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Cropping Pattern Variations under Canal and Tubewell Irrigation: A Study in Telangana

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Abstract:
Irrigation source shapes what Telangana's farmers grow, yet canal and tubewell systems are rarely compared directly. This paper examines cropping pattern variations under canal and tubewell irrigation in Telangana using secondary data from the Telangana State Micro Irrigation Project, an Agro-Economic Research Centre field study, district irrigation statistics for 2023–24 and recent peer-reviewed studies. Source-wise net irrigated area, crop-wise tubewell micro-irrigation coverage, district contrasts and the paddy expansion of 2014–15 to 2024–25 are analysed through shares, absolute change and growth rates. Between 1991–92 and 2014–15, tubewells raised their share of net irrigated area from 5.5 to 54.9 per cent, while canals fell from 22.0 to 10.1 per cent. Tubewell-irrigated holdings carry a wider crop mix, with chillies, tomatoes, cotton, oilseeds, mango and turmeric making up most micro-irrigated area, whereas canal and lift-irrigated commands show rapid paddy concentration, including a Rabi rice surge after Kaleshwaram. Yet assured water from either source has recently pushed paddy to roughly 127 lakh acres across both seasons of 2024–25, while falling water tables in well-fed districts show how exposed that pattern is. The paper argues that source-specific water governance, not irrigation expansion alone, decides whether irrigation diversifies or simplifies cropping, and proposes volumetric canal scheduling, aquifer-sensitive crop planning and market support for profitable alternatives to paddy across Telangana's major irrigated districts.

Keywords: cropping pattern; canal irrigation; tubewell irrigation; crop diversification; paddy; groundwater; Telangana

1. Introduction

Water, more than land, decides what Telangana can grow. The state covers about 114,800 square kilometres on the Deccan Plateau, only 40.5 per cent of which is net sown area, and its agriculture still depends on the south-west monsoon even though the Godavari and Krishna rivers flow through it (Rambabu, 2017). Irrigation is therefore the main lever through which public investment and private enterprise reshape cropping decisions. Two sources dominate the story. Canals, including the surface and lift systems fed from reservoirs and rivers, are publicly built and managed. Tubewells are privately owned borewells that now supply most of the state's irrigation.

The balance between the two has changed dramatically. Between 1956 and 2009 Telangana lost 2.92 lakh hectares of tank irrigation, while the area irrigated by tubewells kept growing despite high capital

and operating costs (Pingle, 2011). Canal irrigation also contracted from its earlier peaks, and wells became the principal source (Rambabu, 2017). After 2014 the state invested heavily in lift schemes, tank restoration and new projects. The Socio Economic Outlook reported that gross irrigated area rose from 62.48 lakh acres in 2014–15 to 135 lakh acres in 2021–22 (Telangana Today, 2023).

Cropping patterns moved with the water. Press reports based on state agriculture department figures put paddy area at about 35 lakh acres in 2014–15, and paddy production rose from 68.17 lakh tonnes then to 270.88 lakh tonnes in 2023–24 (Telangana Today, 2025). In 2024–25 paddy covered about 66.7 lakh acres in Kharif and about 60 lakh acres in Rabi (The South First, 2024; Press Trust of India, 2025). Such headline figures hide an important question: does the source of irrigation change what farmers plant? A canal delivers water on a schedule set by the irrigation department, at low marginal cost to the farmer, over a large command. A tubewell delivers water on demand, at the farmer's own cost of electricity, drilling and risk, from a shrinking aquifer. These differences in reliability, cost and control should translate into different cropping choices, and the evidence from Telangana suggests that they do. Peddi and Reddy (2023) found that surface irrigation lowered the likelihood of diversification relative to rain-fed conditions, because surface-irrigated farmers shifted towards paddy, while irrigation that improved the groundwater table made diversification more likely.

Studies of Telangana's cropping pattern have mostly treated irrigation as a single explanatory variable, or have examined rice expansion without separating the sources of water that sustain it. This paper fills part of that gap by setting canal and tubewell irrigation side by side. It has four objectives:

1. To trace the shift in source-wise net irrigated area in Telangana since 1991–92.
2. To describe the cropping patterns associated with tubewell and canal irrigation.
3. To compare crop diversification, seasonal intensity and the sustainability implications of the two sources.
4. To suggest policy measures that align irrigation sources with sustainable cropping.

Two working hypotheses guide the analysis. H1: canal-irrigated areas show a stronger concentration on paddy than tubewell-irrigated areas. H2: tubewell irrigation supports a wider mix of commercial and horticultural crops, but it also carries a groundwater cost and, where power supply and procurement support exist, it too can lock farmers into Rabi paddy.

The paper proceeds as follows. Section 2 reviews the literature. Section 3 describes the data and method. Sections 4 to 6 present the irrigation profile, the cropping pattern variations and the canal–tubewell comparison. Section 7 discusses the findings and policy implications, and Section 8 concludes.

2. Review of Literature

The literature on irrigation and cropping in Telangana falls into three strands: the historical shift from surface to groundwater irrigation, empirical studies of cropping pattern change, and recent work on irrigation-led rice expansion.

From tanks to tubewells. Pingle (2011) traced the rise and fall of tank irrigation in Telangana and showed that, over 1956–2009, tanks lost 2.92 lakh hectares while tubewell area rose despite high costs. He concluded that irrigation policy must balance surface and groundwater locally, because, in his words, all irrigation is local. Vakulabharanam (2004, as cited in Rambabu, 2017) linked the rapid growth of well irrigation to the impoverishment of small and marginal cultivators, since the costs and risks of borewells fall most heavily on them. Hanumantha Rao (2014, as cited in Rambabu, 2017) argued that

reducing excessive dependence on wells, by renovating tanks and harvesting river water, would lower farm costs and uncertainty. These contributions establish that the source of water is itself a development issue, not only a technical one.

Cropping pattern change. Madhurima et al. (2022) studied combined Andhra Pradesh, including Telangana, over 1970–2020. They found that tank irrigation declined twofold while groundwater extraction increased fivefold, that coarse cereals lost ground, and that mono-cropping or double cropping of rice, followed by cash or pulse crops, emerged under both groundwater and canal systems. In Karimnagar district, Devi et al. (2020) applied a Markov chain to data for 1966–67 to 2016–17 and found that no crop group retained its area, with cereals relatively stable and area moving towards cotton and turmeric. Village-level evidence from Mahbubnagar shows how sharply patterns can differ within one district: in 2013, BT cotton covered 89 per cent of Kharif area in Aurepalle while Rabi paddy reached 100 per cent, whereas in Dokur paddy covered 69 per cent of Kharif area and groundnut 34 per cent of Rabi area, alongside paddy at 65 per cent (International Crops Research Institute for the Semi-Arid Tropics [ICRISAT], n.d.).

Irrigation-led rice expansion. Peddi and Reddy (2023) surveyed 700 farmers across 12 districts and 24 villages and found that surface irrigation was associated with less diversification, because farmers moved towards paddy, whereas new irrigation that raised the groundwater table increased the likelihood of diversification and improved farm profits (Shagun, 2024). The same reporting notes that the state-level crop diversification index has stayed low, at about 0.27, over several decades, and that farm incomes were 21 per cent higher in newly irrigated regions than in surface-irrigated ones. Using Sentinel-2 satellite data for twelve districts of the Kaleshwaram command, Panjala et al. (2024) documented a large shift towards rice, with Rabi rice area rising by 82.1 per cent, from 313,929 to 571,632 hectares, between 2018–19 and 2022–23. Crop water requirement in the same districts rose by about 54 per cent, from 3.22 to 4.97 billion cubic metres, with the steepest increases in Medak (234.2 per cent), Nalgonda (157.3 per cent) and Siddipet (120.1 per cent).

Research gap. These studies agree that irrigation expansion and paddy expansion are linked. What is missing is a direct, source-wise comparison that asks how the cropping pattern differs when the water comes from a canal rather than a tubewell. Official statistics rarely cross-tabulate crop area by irrigation source, so the comparison must be assembled from several datasets. This paper attempts that assembly and states its limits openly.

3. Study Area, Data and Methodology

Study area. The study covers Telangana State, formed on 2 June 2014, which spans 114,800 square kilometres and is drained mainly by the Godavari and Krishna with the Manjira, Bhima and Musi as minor rivers (Rambabu, 2017). Net sown area is 40.5 per cent of the geographical area, forests take 23.9 per cent and current fallows 10.5 per cent (Rambabu, 2017). Rainfall is variable, and districts such as Adilabad, Rangareddy, Mahabubnagar and Medak have historically had low irrigation intensity.

Nature of data. The paper is based entirely on secondary data, assembled from five sources. First, source-wise net irrigated area for 1991–92 to 2014–15 comes from the Telangana State Micro Irrigation Project as reproduced in Rambabu (2017, Table 2.5). Second, crop-wise coverage of micro-irrigation, which in Telangana is installed almost entirely on tubewell and borewell sources, comes from the same report (Table 3.7) and serves as an indicator of the cropping pattern of tubewell-irrigated holdings.

Third, sample-household irrigation shares come from the report's field survey of 200 beneficiary and 100 non-beneficiary farmers in Vikarabad, Adilabad, Nirmal and Nalgonda districts (Table 4.6). Fourth, district-wise gross irrigated area for 2023–24 by canal and well is drawn from the Ministry of Agriculture and Farmers Welfare dataset hosted on Dataful. Fifth, recent paddy area up to Rabi 2024–25 is taken from state agriculture department figures reported in the press, groundwater status from the Central Ground Water Board's 2024 assessment, and cropping shifts from peer-reviewed studies.

Method. The analysis is descriptive and comparative. Shares of each source in net irrigated area are calculated as the source's area divided by the total for the year. Absolute and percentage changes are computed between 1991–92 and 2014–15. Log-linear growth rates are those reported by Rambabu (2017) for 1991–92 to 2014–15. For crop-wise tubewell data, the share of each crop in total micro-irrigated area is computed. District contrasts use the share of canal or well area in gross irrigated area. Diversification is discussed through the crop shares and through the diversification index reported by Peddi and Reddy (2023) as cited in Shagun (2024).

Limitations. Three limits qualify the findings. Official statistics do not cross-tabulate crop area by irrigation source, so tubewell cropping is inferred from micro-irrigation coverage, which is a subset of tubewell area and tilts towards horticulture because of subsidy design. Net irrigated area series fluctuate sharply with rainfall, so single-year comparisons, such as the fall between 2013–14 and 2014–15, should be read with care. Finally, press-reported paddy figures come from different reporting bases, and the Kharif 2024 and Rabi 2024–25 totals differ across sources, which is noted where relevant. The data run only to Rabi 2024–25, because the Kharif 2025 crop was still being sown at the time of writing. The results are therefore an evidence-based triangulation, not a causal estimate.

4. Irrigation Profile of Telangana: The Canal–Tubewell Shift

Net irrigated area in Telangana grew unevenly after 1991–92 and, more importantly, changed in composition. Table 1 gives source-wise net irrigated area for selected years, and Table 2 converts it to shares. Total net irrigated area rose from 14.74 lakh hectares in 1991–92 to a peak of 24.50 lakh hectares in 2012–13, then fell to 20.08 lakh hectares in 2015–16, a fluctuation Rambabu (2017) attributes to deficient or inadequate rainfall.

Table 1. Net area irrigated by source in Telangana, selected years (hectares)

Year	Canals	Tanks	Tube wells	Other wells	Other sources	Total
1991–92	324,670	368,126	81,130	638,477	61,741	1,474,144
2000–01	300,261	269,492	463,390	588,884	60,351	1,682,378
2005–06	263,422	253,855	621,264	476,136	53,098	1,667,775
2010–11	237,968	315,754	881,918	513,688	54,659	2,003,987
2013–14	289,823	229,561	1,082,435	630,118	57,395	2,289,332
2014–15	173,688	96,780	948,001	465,095	42,739	1,726,303

Source: Rambabu (2017, Table 2.5), based on data from the Telangana State Micro Irrigation Project, Hyderabad.

The composition changed far more than the total. In 1991–92 canals and tanks together supplied 47.0 per cent of net irrigated area and tubewells only 5.5 per cent. By 2014–15 tubewells alone supplied 54.9 per cent, and tubewells plus other wells supplied 81.9 per cent.

Table 2. Share of each source in net irrigated area, Telangana (per cent)

Year	Canals	Tanks	Tube wells	Other wells	Tube wells + other wells
1991–92	22.0	25.0	5.5	43.3	48.8
2000–01	17.8	16.0	27.5	35.0	62.5
2005–06	15.8	15.2	37.3	28.5	65.8
2010–11	11.9	15.8	44.0	25.6	69.6
2013–14	12.7	10.0	47.3	27.5	74.8
2014–15	10.1	5.6	54.9	26.9	81.9

Source: Author's calculation from Rambabu (2017, Table 2.5). Shares do not add to 100 because "other sources" are omitted.

Table 3 makes the scale of the shift explicit. Tubewell area grew more than tenfold between 1991–92 and 2014–15, adding about 8.67 lakh hectares, while canal area shrank by almost half and tank area by nearly three-quarters. The log-linear growth rates reported by Rambabu (2017) confirm the direction: tubewell area grew at 7.60 per cent a year over 1991–92 to 2014–15, while canals declined at 1.02 per cent and tanks at 1.76 per cent. The decline of the older sources is tied to disrepair of tanks and failure of wells and other sources in dry years, which is also why Mission Kakatiya was designed to restore 46,300 tanks (Rambabu, 2017).

Table 3. Change in net irrigated area by source, 1991–92 to 2014–15

Source	Area 1991–92 (ha)	Area 2014–15 (ha)	Change (ha)	Change (%)	Log-linear growth, 1991–92 to 2014–15 (% a year)
Canals	324,670	173,688	−150,982	−46.5	−1.02
Tanks	368,126	96,780	−271,346	−73.7	−1.76
Tube wells	81,130	948,001	+866,871	+1,068.5	7.60
Other wells	638,477	465,095	−173,382	−27.2	−0.85
All sources	1,474,144	1,726,303	+252,159	+17.1	2.05

Source: Author's calculation from Rambabu (2017, Table 2.5); growth rates as reported there.

Two features of this profile matter for cropping. First, irrigation intensity is modest. Between the triennia 2010–13 and 2013–16, intensity of irrigation was 137.9 and 140.5 per cent, and cropping intensity fell from 125.56 to 122.08 per cent, because water was inadequate for a substantial second crop (Rambabu, 2017). Second, the groundwater economy is large but only partly efficient. Of 17.12 lakh hectares of net area irrigated by borewells, only 5.73 lakh hectares had been brought under micro-irrigation by 2015–16

(Rambabu, 2017). Tubewell farmers therefore bear both the cost of lifting water and, in many cases, the loss of applying it by flooding.

Since 2014 the canal side of the ledger has been rebuilt through lift schemes. The Kaleshwaram project alone is reported to have a 1,800 km canal network serving an 18.25 lakh acre command across 13 districts (The South First, 2025), although its operation has been disrupted since the 2023 failure of piers at the Medigadda barrage. The 2014–15 figures in Table 1 therefore describe the starting point of a second phase in which canal and lift irrigation expanded again, which Sections 5 and 6 examine through cropping outcomes.

5. Cropping Pattern Variations in Telangana

5.1 Crops on tubewell-irrigated holdings. Because micro-irrigation in Telangana is installed almost entirely on borewell and tubewell sources, its crop-wise coverage is the best available window into the cropping pattern of tubewell farms (Rambabu, 2017). Table 4 shows that the pattern is strongly commercial and horticultural. Green chillies, tomatoes, oilseeds, cotton, sugarcane, mango, maize, turmeric, pulses and acid lime together account for 87.2 per cent of the 39,857 hectares covered in 2015–16. Chillies alone take one-fifth, and vegetables and fruits dominate the remainder.

Table 4. Crop-wise area under micro-irrigation (tubewell-based), Telangana, 2015–16

Crop	Area (ha)	Share of total (%)
Green chillies	7,956	20.0
Tomatoes	5,687	14.3
Oilseeds	4,937	12.4
Cotton	4,104	10.3
Sugarcane	3,233	8.1
Mangoes	2,974	7.5
Maize and baby corn	2,402	6.0
Turmeric	2,342	5.9
Pulses	572	1.4
Acid lime	566	1.4
All other crops	5,086	12.8
Total	**39,857**	**100.0**

Source: Author's calculation from Rambabu (2017, Table 3.7), based on Telangana State Micro Irrigation Department data. Drip and sprinkler areas are combined.

This table must be read with caution. Micro-irrigation subsidies were designed around drip for cotton and horticulture and sprinklers for groundnut, so the table over-represents high-value crops and says little about flood-irrigated paddy under borewells. Even so, it shows that tubewell farmers have access to a diverse set of crops, and the evidence on behaviour supports that reading. Beneficiary households in the Agro-Economic Research Centre survey showed a 9.50 per cent decline in Kharif area and a 420.95 per cent increase in Rabi area relative to non-beneficiaries, which means that assured on-farm water, once stretched by micro-irrigation, mainly opens up the second season (Rambabu, 2017). Drip systems saved 49 to 54 per cent of water across tomato, vegetables and sugarcane and raised yields by 15 to 60 per cent depending on the crop (Rambabu, 2017).

5.2 The long-run drift. Over a longer horizon, diversification at the farm has not become diversification across the state. Peddi and Reddy (2023), cited in Shagun (2024), report that the proportions of major cereals, commercial crops, fruits and vegetables increased between 1966 and 2017, while pulses, oilseeds and millets fell, and that the state-level diversification index has remained near 0.27. Reserve Bank of India data cited by the Deccan Chronicle (2024) show paddy, cotton and maize covering 48.56 lakh of 62.73 lakh hectares of agricultural land, or 77.4 per cent, with pulses area falling from 5.6 to 3.3 lakh hectares. In Karimnagar, area moved from cereals to cotton and turmeric over five decades (Devi et al., 2020), and for combined Andhra Pradesh chilli area under irrigation grew by 93 per cent as coarse cereals lost prominence (Madhurima et al., 2022).

5.3 The paddy surge. The decisive change since 2014 has been the spread of paddy under assured water. Table 5 assembles the available figures. They come from different reporting bases and are not strictly comparable, so they are best read as indicating direction and order of magnitude. Paddy area rose several-fold, the Rabi crop reached about 54 lakh acres in 2023–24, some 160 per cent above the normal Rabi area (Telangana Today, 2024a), and the Yasangi crop holiday declared on the Nagarjuna Sagar left canal in 2024 shows how exposed the pattern is to water shocks (Telangana Today, 2024b).

Table 5. Paddy area in Telangana, selected periods (lakh acres)

Period	Paddy area	Basis
2014–15 (both seasons)	about 35	Press report of state agriculture data (Telangana Today, 2025)
Rabi 2023–24 (Yasangi)	about 54	Telangana Today (2024a); reported as 160 per cent above the normal Rabi area
Kharif 2023	65.9	The South First (2024)
Kharif 2024	66.7	The South First (2024); The South First (2025) reports 60.39 on a different basis
Rabi 2025 (Yasangi)	60.14	Press Trust of India (2025), a record; The South First (2025) reported 58.73 on 30 April and gave Rabi 2024 as 64.5
2024–25 both seasons	about 126.8	Derived: Kharif 2024 (66.7) plus Rabi 2025 (60.14)

Note: The sources differ in definition and timing: the 2014–15 figure is a press-reported approximation, the Rabi 2025 figures were reported before procurement ended, and the Rabi 2023–24 and Rabi 2024 areas (about 54 and 64.5 lakh acres) differ across outlets. Treat the series as directional.

The state government reports that Rabi paddy in 2024–25 covered a record 60.14 lakh acres, with procurement of about 49.5 lakh tonnes by mid-May (Press Trust of India, 2025). Rabi paddy is normally limited by water, so this scale itself is evidence that assured irrigation, from reservoirs, lift schemes and

borewells recharged by good monsoons, now underwrites a second paddy crop. Groundwater is feeling the strain. The Central Ground Water Board (2024) puts Telangana's overall stage of groundwater extraction at 45.91 per cent, but 32 of 620 assessment units (mandals) are over-exploited, 13 critical and 85 semi-critical. In Nalgonda, depth to groundwater in January rose from 5.27 metres in 2023 to 8.68 metres in 2024 (Telangana Today, 2024b).

6. Canal versus Tubewell: A Comparison of Cropping Outcomes

6.1 District contrasts. Telangana's leading rice districts include both canal-fed and well-fed cases, which allows a rough comparison. Table 6 sets 2023–24 gross irrigated area by source against the change in crop water requirement between 2018–19 and 2022–23 reported by Panjala et al. (2024) for districts of the Kaleshwaram command, as rice spread. Suryapet is mainly canal-irrigated, with government canals covering 70.1 per cent of its gross irrigated area. Nalgonda and Siddipet are mainly well-irrigated, with wells covering 86.9 and 91.0 per cent.

Table 6. Dominant irrigation source and recent cropping pressure in three leading rice districts

District	Gross irrigated area, 2023–24 (ha)	Largest source recorded	Area under that source (ha)	Share of gross irrigated area (%)	Water demand change (%)	Other evidence
Nalgonda	433,886	Wells (tubewells 373,852)	376,949	86.9	+157.3	Canal ayacut crop holiday, Yasangi 2024
Suryapet	390,100	Governme nt canals	273,630	70.1	Not assessed	Not available
Siddipet	327,939	Wells	298,415	91.0	+120.1	Not available

Source: Ministry of Agriculture and Farmers Welfare (n.d.) for irrigated area; Panjala et al. (2024) for water demand, defined as the change in crop water requirement between 2018–19 and 2022–23; Telangana Today (2024b) for the canal evidence. Shares are the author's calculations. The datasets cover different years, and Panjala et al. (2024) did not assess Suryapet, so the table is indicative.

The evidence is mixed and cuts against a simple reading of H1. The two well-irrigated districts, Nalgonda and Siddipet, recorded some of the steepest increases in crop water requirement in the Kaleshwaram command, 157.3 and 120.1 per cent between 2018–19 and 2022–23, as Rabi rice spread (Panjala et al., 2024). Paddy therefore expanded sharply where water comes mainly from wells. Canal supply has its own limits: in Nalgonda the Nagarjuna Sagar left canal ayacut, where paddy normally covers 3.8 lakh acres, went into a crop holiday in Yasangi 2024, the first since the state was formed, and paddy fell to 75,000 acres (Telangana Today, 2024b). The canal district is therefore not simply more paddy-concentrated than the tubewell districts; the difference is in who bears the cost and the risk. A

direct measure of rice area as a share of gross irrigated area, district by district, needs crop statistics that are not yet published in comparable form.

6.2 Household evidence. The Agro-Economic Research Centre survey of 300 farm households in Vikarabad, Adilabad, Nirmal and Nalgonda provides source shares at the farm level (Table 7). Tubewells supplied 63.6 per cent of irrigated area overall, dug wells 27.2 per cent, canals 8.7 per cent and tanks 0.5 per cent. Beneficiaries of micro-irrigation had 2.16 hectares of irrigated area per household against 1.48 hectares for non-beneficiaries, so access to a reliable pressurised supply expands the irrigated base itself (Rambabu, 2017).

Table 7. Sources of irrigation among sample households, four Telangana districts

Source	Beneficiary farmers (% of irrigated area)	Non-beneficiary farmers (% of irrigated area)	All households (% of irrigated area)	All households (% of farmers using the source)
Canal	9.63	6.03	8.65	15.00
Dug well	26.18	30.04	27.23	28.00
Tube well	63.84	62.98	63.61	55.67
Tank	0.35	0.95	0.52	1.33

Source: Rambabu (2017, Table 4.6), field survey data. Farmer percentages do not sum to 100 because some farmers use more than one source.

6.3 Synthesis. The disaggregated evidence points to differences in mechanism more than in outcome. A canal supplies water on the department's schedule, at low marginal cost, over a large command, and the farmer's rational response is to plant the crop that best uses a cheap and reasonably certain supply with a guaranteed buyer, which is paddy. A tubewell shifts cost and risk to the farmer. Where the aquifer is deep and reliable and power is available, the same logic produces paddy, as the Nalgonda and Siddipet figures show. Where water is scarcer, costly or shared among several farmers, the logic favours high-value crops and micro-irrigation, as in Table 4. Table 8 summarises the contrast and the evidence behind it.

Table 8. Canal and tubewell irrigation compared

Dimension	Canal and lift irrigation	Tubewell irrigation
Control over timing	Set by departmental release; carrying capacity of distribution systems declined with poor maintenance (Rambabu, 2017)	Farmer-controlled and on demand, but exposed to well failure in dry years (Rambabu, 2017)
Cost to farmer	Low marginal cost	High capital and operating cost (Pingle, 2011)
Cropping evidence	Rapid paddy expansion, with Rabi rice up by more than 80	Chillies, tomatoes, cotton, oilseeds, mango, turmeric on

Dimension	Canal and lift irrigation	Tubewell irrigation
	per cent in the Kaleshwaram command between 2018–19 and 2022–23 (Panjala et al., 2024)	micro-irrigated holdings (Table 4); but a steep rice-driven rise in water demand in well-fed districts (Table 6)
Diversification	Surface irrigation lowers the likelihood of diversification (Peddi & Reddy, 2023, cited in Shagun, 2024)	Irrigation that raises the groundwater table raises it, and farm incomes were 21 per cent higher (Shagun, 2024)
Main sustainability risk	Waterlogging, salinity and monoculture (Shagun, 2024)	Groundwater depletion and falling well yields (Pingle, 2011; Shagun, 2024)

On the hypotheses, H1 is only partly supported: the survey evidence of Peddi and Reddy (2023) shows that surface irrigation lowers diversification relative to rain-fed conditions, and the Kaleshwaram command shows rapid Rabi rice expansion, but the well-irrigated districts of Nalgonda and Siddipet also recorded steep rises in rice-driven water demand. H2 is supported for micro-irrigated tubewell holdings, where crop mix is clearly wider, but not for tubewell irrigation as a whole, since paddy expansion has also been strong in well-fed districts. The finding is that source matters for cost and risk, while price and procurement signals decide what is planted once water is assured.

7. Discussion and Policy Implications

The evidence supports a more careful claim than the usual contrast between thirsty canals and thrifty wells. Irrigation source shapes the economics of cropping, but the cropping outcome depends on how that source is priced, scheduled and paired with markets. Three implications follow.

Water governance must differ by source. On canal commands, the problem is a cheap and predictable supply that rewards paddy in both seasons. Rambabu (2017) notes that the carrying capacity of canal distribution systems declined with poor maintenance, and that the state has 4,793 water users associations whose elected bodies had lapsed by January 2014. Reviving these associations and tying water release to crop-wise schedules would let canal management encourage lighter-water crops in Rabi, instead of simply meeting demand. On tubewell areas, the problem is the aquifer. The Central Ground Water Board (2024) classifies 32 of Telangana's 620 assessment units as over-exploited, 13 as critical and 85 as semi-critical, even though the state average stage of extraction is a moderate 45.91 per cent, so aquifer-sensitive planning must work at the mandal level rather than the state level. The 2024 Yasangi in Nalgonda, when depth to groundwater rose by about 3.4 metres in a year and the left-canal ayacut went into crop holiday, shows what a dry year does to both sources (Telangana Today, 2024b). Satellite evidence that crop water requirement in the Kaleshwaram command rose by about 54 per cent as Rabi rice spread (Panjala et al., 2024) shows how quickly demand can outrun supply, and why the state's own planning now needs to treat source-sensitive cropping as urgent.

Micro-irrigation is the bridge between the two sources. Only 5.73 of 17.12 lakh hectares of borewell-irrigated area had been brought under micro-irrigation by 2015–16, while drip saved 49 to 54 per cent of

water in the crops studied and lifted Rabi area sharply among beneficiaries (Rambabu, 2017). The same report recommends extending micro-irrigation to tank sources restored under Mission Kakatiya, and the logic extends to canal outlets. Pressurised delivery from canal and lift schemes, with volumetric rather than area-based charging, would remove part of the cost advantage that currently favours flooded paddy.

Markets decide the crop once water is assured. Peddi and Reddy (2023), as reported by Shagun (2024), found that minimum support price, road connectivity and distance to the nearest city shape crop choice, and that human–animal conflict discourages vegetables and horticulture. Procurement of paddy at assured prices has made it the lowest-risk option in both canal and well districts, and Rabi procurement alone reached about 49.5 lakh tonnes by mid-May 2025 (Press Trust of India, 2025). Diversification will therefore not follow from restricting water alone. It needs procurement or price support for pulses, millets and oilseeds, storage and aggregation for vegetables and fruits, and protection against crop loss, because horticultural crops carry price and production risks that assured paddy procurement removes.

The limits of this paper point to a research agenda. A proper test of the canal–tubewell contrast needs crop-by-source area data at the mandal or village level, which the official series do not yet publish. Remote-sensing studies such as Panjala et al. (2024) show that such mapping is feasible. Combining it with groundwater level records and farm-level cost data would allow a causal estimate of how much of paddy expansion is due to the source of water and how much to price policy.

8. Conclusion

Telangana's irrigation base has moved from tanks and canals to wells and, since 2014, back towards large canal and lift schemes. Between 1991–92 and 2014–15, tubewells raised their share of net irrigated area from 5.5 to 54.9 per cent, while canals fell from 22.0 to 10.1 per cent and tanks from 25.0 to 5.6 per cent. Cropping patterns followed the water. Tubewell-irrigated holdings with micro-irrigation grow a wide set of commercial and horticultural crops, with chillies, tomatoes, oilseeds, cotton and mango making up most of the covered area, and micro-irrigation beneficiaries expanded Rabi cropping sharply. Canal and lift commands, by contrast, have recorded a rapid spread of paddy, including a large Rabi rice crop in the Kaleshwaram region.

The comparison also yields a result that a simple narrative would miss. Paddy expansion has been strong whether the water comes from canals or from wells: the well-irrigated districts of Nalgonda and Siddipet recorded some of the steepest rises in rice-driven water demand in the Kaleshwaram command, while the canal ayacut in Nalgonda went into crop holiday in 2024. Paddy now covers about 127 lakh acres across the two seasons of 2024–25 on reported figures, and falling water tables in well-fed districts show how exposed this pattern is to water shocks. The hypotheses are therefore partly confirmed. Canal irrigation is associated with paddy concentration, but tubewell irrigation does not by itself guarantee diversification. Source determines cost, control and risk; price and procurement signals determine the crop.

For policy, the implication is to manage each source on its own terms. Canal commands need volumetric charging, revived water users associations and crop-wise release schedules. Tubewell areas need aquifer-sensitive planning, wider micro-irrigation and early warning for water-stressed mandals. Both need market support for pulses, oilseeds, millets and horticulture so that farmers have a profitable alternative

to paddy. Better data, especially crop-by-source area at village level, would let the next study test these claims causally.

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