Even before the subsidy program, these groups struggled with access to capital and infrastructure; after the scheme's rollout, these inequalities have widened.

Although the PMKSY subsidy covers 75–80 percent of micro-irrigation system costs, the remaining 20–25 percent contribution–amounting to ₹20,000–₹30,000 ($241–$361) per hectare–remains out of reach for many marginalized farmers (Ramachandran & Rao, 2018). Meanwhile, larger landholders with better financial resources and administrative support can navigate the system with ease: some even split land holdings and drill multiple borewells to receive multiple subsidies, amplifying their gains. This dynamic has worsened rural inequality by enabling wealthier farmers to expand irrigated cultivation and productivity, while marginalized groups are left behind, unable to adopt the same technologies.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

e. Evaluation

The state government treats the program as a policy success. Officials point to the millions of hectares under subsidy and farms enabled to irrigate sustainably, especially in drought-prone Vidarbha and Marathwada.

From the government's fiscal view, the subsidies represent a heavy recurring cost–over ₹900 crore ($1.08 billion) from the Centre and the state in recent years–but are justified as essential rural investment. However, local communities have less favourable views on the long-term impact of widespread drip irrigation adoption: villagers note that as more neighbors go onto drip, groundwater levels are appreciably falling. Field reports from cotton districts, for instance, describe wells that used to stay full year-round now drying sooner (Viswanathan, Koundinya, & Fernandes, 2022). While drip has eliminated the old practice of leaving land fallow between seasons (since now even low-groundwater fields can be irrigated), this comes at the cost of communal water reserves. In effect, one farmer's drip irrigation may reduce the spring flow that other fields formerly tapped. This conflict of interest–higher private yield versus public water–is a key trade-off of the program.

On the negative side, the fiscal funds devoted to these subsidies might have alternatives. Hence, there is an opportunity cost to the government. Critics argue that Maharashtra's financial and administrative capacity could also be invested in more eco-friendly innovations, such as watershed development or check-dam construction to recharge aquifers – solutions that benefit entire communities over the long run. Likewise, by heavily incentivizing cash crops like cotton and sugarcane (which demand more irrigation), the scheme may have indirectly encouraged cultivation patterns unsuited to an arid state.

Officials and experts acknowledge weak monitoring–there's no systematic post-installation audit of water savings or yield gains–and beneficiaries report bureaucratic delays in approvals and payments, creating inefficiencies that undermine subsidy effectiveness. Ecologically, the percolation advantages of surface irrigation are lost for every acre under drip; socially, the scheme tends to favor better-off farmers. True benefits, therefore, depend on complementary groundwater-management rules, crop-choice guidance, community water budgeting, and treating the aquifer as a shared resource.

Therefore, Maharashtra's micro-irrigation policy illustrates the critical importance of aligning technological subsidies with social equity and environmental planning. Taken together, these patterns suggest a dual reality: farmers who could access and finance micro-irrigation did experience real gains in yields and incomes, but many poorer cultivators were excluded, and the collective water balance in villages often worsened. While the scheme achieved widespread

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

coverage and demonstrated strong on-farm benefits, it revealed how well-meaning subsidies can reinforce existing structural inequalities and unintentionally degrade shared resources. The reliance on digital platforms like MahaDBT streamlined disbursal but also excluded digitally and financially marginalized groups, who often lacked land titles or formal credit access. More broadly, the policy's failure to anticipate communal impacts–such as the drop in groundwater levels due to reduced aquifer recharge and increased irrigated acreage–underscores the need to design subsidies not just around individual efficiency gains but around basin-wide water resilience. Maharashtra's experience suggests that future irrigation policy must treat groundwater as a common-pool resource, explicitly accounting for collective ecological impacts, and must incorporate guardrails–such as usage caps, community-based water governance, or restrictions on water-intensive crops–to ensure long-term sustainability.

V. Case 2: Gujarat

a. Policy Framework & Subsidy Structure

Initiated in 2005–06, Jyotigram Yojana separated rural electricity feeders so that farm power supply could be rationed (typically 8–12 hours/day) while guaranteeing an uninterrupted 24-hour supply to households and industry. This required a capital investment of about $260 million (roughly ₹1,200–1,500 crore at the time) to rewire 18,000 villages and install high-voltage distribution (HVDS) transformers (NITI Aayog, 2023). Post-reform, agricultural consumers remained on a highly subsidized flat tariff, but the total volume of electricity consumed by farms fell sharply. State reports note that aggregate technical and commercial losses recovery improved, and agriculture subsidies were roughly halved relative to pre-reform levels.

Electricity reforms have been credited with multiple benefits: reliable power spurred rural enterprise and better services, even as farm supply became predictable. Crucially, rationing broke the open-access regime farmers had under a flat tariff (which had encouraged indiscriminate pumping). Empirical studies suggest reduced groundwater pumping: Shah et al. (2008) find that irrigation area initially contracted and diesel substitution rose as farmers could no longer pump 24×7, indicating less groundwater extraction. In effect, the regulated but higher-quality farm supply improved "optimum use of water" and aided conservation of groundwater. However, some negative impacts were noted, including that marginal and sharecropping farmers, who represent around 20-25 percent of all farmers (without electricity connections), lost access to purchased groundwater, prompting calls for targeted relief programs.

Overall, Jyotigram has been widely deemed a success in stabilizing Gujarat's power sector and curbing indiscriminate groundwater pumping. Evaluations by institutions such as the International Water Management Institute (IWMI), the World Bank, and the Planning

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Commission (now NITI Aayog) have praised the program for rationalizing rural electricity use while improving farm efficiency ("Impacts of water and energy sector reforms in Gujarat", 2018). Groundwater trends corroborate this assessment: satellite-based studies–such as those using NASA's GRACE data–show net gains in Gujarat's aquifers over 2003–2014 despite declining rainfall, a reversal analysts attribute to policy reforms including feeder segregation under Jyotigram.

Gujarat aggressively subsidizes micro-irrigation to promote water-efficient farming. Since 2005, the state and Centre have covered 50–70 percent of system costs. Subsidies are highest for small, tribal, or "dark zone" farmers: small/marginal farmers in dark areas get up to 80 percent of cost (capped at ₹80,000 or $964 per ha), while SC/ST farmers can receive up to 90–100 percent (₹1 lakh or $1,205 per ha max) (Viswanathan, Koundinya, & Fernandes, 2022). By 2014, about 640 thousand farmers had installed micro-irrigation on around 1 million hectares, with ~₹2,866 cr of subsidies disbursed (₹1,843 crore or $221.2 million from Gujarat, ₹1,023 cr or $122.76 million from central). The result has been a major shift: by 2014, roughly half the micro-irrigation area was drip and half sprinkler, covering high-value and staple crops alike.

b. Benefits to Agricultural Productivity

Viswanathan *et al.* (2022) report that among 650 sampled farmers, ~89 percent noted large yield gains and water savings after adopting micro-irrigation. About 61 percent reported lower groundwater use, and 55 percent reduced fertilizer/pesticide use. Savings in irrigation and pumping costs are widely documented. Higher yields and incomes resulted: smallholders irrigating with drip/sprinkler diversified into onions, vegetables, and export crops, roughly doubling net returns per hectare in some cases (Mukherji *et al.* 2010). In aggregate, Gujarat's farm productivity and irrigation efficiency have risen, complementing the "second Green Revolution" goal of the subsidy program.

The state spent thousands of crores on micro-irrigation alone by 2014, demonstrating the substantial trade-off and amount of government spending needed. Opportunities foregone include other rural investments or more targeted poverty relief. Critics note that richer farmers often capture more absolute subsidy, even if percentages favor the poor, and that many smallholders still cannot afford the unsubsidized portion of micro-irrigation for their full land. Nevertheless, the macro benefit – reduced aquifer drawdown – is clear. At the same time, evidence suggests that these benefits accrued disproportionately to middle-income farmers, who could afford the residual costs of drip systems, while the poorest–often land-fragmented or without pump connections–remained largely excluded from the gains. NITI Aayog notes that Gujarat's canal projects and watershed works, combined with micro-irrigation, have helped stabilize its water table relative to other arid states (NITI Aayog, 2023).

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

c. Environmental Impacts & Groundwater Depletion

Despite these gains, Gujarat's irrigation reforms have also led to unintended environmental stress. Feeder segregation, the separation of electricity supply for agricultural pumps from that for domestic and industrial users, combined with subsidized micro-irrigation, encouraged farmers to expand cultivation. This shift led to a greater focus on high-value, water-intensive crops in regions that had historically depended on limited monsoon recharge. While drip systems cut field-level water use, they also eliminated the "excess" percolation under flood irrigation that once replenished shallow aquifers, reducing return flows to nearby wells. Moreover, the fiscal backing of micro-irrigation without accompanying groundwater abstraction limits spurred a classic rebound effect: farmers expanded irrigated acreage and deepened borewells to exploit their full subsidy, driving down water tables in parts of Saurashtra and Kutch. In "dark zone" blocks, studies report that despite recharge structures, extraction remains above sustainable thresholds. Soil salinization and localized aquifer drawdown have followed in some command areas, signaling that technology-led efficiency alone cannot secure basin-wide water sustainability.

d. Equity Implications for Marginalized Farmers

Gujarat's farmers are predominantly smallholders. The 2015–16 Agricultural Census reports an average operational holding of only 1.88 hectares in Gujarat, well below India's 2.28 hectares in 1970-71, with 86 percent of holdings classified as marginal (<2 hectares)(Government of India, Ministry of Agriculture & Farmers' Welfare, 2019). This structure has emerged due to long-term trends of land fragmentation driven by inheritance customs, rising rural population pressure, and the absence of widespread land consolidation reforms. Additionally, past land redistribution efforts, while increasing equity, divided holdings among numerous self-cultivators. The state's semi-arid agro-climatic conditions have also encouraged diversified, small-scale farming, limiting the feasibility of large landholdings in many regions. Moreover, this land fragmentation means many recipients could only cover a few hectares under micro-irrigation even if they availed a subsidy. Electricity reforms similarly impacted predominantly those with pumps. Official data indicate that in the early 2010s, fewer than a quarter of Gujarat's smallest landholders, those owning under 1 ha, had electricity connections for agricultural use. For example, smaller farms (under 1 ha) accounted for approximately 55 percent of all farms in 2014, yet electricity subsidies and connections were predominantly captured by medium to large farmers, who represented only about 30 percent of holdings. This imbalance meant that Jyotigram and micro-irrigation subsidies functioned less as pro-poor interventions than as supports for middle-tier cultivators, reinforcing the divide between farmers with secure water access and those without. In socio-economic terms, Gujarat's farm population is wealthier than many states (the NSS Situation Assessment Survey shows higher incomes for comparable land

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

classes). Thus, many subsidy gains may have flowed to middle-income cultivators. Tribal districts (e.g., Dahod, Narmada) received special attention through higher subsidy rates, reflecting their lower resource base.

e. Evaluation

Gujarat’s integrated subsidy framework–feeder segregation under Jyotigram, generous micro-irrigation grants via GGRC/PMKSY, and large-scale groundwater recharge projects–has demonstrably improved power sector health, farmer incomes, and field-level water productivity, especially for cash crops like cotton, groundnut, and vegetables. Yet these policies have also reshaped cropping patterns toward more water-intensive agriculture, reduced natural aquifer recharge, and enabled a rebound in groundwater extraction that, in certain “dark zone” districts, continues to exceed sustainable limits. The case underscores that while targeted subsidies and infrastructure can curb indiscriminate pumping and boost yields, lasting water security demands enforceable groundwater governance, crop planning, and community-level resource management alongside technological interventions.

Gujarat’s experience demonstrates the potential of combining infrastructural and institutional reforms to improve water-use efficiency without entirely abandoning agricultural subsidies. The state's policies–especially the Jyotigram Yojana and targeted micro-irrigation subsidies–show that rationed electricity, when paired with technological support and tailored incentives, can significantly reduce indiscriminate groundwater extraction and improve farm productivity. Importantly, Gujarat’s reforms restructured the incentives farmers face, shifting from open-ended free inputs to conditional support tied to efficiency and conservation. However, the case also highlights the unintended consequences of such reforms, including increased cultivation of water-intensive cash crops and a rebound effect in groundwater extraction in vulnerable regions. These outcomes reveal that while micro-irrigation can enhance field-level efficiency, it must be embedded within a broader regulatory framework that governs total water withdrawal. Gujarat’s policy model offers important lessons: subsidies should be performance-oriented and spatially targeted, infrastructure should be coupled with monitoring, and environmental safeguards must anticipate behavioral adaptations. In sum, Gujarat’s reforms were quite successful in reducing wasteful pumping, stabilizing the power sector, and raising farm incomes, but they did not fully resolve the equity challenge: the poorest farmers–often those most vulnerable to water stress–benefited least from the state’s ambitious reforms. The state exemplifies a middle path where state support remains substantial but is structured to nudge farmers toward more sustainable practices–an approach that could inform irrigation subsidy reforms in similarly water-stressed regions.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

VI. Case 3: Punjab

a. Policy Framework & Subsidy Structure

Punjab's policy of providing free electricity for agricultural tube wells, introduced in January 1997, was driven by a combination of political strategy and ground realities related to climate, rural livelihoods, and farmer finances. Initiated by Chief Minister Rajinder Kaur Bhattal, the scheme initially targeted farmers with up to seven acres of land, but was quickly expanded by her successor, Parkash Singh Badal, to include all farmers regardless of landholding size. This expansion was seen as the most viable option due to several pressing factors. Punjab's semi-arid climate and declining rainfall patterns made irrigation essential for crop survival, particularly for water-intensive crops like paddy. The widespread adoption of tube wells during the Green Revolution had made electricity a vital input for sustaining agriculture. Moreover, a large portion of Punjab's population resided in rural areas and depended directly on agriculture for their livelihood. With input costs rising and crop prices often stagnant, many farmers were trapped in cycles of debt and financial insecurity. Free electricity was seen as an immediate relief and a way to prevent further agrarian distress. Politically, the move helped consolidate rural support, while economically, it was framed as a necessary subsidy to maintain food security and stabilize farmer incomes in a time of mounting stress. Since 1997, any registered agricultural pump set in Punjab has been entitled to free electricity, making irrigation power entirely subsidized by the state. While earlier policies required larger farmers to pay a flat fee per horsepower, these charges were gradually phased out and fully abandoned by 2005.

Today, all agricultural electricity usage is billed directly to the state government via the Punjab State Power Corporation Ltd (PSPCL), with farmers bearing no cost. Various reform proposals–such as those by the Punjab State Farmers' and Farm Workers' Commission in 2013 and 2018 to limit free power by landholding size (e.g., 4–10 hectares) or income–have never been implemented. Punjab's subsidy stands out nationally not only for its comprehensiveness but also because the state's own electricity supply cost is relatively low: in FY 2020–21, Punjab's average cost of electricity was ₹5.70 ($0.074) per kWh compared with an all-India average of ₹6.20 ($0.068) per kWh. This lower base cost helped make full farm-power subsidies politically and economically more viable, alongside Punjab's high groundwater-based irrigation needs, the strong influence of its farming community, and limited surface-water availability.

b. Benefits to Agricultural Productivity

Under the current structure, Punjab provides untimed, unmetered electricity to the agriculture sector by default. According to the Punjab State Power Corporation Ltd (PSPCL) and state regulators, "supply to agriculture tube wells is free as per policy of the Government" (Punjab

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

State Power Corporation Ltd [PSPCL], 2025). While bulk charging was briefly reintroduced between 2002–05 (at ₹60 or $0.72 per BHP per month) and again for a short period in 2010 (₹50 or $0.6 per BHP per month), free power was quickly reinstated. In effect, Punjab has fully abandoned metering and tariffs for irrigation: the subsidy simply reflects the unpaid cost of supplying electricity to these pump sets. Over the years, authorities have occasionally floated reforms–such as capping the number of free units, charging only large or non-marginal farmers, or using direct cash transfers–but these have never been implemented. A major reason is political: after nearly three decades of uninterrupted free electricity, any attempt to reintroduce charges, however limited, faces immediate backlash from the influential farming community. Charging farmers for something they have come to see as a right–not a subsidy–has proven politically unpopular across party lines. As a result, since 1997, Punjab's policy has consistently granted free grid electricity to all agricultural pump sets, with no current limits based on landholding size, usage level, or pump capacity.

The subsidy cost of free farm power is enormous and has grown steadily. PSPCL reports that between January 1997 and FY 2023–24, it supplied ₹1,23,904 crore ($14.86 billion USD) in cumulative power at no charge to agriculture (Tribune India, 2023). State budget documents indicate that nearly half of Punjab's power subsidy now goes to farmers: for FY 2024–25, about ₹10,000 crore ($1.2 billion USD) is earmarked for agricultural electricity, which is around 45–49% of the total subsidies. The burden has risen dramatically: annual agri-power subsidy was only ₹604.5 crore ($72.8 million USD) in 1997–98, but climbed to over ₹10,000 crore ($1.2 billion USD) by FY2022–23 (PSPCL, 2025). As of 2025, nearly 10 percent of Punjab's state budget is consumed by power subsidies (agriculture plus other categories). Economic analysts warn that this burden is crowding out other spending as debt has risen partly due to rising subsidy outlays.

Meanwhile, irrigation electricity consumption soared: in 1997–98, Punjab's farms used 6,049 million units (MU), which rose to ~11,226 MU by 2018–19. Recent reports project agricultural consumption on the order of 12,000–13,000 MU per year. Every year, farmers pump vast volumes of groundwater with these electric pumps, enabled by the no-cost power. Because the supply is not metered, the recorded use is effectively the power billed to the government (often estimated or aggregated). Moreover, regulators have flagged data issues: a 2014 PSERC audit accused PSPCL of "fudging" figures, potentially inflating the subsidy claim by ~₹1,000 crore ($120.5 million USD) during 2010–2015 PSPCL (2025). Despite these technical issues, the clear trend is one of widespread adoption of tube-well irrigation under cheap power, with no observed cap or phase-out in sight.

c. Environmental Impacts & Groundwater Depletion

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Punjab's flat power subsidy has greatly distorted water use. With nearly costless electricity, farmers have little incentive to conserve water: inefficiencies prevail. On average, 3,500–4,000 liters of groundwater are needed to produce 1 kg of paddy in Punjab ("Maximizing water use efficiency in rice farming", 2022). This inefficiency has fueled acute groundwater depletion. In central Punjab, the water table is falling by roughly 1 meter per year on average. Statewide, 97 percent of groundwater extraction goes to irrigation, almost all of it pumped electrically. Surveys and tribunal data in 2022 indicate that 119 of 138 blocks (86 percent) are over-exploited in Punjab (extraction exceeding recharge), including 60 blocks where extraction is 201–300 percent of sustainable recharge. Experts warn that if the current pumping continues, Punjab may exhaust its usable groundwater within a few decades. The NGT estimated Punjab could be virtually dry by 2039 under business-as-usual extraction (National Green Tribunal, 2024). In short, free power has encouraged profligate pumping – farmers commonly use flood irrigation and high-capacity pumps rather than water-saving methods.

Punjab's electricity subsidy has had major environmental side effects beyond groundwater. The policy entrenched the rice–wheat cropping cycle, which leaves abundant paddy straw each autumn. Unable or unwilling to invest in expensive residue management, farmers typically burn this stubble. As one analysis notes, Punjab accounts for over 21 million tons of rice straw burnt each year in north India (Earth Observatory, 2014). In fact, most stubble-burning incidents in late autumn originate in Punjab and neighbouring Haryana. The practice contributes heavily to regional air pollution as seen by Punjab's average annual PM25 concentration increasing from 47.3 µg/m³ in 1998–shortly after the subsidy began–to 70.9 µg/m³ in 2020, an increase of nearly 50 percent. It's unclear exactly how much of this deterioration is due to rice-straw burning versus other sources, but it is safe to conclude that stubble burning significantly exacerbates already poor air quality.

d. Equity Implications for Marginalized Farmers

Punjab's free-power policy is widely seen as regressive. Studies show that better-off farmers gain most of the subsidy, while marginal farmers accrue little direct benefit. A government report noted that "the facility is being availed of not only by the small and marginal farmers, but even big farmers," burdening the exchequer. An expert commission bluntly labeled the policy "highly regressive," pointing out that a disproportionate share of free power goes to large farms (which often operate higher-HP pumps and multiple wells). Indeed, the average subsidy per connection varies widely by region and pump size: in over-exploited blocks, farmers pay for bigger motors and consume more units, receiving subsidies up to ~₹90,000 ($1,085) per year per pump (vs a ₹54,000 or $650 USD statewide average in 2022–23). In contrast, smallholders with single small pumps may use far less power (and some even operate without official connections), so the subsidy's impact on their incomes is smaller. In practice, this means a marginal farmer with a

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

single 5-horsepower pump might save only ₹5,000–₹7,000 annually–a small fraction of household income. By contrast, a large farmer with multiple 15-horsepower pumps can capture subsidies worth several lakh rupees a year, effectively converting free electricity into a state-financed transfer many times larger than what marginal farmers receive. The net result is that free power has exacerbated inequalities in agriculture, channeling state funds into the most resource-rich farms.

e. Evaluation

Critics argue that Punjab's electricity subsidy comes at a steep social and fiscal cost, offering limited and uneven benefits in return. The state spending on farm power subsidies are resources that, many contend, could be more effectively used for direct income support to all farmers, water conservation initiatives, drip irrigation systems, or crop diversification programs. As economist S.S. Johl noted, free power has led to rampant groundwater overuse with minimal long-term benefits for small or marginal farmers beyond what broader agricultural policy already provides (The Tribune, 2017). Moreover, the subsidy creates economic distortions: by reducing farmers' production costs artificially, it inflates grain output, leading to lower market prices nationally. While consumers outside Punjab may benefit from cheaper rice and wheat, the burden of financing this de facto price subsidy falls entirely on the Punjab government. This imbalance means the state is not recovering the economic value of the electricity it supplies, leading to inefficient resource use and unsustainable fiscal stress and highlighting a fundamental pricing failure.

There is a clear opportunity cost: every rupee spent on free power could have been used for critical public services such as education, healthcare, rural infrastructure, or more targeted and progressive forms of farm support. Punjab's mounting debt–projected to reach ₹5 lakh crore ($60.24 billion) by 2027–is partly driven by such unsustainable subsidies. For instance, Punjab's government school system continues to face severe teacher shortages, under-resourced facilities, and poor learning outcomes, especially in rural areas. Redirecting even a portion of the annual power subsidy could significantly improve school infrastructure, hire qualified teachers, and implement quality learning programs, helping break intergenerational cycles of poverty. But despite any solutions, the continuation of free power is effectively assured by current politics: in July 2024, Chief Minister Mann explicitly stated he will "not touch" farm electricity subsidies (HealthPolicyWatch, 2022). This is due to it being politically sensitive, as such a move would be unpopular. Moreover, a sudden withdrawal after decades of dependence would be detrimental to farmers' livelihoods.

The main takeaway from Punjab's experience is that unconditional, unmetered subsidies–while politically expedient–can create deep structural inefficiencies that are costly both fiscally and

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

environmentally. The policy of free electricity has incentivized unchecked extraction of groundwater and reinforced ecologically harmful crop choices, while offering disproportionate benefits to larger landowners. A critical policy lesson is the need to avoid giving inputs like electricity or water entirely for free.

VII. Discussion

The central lesson from this comparative analysis is that while each state's agroclimatic and political context demands a tailored subsidy design, blanket input subsidies consistently generate long-term ecological and social harm, whereas conditional and performance-based models provide the clearest path toward balancing farmer support with sustainability. Irrigation subsidies in Maharashtra, Gujarat, and Punjab have undoubtedly driven productivity and accelerated the adoption of water-saving technologies, but they also reveal the critical risks of treating resource efficiency and equity as secondary concerns. The agroclimatic, economic, and political contexts of each state influenced how they tackled the irrigation problem, but none of them were able to achieve real sustainability without making trade-offs. Punjab's universal free electricity delivered short-term agricultural security and political support but triggered chronic groundwater depletion and entrenched inefficient cropping patterns. Gujarat's integrated reforms, including feeder segregation, micro-irrigation subsidies, and aquifer recharge, offer a more balanced and structured approach, though still vulnerable to rebound effects and groundwater stress. Maharashtra's PMKSY-led drip and sprinkler push showed how direct subsidies paired with digital governance could reduce leakage and increase transparency, but also how the absence of strong groundwater governance and equity mechanisms can leave marginalized farmers behind and strain aquifers through unintended overuse.

Among these, Gujarat stands out as the state that best aligns policy ambition with local environmental constraints. The Jyotigram Yojana's feeder segregation tackled the root cause of open-access over-pumping and created space for complementary reforms like high subsidies in "dark zones" and substantial investments in water-harvesting infrastructure. Unlike Punjab, where electricity remains unmetered and unaccounted for, Gujarat's power regulation allowed for a predictable farm supply while curbing wasteful use. Maharashtra's reforms, while promising in intent, were limited in depth–its drip irrigation expansion was impressive, but the lack of enforcement mechanisms and social safeguards left the ecological benefits thin and equity gaps wide. Punjab, by contrast, is an example of how populist subsidies without checks—no targeting, no pricing, no monitoring–can drive systemic environmental degradation and fiscal imbalance, even as they support farm livelihoods.

Each subsidy model reflects its regional logic. In arid Gujarat, separating farm power and regulating access addressed energy-water linkages head-on. In semi-arid, drought-prone

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Maharashtra, high subsidies for precision irrigation were appropriate to offset adoption costs, but needed stronger institutional scaffolding. In Punjab, the original rationale for free electricity–to support grain production and rural incomes during the Green Revolution–may have been justified decades ago, but has outlived its ecological and economic relevance. The critical takeaway is that subsidies must not be static entitlements; their structure must evolve with regional realities, and must be matched with crop planning, usage caps, and pricing reforms. Taken together, these cases suggest that India's future irrigation policy cannot rely on static entitlements. The most promising direction lies in adaptive, conditional subsidies–linking support to measurable outcomes such as groundwater recharge, crop diversification, or efficiency gains–rather than unconditional input subsidies.

Had these policies not existed, outcomes would have diverged. Without Maharashtra's drip subsidies, many farmers–especially in drought-prone Vidarbha–would lack access to water-efficient technologies altogether, worsening rural distress and yield gaps. In Gujarat, absent Jyotigram and MIS support, unchecked pumping under a flat tariff would likely have pushed more regions into critical aquifer stress, leading to long-term declines in productivity. Punjab's counterfactual, however, may offer the most telling lesson: without free electricity, the state might have avoided much of the ecological damage now threatening its agricultural future. Crop patterns could have diversified earlier, electricity costs would be more manageable, and water tables might not be collapsing. While farmers may have experienced some short-term financial strain, targeted support could have substituted for blanket subsidies, protecting the most vulnerable without inducing environmental collapse.

VIII. Conclusion

In summary, the evidence suggests that no single policy is universally superior, but Gujarat's integrative and adaptive approach stands out as the most effective relative to its goals and constraints. The broader lesson is clear: irrigation subsidies must be dynamic, data-informed, and regionally tailored. Efficiency without governance leads to rebound; equity without monitoring leads to elite capture. Future reforms must pair subsidies with enforceable groundwater limits, incentives for sustainable crops, and systems that recognize water as a shared resource. If subsidies are to support both farmer resilience and environmental sustainability, they must be conditional, monitored, and recalibrated–turning short-term gains into long-term security. In practice, this means phasing out universal free power and moving toward Gujarat-style supply regulation combined with performance-based payments, so that public funds reward sustainable use rather than subsidize depletion.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

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