07
2017

Despite some inconsistencies and shortcomings, data from the minor irrigation census remains the most reliable source of information about bulk of the minor irrigation economy of India. The IWMI-Tata Program has long believed that the dataset is underused, partly due to difficulty in accessing it and partly due to the dry nature of long tables used to present it. In 2014, ITP helped the Statistics Wing of the Minor Irrigation Cell bring out an analytical report based on data from the fourth minor irrigation census. This Highlight presents preliminary insights from district-level (provisional) data released for the fifth MI census.

IWMI-TATA
Water Policy Program

Water Policy Research
HIGHLIGHT

Evolving Nature of India's Irrigation Economy

Insights from the Fifth Minor Irrigation Census

Abhishek Rajan and
Shilp Verma

Evolving Nature of India's Irrigation Economy

Insights from the Fifth Minor Irrigation Census[*†]

Research highlight based on ITP (2017)

1. Introduction

Minor irrigation schemes are defined as those irrigation schemes or structures, in either groundwater or surface water category, which have Culturable Command Area (CCA) up to 2000 ha. Owing to low capital investment, short gestation period and widespread coverage, they deliver irrigation benefits to millions of farmers and account for a major share (> 60 %) of the total irrigation economy of the country. The Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR) conducts a census of minor irrigation structures to obtain detailed information on their existence, ownership, working condition, cost of construction, operational expenses and related issues. The census provides a clear picture of the distribution and utilization of different types of minor irrigation schemes and is the only available data at the national scale on minor irrigation. So far, five minor irrigation censuses (MIC) have been completed with reference years 1986-87 (GoI 1993), 1993-94 (GoI 2001), 2000-01 (GoI 2005), 2006-07 (Go 2014) and 2013-14 (GoI 2017).

In 2014, the IWMI-Tata Program assisted MoWR to analyse data from the fourth MIC and prepare an analytical report to encourage its wider use in policy making and program implementation. In 2017, when the data collection for the fifth MIC was completed, MoWR shared the (provisional) data with IWMI. ITP researchers used the data to prepare an analytical report and shared it with MoWR (ITP 2017). The official report of the fifth MIC was published on the MoWR website in December 2017. The purpose of this Highlight is to present key insights from the ITP report to shed light on the evolving nature of India's minor irrigation economy.

2. Data and Methods

This paper uses data from the fourth and fifth MI Censuses. Both the censuses covered 33 states and union territories. The fifth census covered 673 districts and more than 650,000 villages to gather information on 21.71 million minor irrigation schemes. Where relevant, we also use data from eighth and ninth Agriculture Censuses (MoA 2012; MoA 2015) and CGWB's data on dynamic groundwater resource of India (CGWB 2011).

Table 1 compares state-wise number of MI structures covered in the provisional data that we have analysed and the numbers in the data officially released. The official numbers are marginally higher in a few states, with the largest difference being in Madhya Pradesh where the official data included 1,513 more structures vis-à-vis the provisional data. However, overall the difference is negligible, less than 0.01%. We have used the revised data for state-level analyses; the district-level analyses relies primarily on provisional data.

Since the first MI census in 1987, MI structures have been classified into 5 categories: [1] Dugwells (DWs); [2] Shallow Tubewells (STWs); [3] Deep Tubewells (DTWs); [4] Surface flow schemes; and [5] Surface lift schemes. The fifth MI census introduced a new category – Medium Tubewells (MTWs)[1].

3. Key Highlights

3.1 Number and Type of MI Schemes

The total number of minor irrigation structures continues to grow, *albeit* at a slower rate and with some change in the relative share of different scheme types. Between the fourth census (reference year: 2006-07) and the fifth census (reference year: 2013-14), the total number of structures increased by more than 700,000 to 21.71 million. While the surface schemes declined marginally from 1.25 million to 1.19 million, the number of groundwater schemes increased from 19.76 million to 20.52 million (Table 2).

Dugwells continue to dominate the MI landscape (8.8 m; 40%); followed by STWs (5.9 m; 27%); and MTWs (3.2 m; 15%). However, both DWs and STWs have declined in absolute numbers compared to the fourth MI census. Deep tubewells (DTWs) have increased significantly from 1.4 million (7%) in 2006-07 to 2.6 million (12%) in 2013-14. Surface flow schemes (S-Flow) have declined marginally from 0.60 million to 0.59 million (3%) and surface lift schemes (S-Lift) have declined from 0.65 million to 0.60 million (3%) (Figure 1).

* This Highlight is based on research carried out under the IWMI-Tata Program (ITP) with additional support from the CGIAR Research Program on Water, Land and Ecosystems (WLE). It is not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or its funding partners.

† Corresponding author: Abhishek Rajan [rajan_msit@yahoo.com]

[1] The category has been created by bifurcating the STW category into STW and MTW based on the depth of the scheme. Till the fourth census, depth of STWs was up to 70 meters. In fifth census, depth of STWs has been limited to 35 meters while MTWs have depth in the 35-70 meters range.

Table 1: Comparison of provisional and official data for fifth MI census

State / UT	Number of MI Structures		Absolute Difference	% Difference
	Provisional Data	Final Data		
Andaman & Nicobar Islands	2,710	2,710	-	-
Andhra Pradesh	1,054,356	1,054,356	-	-
Arunachal Pradesh	4,779	4,779	-	-
Assam	136,520	136,520	-	-
Bihar	649,992	649,992	-	-
Chandigarh	52	52	-	-
Chhattisgarh	315,708	315,708	-	-
Delhi	7,506	7,506	-	-
Goa	7,755	7,755	-	-
Gujarat	1,330,225	1,330,226	+1	+0.000%
Haryana	350,909	350,909	-	-
Himachal Pradesh	20,774	20,774	-	-
Jammu & Kashmir	11,313	11,313	-	-
Jharkhand	251,224	251,224	-	-
Karnataka	1,353,880	1,353,889	+9	+0.001%
Kerala	103,657	103,657	-	-
Madhya Pradesh	2,080,716	2,082,229	+1,513	+0.073%
Maharashtra	2,920,869	2,920,874	+5	+0.000%
Manipur	866	866	-	-
Meghalaya	9,238	9,238	-	-
Mizoram	4,281	4,281	-	-
Nagaland	17,106	17,106	-	-
Odisha	491,394	491,394	-	-
Puducherry	4,498	4,498	-	-
Punjab	1,120,963	1,120,963	-	-
Rajasthan	1,471,068	1,471,068	-	-
Sikkim	1,749	1,749	-	-
Tamil Nadu	2,072,468	2,072,517	+50	0.002%
Telangana	1,522,292	1,522,292	-	-
Tripura	5,073	5,073	-	-
Uttar Pradesh	3,801,284	3,801,286	-	-
Uttarakhand	91,518	91,518	-	-
West Bengal	495,811	495,811	-	-
ALL INDIA	**21,712,554**	**21,714,133**	**+1,579**	**+0.007%**

Uttar Pradesh is home to the most number of MI schemes (3.8 m). Type wise, Maharashtra has the most number of dugwells (2.3 m); Uttar Pradesh has the most number of shallow tubewells (3.3 m); Telangana has the most number of medium tubewells (0.6 m); Punjab has the most number of deep tubewells (0.5 m); and Maharashtra has the most number of surface lift (0.2 m) and surface flow (0.1 m) schemes. Analysing data from the first four MI censuses, Mukherji *et al.* (2013) had observed a decline in the number of DWs and their rapid replacement with STWs and DTWs in response to declining groundwater tables. The trend continues in the fifth census, particularly with the alarming rise in number of DTWs (Figure 2).

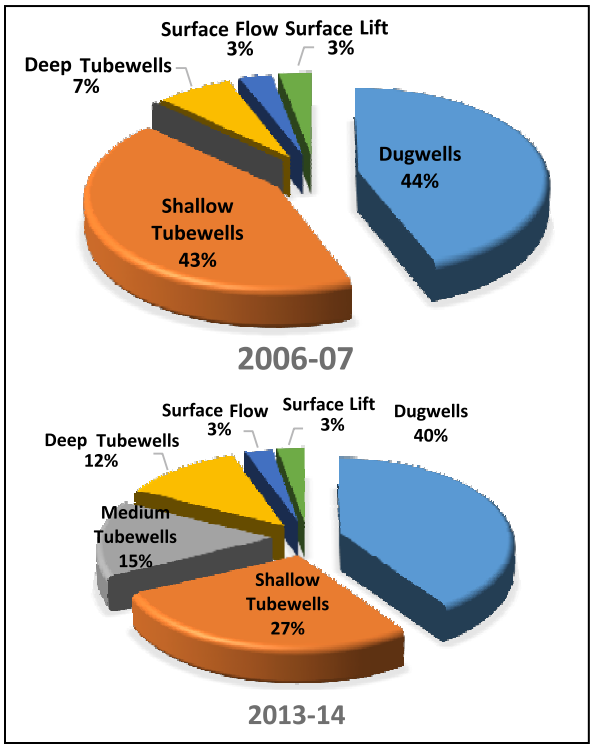

Figure 1: Distribution of MI schemes by type, 2006-07 and 2013-14

Table 2: Type-wise number of minor irrigation structures reported over the years (1987 to 2013-14)

Type of Structure	First Census (1987)	Second Census (1993-94)	Third Census (2000-01)	Fourth Census (2006-07)	Fifth Census (2013-14)
Dugwells (DWs)	7,320,586	4,466,958	9,617,381	9,200,191	8,784,359
Shallow Tubewells (STWs) Medium Tubewells (MTWs)	4,773,071	5,080,725	8,355,693	9,104,665	5,940,656 3,176,684
Deep Tubewells (DTWs)	103,814	104,309	530,194	1,452,964	2,618,606
Total Groundwater Schemes	***12,197,471***	***9,651,992***	***18,503,268***	***19,757,820***	***20,520,305***
Surface Flow Schemes (S-Flow)	436,466	418,584	642,013	601,115	592,156
Surface Lift Schemes (S-Lift)	481,045	352,916	606,918	647,738	600,093
Total Surface Water Schemes	***917,511***	***771,500***	***1,248,931***	***1,248,853***	***1,192,249***
ALL MI STRUCTURES (millions)	**13.11**	**10.42**	**19.75**	**21.00**	**21.71**

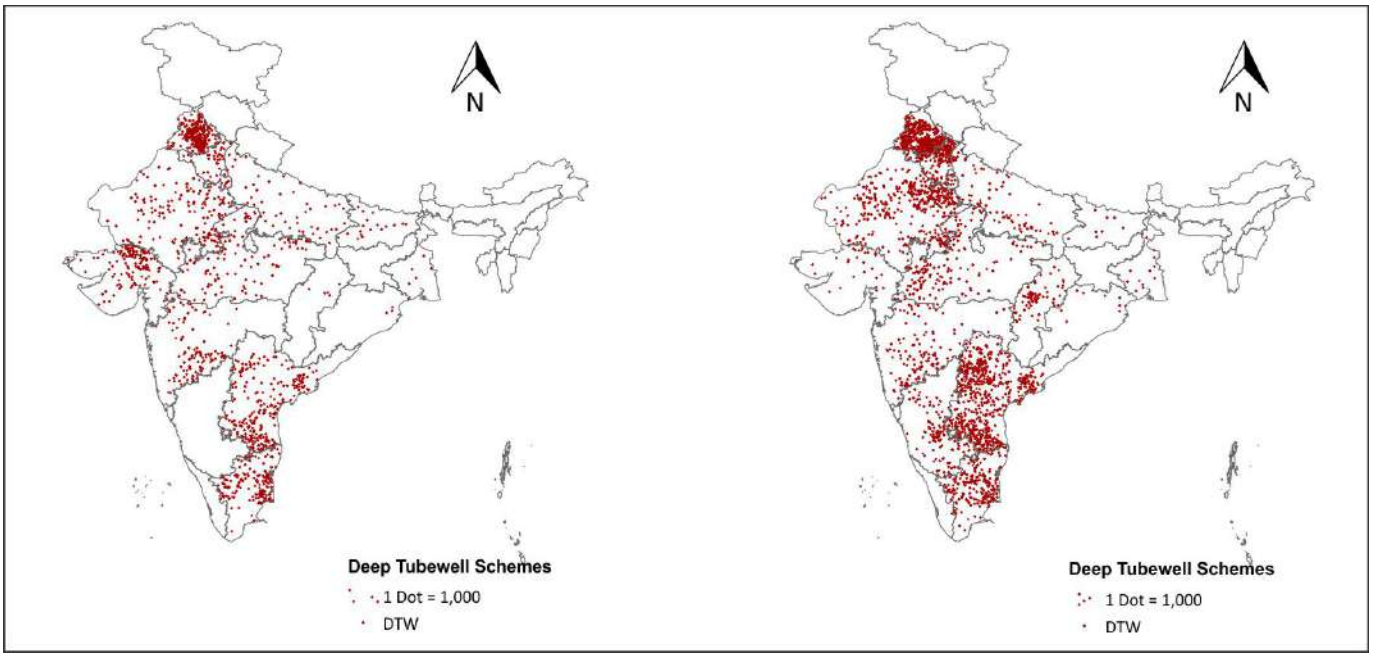

Figure 2: District-wise number of Deep Tubewells (DTWs), 2006-07 and 2013-14

3.2 Irrigation Potential Created and Utilized

Irrigation potential created (IPC) by MI schemes has increased from 84.0 million ha (mha) to nearly 89.5 mha. IPC through groundwater schemes has increased from 70.0 mha to 78.9 mha while that through surface water schemes has declined from 14.0 mha to 10.6 mha. The fourth MI census reported a reduction in the gap between IPC and IPU (from 22 mha in the 2000-01 to 20 mha in 2006-07); the fifth census reports a continuation of this trend as the gap has further reduced to 18.2 mha in 2013-14. By type of MI structure, dugwells, DTWs and surface lift schemes have the highest IPU/IPC ratio (0.82); these are followed closely by MTWs (0.81) and STWs (0.78) while surface flow schemes have the lowest IPU/IPC ratio (0.71) (Figure 3).

3.3 Profiles of MI Structures

3.3.1 Dugwells (DWs)

Dug wells (DWs) are normally open wells of varying sizes dug into water bearing shallow aquifers. DWs grew from 7.3 million in 1987 to a maximum of 9.6 million in 2000-01; after which their number started declining; falling to 9.2 million in 2006-07 and further to 8.8 million in 2013-14. The highest concentration of dug wells is found in the hard rock peninsula of Saurashtra (Gujarat) and parts of Tamil Nadu (Figure 4).

Against a potential of 20.6 million hectares (mha), dug wells irrigate 16.8 mha; up from 15.6 mha in 2006-07. All but 1.1% of DWs are privately owned; this has changed from the

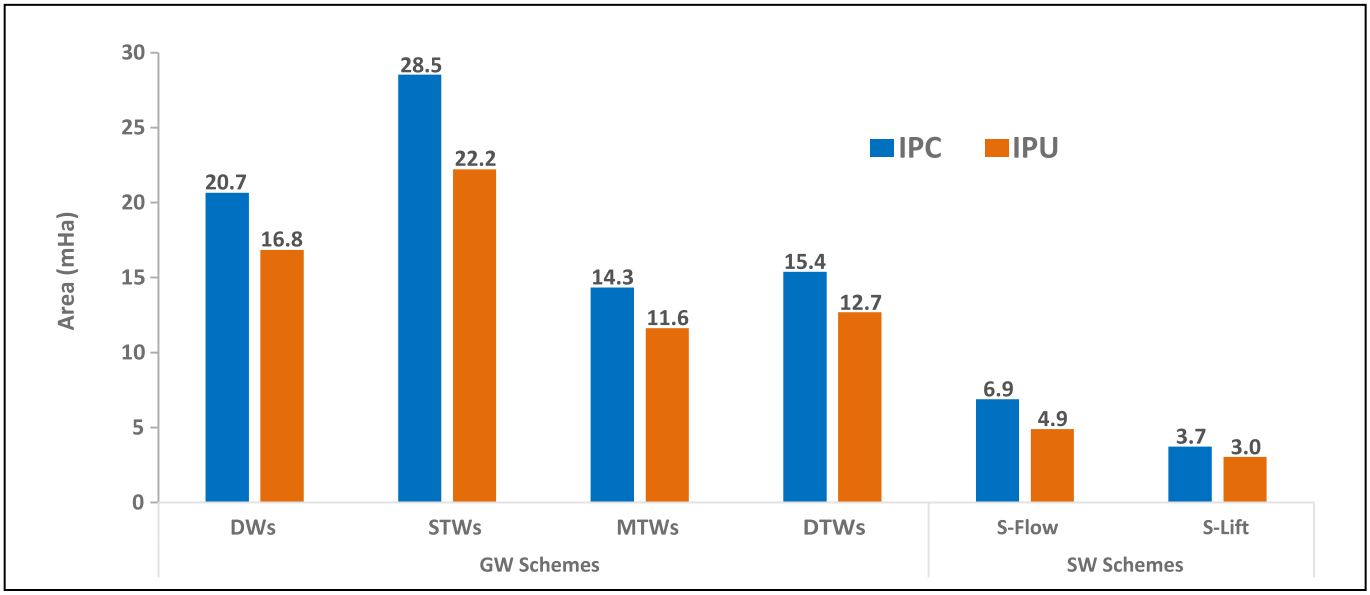

Figure 3: Irrigation Potential Created (IPC) and Irrigation Potential Utilized (IPU) for different structure types, 2013-14

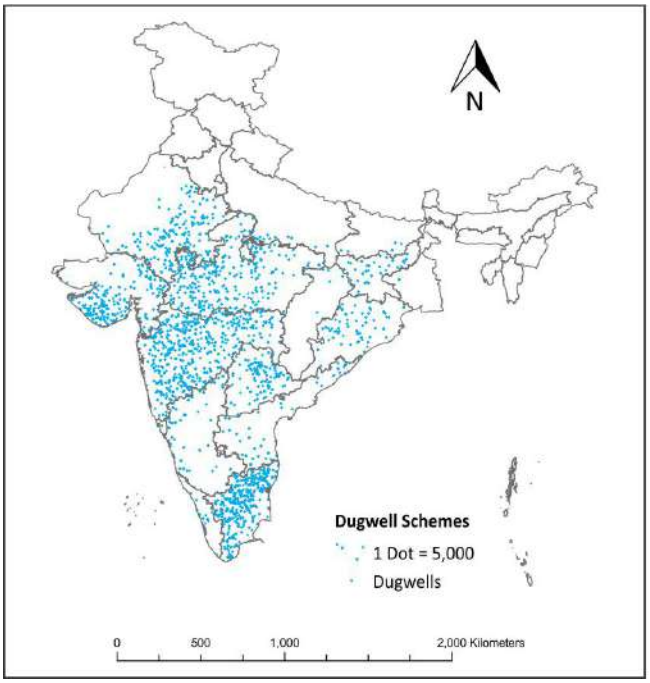

Figure 4: Distribution of Dugwells, 2013-14

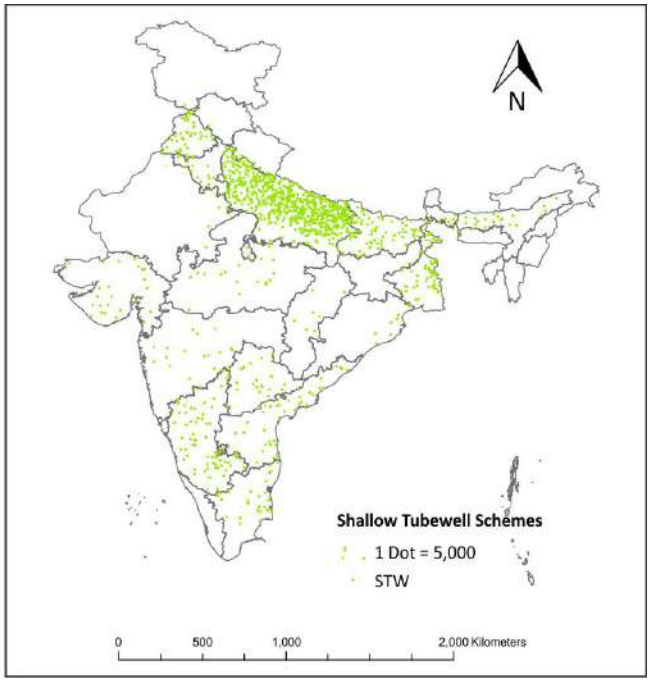

Figure 5: Distribution of Shallow Tubewells (STWs), 2013-14

fourth census where 2.8% of DWs were publically owned. 78% of the dug wells operate in the shallow aquifers with depth less than 20m while another 12.3% have a depth of 20 – 40m; only 4.8% go beyond 70m depth. A little over 70% dug wells are owned by marginal and small farmers; up from 66% in the fourth census. 23.4% of the dug wells are jointly owned by groups of farmers; up from 20% in the fourth census. 85.1% DWs operate on electricity; up from only 69% in 2006-07. Dug wells are predominantly financed through the farmers' own savings (71%). 21% DWs cost less than ₹10,000; 19.9% cost between ₹10,000 and ₹50,000; 25.8% between ₹50,000 and ₹1 lakh; 32.2% between ₹1 lakh and ₹10 lakh; and only 1% cost more than ₹10 lakh. 94.4% DWs were reported to be functional with 3.4% temporarily not in use and 2.2% permanently out of use. Low discharge, possibly as a result of decline in groundwater level, was reported as the primary reason for dug wells being temporarily out of use; like-wise, drying up of wells was cited as the most common reason for dug wells being permanently out of use.

3.3.2 Shallow Tubewells (STWs)

A STW consists of a bore hole drilled into the ground with the purpose of tapping groundwater from porous zones in the aquifer. STWs grew from 4.8 million in 1987 to 8.4 million in 2000-01 and further to 9.1 million in 2006-07. In 2013-14, the number of STWs has remained almost unchanged at 9.1 million but 3.2 million of these have now been re-classified as Medium Tubewells (MTWs). Under the new classification, STWs have a maximum depth of 35m. The highest concentration of STWs can be found in the indo-gangetic plains of northern India (Figure 5).

Against an irrigation potential of 28.5 mha, Shallow Tubewells irrigate 22.2 mha. About one-third (33.8%) of STWs operate at a depth of less than 20m while the rest (66.2%) operate between 20 – 40m depth. All but 0.5% of STWs are privately owned; 79% owned by marginal and small farmers; and only 2% by large farmers. The main source of energy for STWs is diesel (63.5%) followed by electricity (35.9%). Predominantly financed through farmers' savings, 98.3% STWs are functional with 1.3% temporarily not in use and 0.4% permanently out of use. Nearly half (48.9%) STWs cost between ₹10,000 and ₹50,000; 27.6% between ₹50,000 and ₹1 lakh; 15.6% between ₹1 lakh and ₹10 lakh; 6.9% less than ₹10,000 and 1% more than ₹10 lakh.

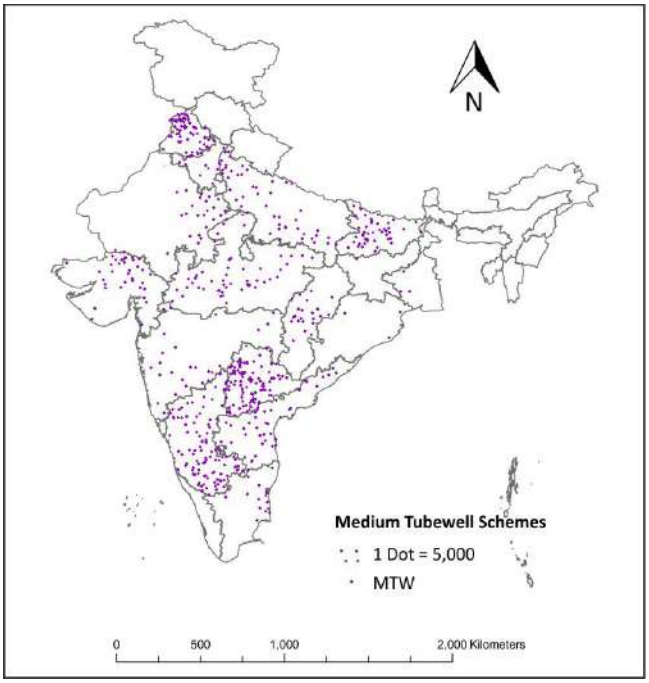

Figure 6: Distribution of Medium Tubewells (MTWs), 2013-14

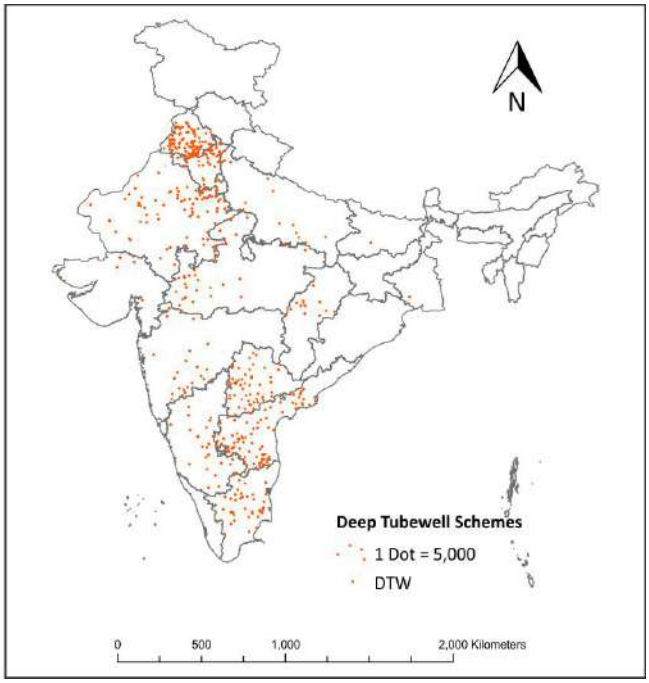

Figure 7: Distribution of Deep Tubewells (DTWs), 2013-14

Mechanical failure (36.3%) and low discharge (24.6%) were reported as the primary reasons for STWs being temporarily out of use; destruction beyond repair (36.2%) and drying up of wells (30.9%) were cited as the most common reason for STWs being permanently out of use.

3.3.3 Medium Tubewells (MTWs)

MTWs is a new category of groundwater schemes introduced in the fifth MI census. MTWs are deeper than STWs but shallower than DTWs, so they operate between 35 – 70 m depth. The highest concentration of MTWs can be found in Punjab, north Bihar, north Gujarat, Telangana, Andhra Pradesh and southern Karnataka (Figure 6).

Against an irrigation potential of 14.3 mha, Medium Tubewells irrigate 11.6 mha; thus the irrigated area by STWs and MTWs together in 2013-14 is 33.8 mha, up from 31.4 mha in 2006-07. Surprisingly, 12.6% of groundwater schemes recorded as MTWs operate at depth between 20 – 40 m and should have been classified as STWs. More than half the MTWs (53.4%) operate at depths between 40 and 60 m while a third (33.9%) operate between 60 – 70m depth. Like in the case of dug wells and STWs, all but 0.4% of MTWs are privately owned. About 65% of MTWs are owned by marginal and small farmers; while only 2.4% are owned by large farmers. Only 7% of MTWs are jointly owned by groups of farmers. MTWs are overwhelmingly electrified (88.4%) and only a few (10.9%) run on diesel. Like dug wells and STWs, MTWs are also predominantly financed through the farmers' own savings (81.4%). 97.9% MTWs are functional with 1.6% temporarily not in use and 0.5% permanently out of use. 38.6% MTWs cost between ₹50,000 and ₹1 lakh; 29.8% between ₹1 lakh and ₹10 lakh; 25.8% between ₹10,000 and ₹50,000; 4.9% less than ₹10,000 and 0.9% more than ₹10 lakh. Low water discharge (55.9%) is reported as the primary reason for MTWs being temporarily out of use; drying up of wells (52.5%) and destruction beyond repair were cited as the most common reasons for MTWs being permanently out of use.

3.3.4 Deep Tubewells (DTWs)

DTWs are tubewells that operate at a depth of more than 70 m. The number of DTWs has grown exponentially from 0.1 million in 1987 to 0.5 million on 2000-01, 1.4 million in 2006-07 and 2.6 million in 2013-14. Almost all DTWs are located in western and peninsular India, with a high concentration in Punjab, Haryana, Rajasthan, Andhra Pradesh, Telangana and other pockets of severe groundwater depletion such as Sangli (Maharashtra) Banaskantha (Gujarat) and Chitradurga (Karnataka) (Figure 7).

Against an irrigation potential of 15.4 mha, Deep Tubewells irrigate 12.7 mha, up from 8 mha in 2006-07. The depth profile of DTWs has changed substantially since the fourth MI census. In 2006-07, 47% of DTWs operated between 70 – 90m depth; in 2013-14, the percentage fell to below 40%. Likewise, in 2006-07, only 10% of the DTWs operated deeper than 150m; in 2013-14, the share of DTWs operating at depths greater than 150m has grown to 15.6%. This clearly indicates a secular and declining trend in groundwater tables. As with dug wells, STWs and MTWs, all but 1.1% of DTWs are privately owned. This has changed from 2006-07 when 4% of DTWs were under public ownership. A little over half (52.3%) of DTWs are owned by marginal and small farmers; while only 4.5% are owned by large farmers. As many as 20% of DTWs are jointly owned by groups of farmers, indicative of their high capital cost. Given the depth at which they operate, it is not surprising that 96.3% DTWs

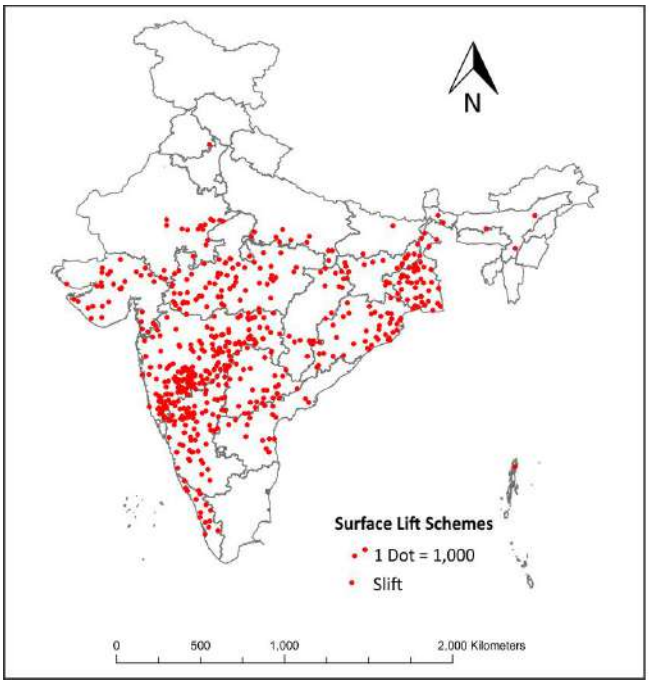

Figure 8: Distribution of Surface Lift Schemes (S-Lift), 2013-14

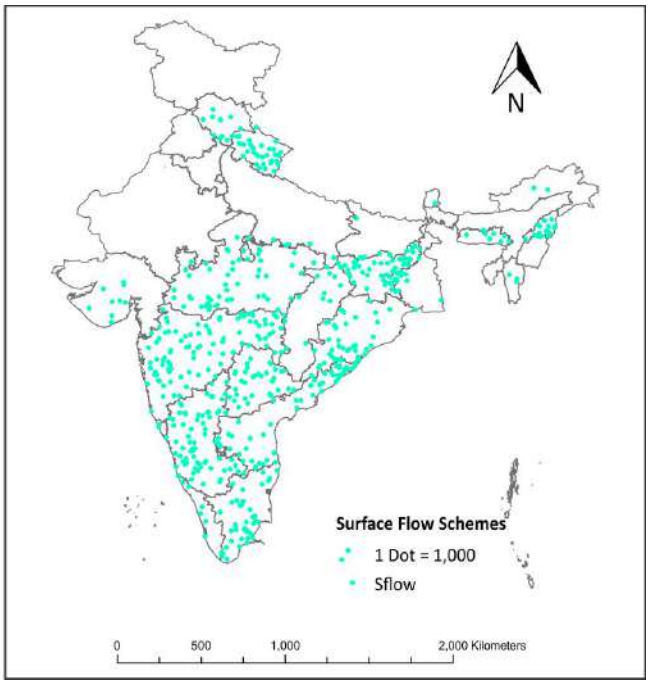

Figure 9: Distribution of Surface Flow Schemes (S-Flow), 2013-14

are run on electricity and only 3.3% run on diesel. Like dug wells, STWs and MTWs, DTWs are also predominantly financed through the farmers' own savings (80.3%). 96.6% DTWs are functional with 2.3% temporarily not in use and 1.1% permanently out of use. Cost wise, more than half (53.1%) cost between ₹1 lakh and ₹10 lakh; 30.9% between ₹50,000 and ₹1 lakh; 8.9% between ₹10,000 and ₹50,000; 4.9% less than ₹10,000 and 2.2% more than ₹10 lakh. Low water discharge (69.1%) is reported as the primary reason for DTWs being temporarily out of use; drying up of wells (66.7%) is cited as the most common reason for DTWs being permanently out of use.

3.3.5 Surface Lift Schemes (S-Lift)

Surface lift schemes have grown from 480 thousand in 1987 to 650 thousand in 2006-07. However, their number has declined since and in 2013-14, a little over 600 thousand SLS were reported. Most schemes in this category are located south of the Indo-Gangetic plains (Figure 8).

Against an irrigation potential of 3.7 mha, S-Lift schemes irrigate 3 mha, up from 2.5 mha in 2006-07. This is despite a significant decline in total number of surface lift schemes. More than half of these schemes lift water from rivers (36.0%) and streams (16.6%); a fourth from tanks (25.0%) and 13.0% from canals. For a large majority of S-Lift schemes (72.9%), storage capacity information is not available. About 10.5% of the schemes have storage capacity of less than 100 m3 while 6.0% have storage capacity in excess of 10,000 m3. About four out of every five (83.4%) surface lift schemes are privately owned. 61.8% of surface lift schemes are owned by marginal and small farmers; 4.9% by large farmers. About a third (34%) of S-Lift schemes are jointly owned by groups of farmers, up from 21% reported in fourth MI census, 2006-07. 66.6% surface lift schemes are powered by electricity while 30.4% operate on diesel. A little over half (56.5%) S-Lift schemes are financed through farmers' own savings while 23.8% rely on bank loans and 16.2% use government funds. 96.7% S-Lift schemes are functional with 2.5% temporarily and 0.7% permanently not in use. In terms of scheme costs, 13.1% S-Lift schemes cost between ₹50,000 and ₹1 lakh; 41% cost less than ₹10,000; 15.9% between ₹10,000 and ₹50,000; and 2.9% more than ₹10 lakh. Inadequate power / fuel is the primary reason for S-Lift schemes being temporarily not in use, followed by low water discharge (21.6%) and mechanical failure (14.2%). Drying up of water source (71.3%) is cited as the most common reason for S-Lift schemes being permanently out of use.

3.3.6 Surface Flow Schemes (S-Flow)

Surface flow schemes grew from 400 thousand in 1987 to nearly 650 thousand in 2000-01. In 2006-07, the number of S-Flow schemes declined to 600 thousand and further to 592 thousand in 2013-14 even as the area irrigated by them continues to rise. S-Flow schemes are mostly located in the Himalayan states of Himachal Pradesh and Uttarakhand; in the undulating terrain of Tribal Central India; as well as across the Deccan Plateau (Figure 9).

Against an irrigation potential of 6.9 mha, S-Flow schemes irrigate 4.9 mha, up from 3.9 mha in 2006-07. This is despite a marginal decline in the number of schemes from 600 to 592 thousand. About 40% of S-Flow schemes source water from tanks and ponds while 16% rely on reservoirs. The schemes also rely on temporary (8.9%) and permanent (5.1%) diversions. About 42.7% of the schemes have storage capacity of less than 100 m^3 while 7.6% have storage capacity in excess of 10,000 m^3; storage information is not available for 38.4% surface flow schemes. Ownership of S-Flow schemes is almost equally split between private

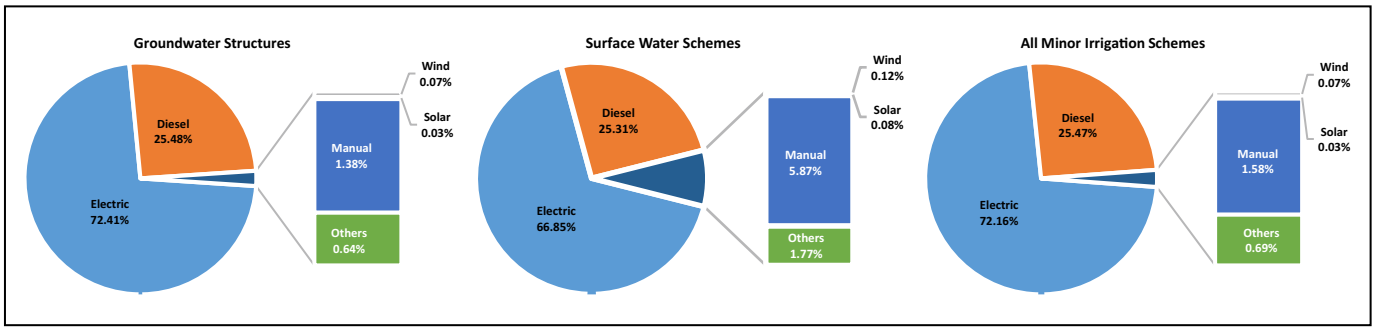

Figure 10: Source of Energy in Minor Irrigation, 2013-14

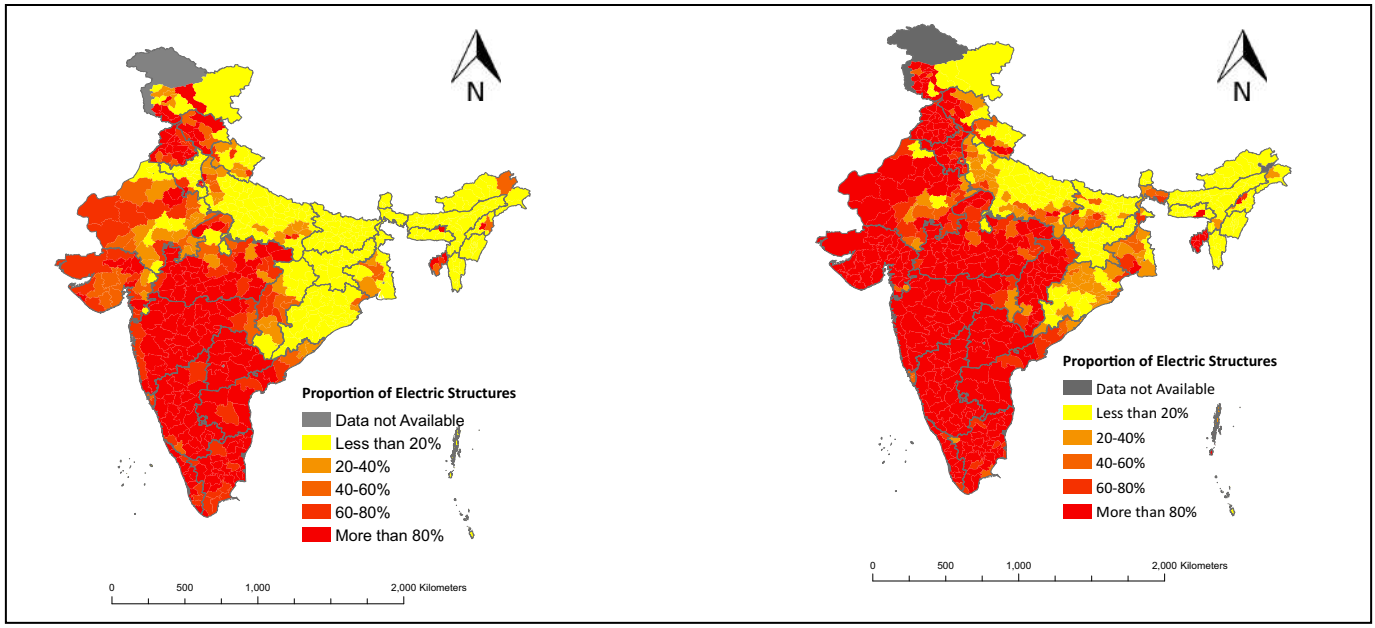

Figure 11: India's evolving Energy Divide, 2006-07 (left) to 2013-14 (right)

(47.8%) and public (52.2%). This has changed from 2006-07 when only 39% were privately owned. Two-third (67.2%) of S-Flow schemes are owned and operated by marginal and small farmers; 6.5% are owned by large farmers. An overwhelming majority (71%) of privately owned S-Flow schemes are jointly owned by groups of farmers. Little over a third (35.2%) S-Flow schemes are financed through farmers' own savings while 44.3% rely on government funds and 13.4% use bank loans. Only 87.6% S-Flow schemes are reported as functional with 9.5% temporarily and 2.9% permanently not in use. Whereas S-Flow schemes are supposed to operate with gravity, provisional data from the fifth MIC data suggests a significant number of them have energy source. Out of roughly 600,000 surface flow schemes, roughly 280,000 schemes report having an energy source. 57.9% of these are powered by electricity; 22.9% by diesel and 19.2% by other energy sources. This probably represents a case of mis-classification and these schemes should be classified as S-Lift schemes. 42.5% S-Flow schemes cost less than ₹10,000; 22.4% between ₹10,000 and ₹50,000; 18.9% between ₹1 lakh and ₹10 lakh; 12.6% between ₹50,000 to ₹1 lakh; and 3.6% more than ₹10 lakh. Possibly owing to the mis-classification discussed earlier, inadequate power / fuel is reported as the leading reason (43.5%) for S-Flow schemes being temporarily not in use, followed by low water discharge (20.3%) and mechanical failure (12.1%). Sinking (42.6%), and drying up of water source (30.4%) are the most common reasons for S-Flow schemes being permanently out of use.

3.4 Energy Use in Minor Irrigation

Overall, the fifth MI census reports 72.16% of MI schemes as electric, 25.47% diesel, 1.58% manual, 0.07% wind-powered, 0.03% solar powered, and 0.69% energised from other sources. The distribution is slightly different between groundwater and surface water schemes. In surface water schemes, there is a higher proportion of manual (5.87%) pumps (Figure 10). Electric pumps dominate in north-western, western and peninsular India while diesel pumps are mostly concentrated in the Gangetic basin in eastern India.

The report of the fourth MI census highlighted the energy divide in India's minor irrigation economy. Figure 11 shows how the divide has evolved and intensified during the period 2006-07 to 2013-14. The yellow areas of the maps represent districts with less than 20% electrified MI schemes while the dark red areas represent districts where more than 80% of the MI schemes are electric.

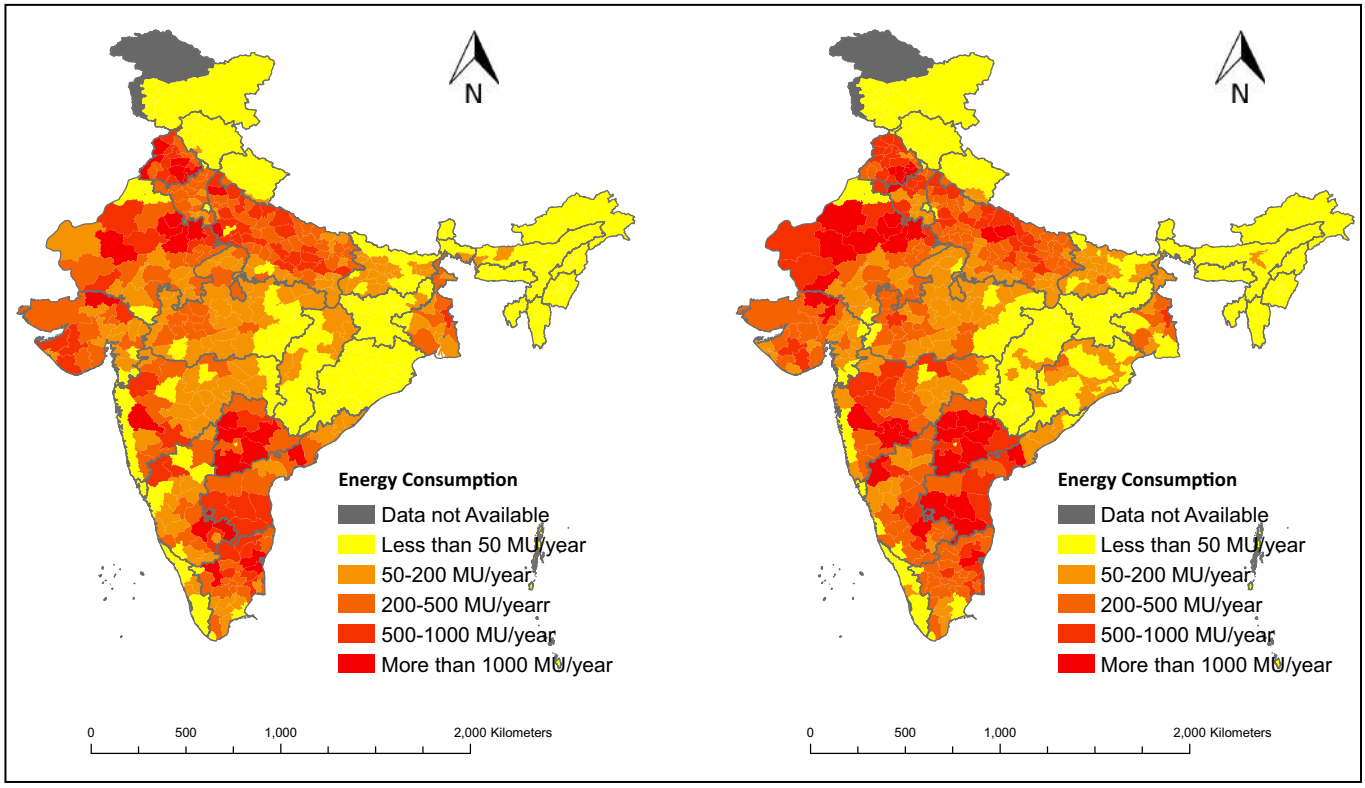

Figure 12: District-wise annual energy use in minor irrigation, 2006-07 (left) and 2013-14 (right)

The minor irrigation census collects information on capacity of pumps (in HP) and cropping season-wise hours of use for every minor irrigation structure. This information can be used to calculate total HP-Hours of operation of energized minor irrigation schemes; electric, diesel or otherwise. Using this information and assuming different values for average pump efficiency, one can estimate total annual energy use by MI schemes (Table 3).

The total installed capacity of mechanized MI structures is reported to be in excess of 106 GW. Of these, 102 GW is for groundwater schemes and 4.3 GW is for surface water MI schemes. It appears that, of all the values of estimated energy consumption by electric pumps in Table 3, energy estimated at 40% pump efficiency is closest to the electricity supplied to agriculture, which was 122 billion units (kWh-equivalent)[2] in 2013-14. The total energy consumed in agriculture in 2013-14 is estimated to be roughly 162 billion units (kWh-equivalent)[3], up from 133 billion units estimated for 2006-07 (Figure 12). This implies an average annual energy consumption of 2281 kWh-equivalent units per hectare of irrigation potential utilized (IPU).

As per estimates of MI Census 2006-07, four districts consumed more than 2 billion units per year; this number has now gone up to 7 districts. Nalgonda district (Telangana) is estimated to consume 3.53 billion units. The other districts consuming more than 2 billion units annually are: Medak (Telangana); Jodhpur and Bikaner (Rajasthan); Sangrur (Punjab); Banaskantha (Gujarat); and Pune (Maharashtra). These 7 districts have more than 0.85 million electric pumps with an installed capacity of 9.4 million HP and consume 20.3 billion units to irrigate an area of nearly 2.8 mha.

Table 3: Estimated Energy Consumption by MI Structures

Assumed Pump Efficiency (%)	Estimated Energy Consumption (in billion kWh-equivalent)		
	Electric	Diesel	Total
30	171.8	43.6	216.5
40	128.9	32.7	162.4
50	103.1	26.2	129.9
60	85.9	21.8	108.3
70	73.6	18.7	92.8

[2] We assume 20% technical and commercial losses in farm power supply and exclude it from the electricity supplied to agriculture which was 153 billion units in 2013-14 (CSO 2017). http://www.mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2017r.pdf.pdf

[3] For estimating energy consumption, we assume 40% pump efficiency.

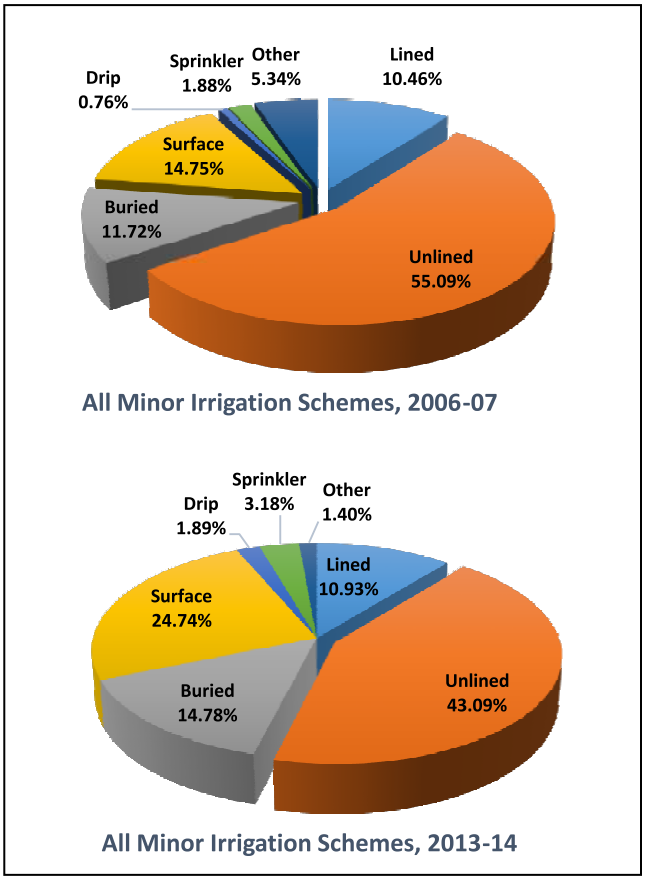

Figure 13: Number of MI schemes equipped with different water distribution systems

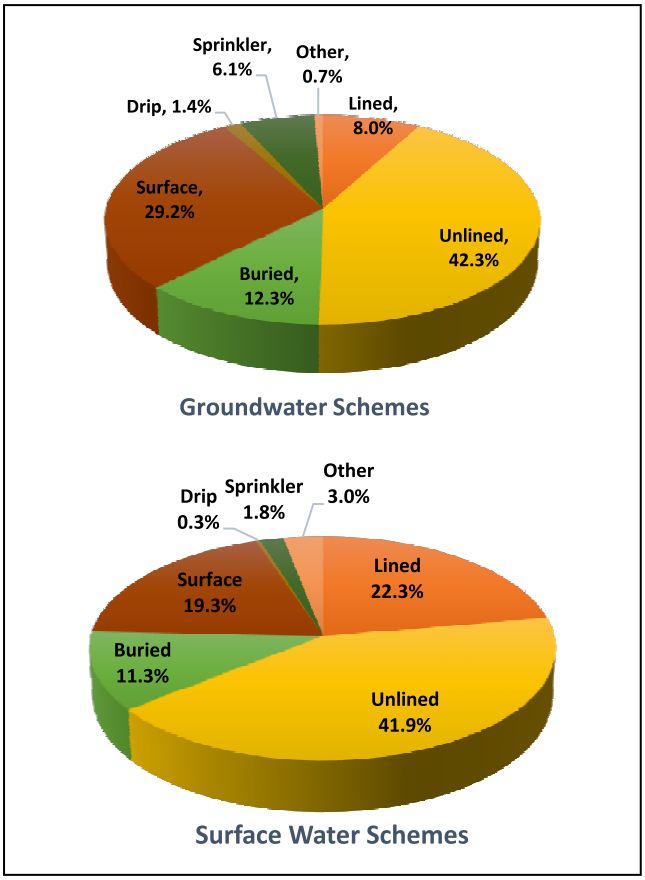

Figure 14: Share of Irrigation Potential Utilized by Water Distribution Systems, 2013-14

3.5 Water Distribution and Irrigation Technologies

Between 2006-07 and 2013-14, we see significant improvement in minor irrigation schemes equipped with improved water distribution systems. Proportion of schemes using unlined open channels has declined (from 55.09% in 2006-07 to 43.09%); while share of MI schemes equipped with buried pipelines (11.72% to 14.78%), surface pipes (14.75% to 24.74%), drip irrigation (0.76% to 1.89%) and sprinklers (1.88% to 3.18%) have all increased significantly (Figure 13).

In terms of minor irrigated area using different water distribution systems, numbers are different for groundwater and surface water schemes. In groundwater schemes, lined channels service only 8% of the IPU while buried pipes service 12.3% and surface pipes service 29.2% of the IPU. 1.4% of groundwater irrigated area is drip irrigated while 6.1% is irrigated with sprinklers. In surface water schemes, 22.3% of the IPU is irrigated through lined channels while buried pipes service 11.3% and surface pipes service 19.3%. 0.3% of surface water irrigated area is drip irrigated while 1.8% is irrigated with sprinklers (Figure 14). There has been significant expansion of drip and sprinkler irrigated area between the 4th and 5th MI censuses. Drip irrigated area has increased from 287,075 Ha in 2006-07 to 849,601 Ha in 2013-14 while sprinkler irrigated area has grown from 2.1 mha in 2006-07 to 3.7 mha in 2013-14.

4. Conclusion

Since the 1980's, India's irrigation economy has been dominated by minor irrigation, especially groundwater and pump irrigation. Over the past fifty years, India and much of South Asia added more irrigated area through expansion of minor irrigation than over the previous 200 years of major and medium irrigation expansion via investments in large reservoirs and canal networks (Shah 2009). Not surprisingly, these structures have become the backbone of the smallholder agriculture economy. Despite some inconsistencies and shortcomings, data from the minor irrigation census represents the most comprehensive and reliable source of information about this critical economy. Over the years, the MIC has improved in breadth as well as in the depth of its coverage and the fifth MIC has not been an exception. With more than 21 million structures spread across more than 650,000 villages, the minor irrigation census is an enormous field and logistical exercise. It has been suggested that the next census will make use of mobile computing and GPS technologies to improve reliability, ease of data gathering and access to MIC data.

Since the last census in 2006-07, India's MI economy has evolved in terms of number of structures, energy source, energy use, delivery technologies etc. Despite some signs of plateauing and decline in the rate of growth, MI structures continue to increase. How long the groundwater juggernaut will continue is difficult to say. While in many parts of western and peninsular India, DWs and STWs are being replaced by DTWs, the density of structures still has tremendous scope for expansion in central and eastern India. As states continue to offer free or highly subsidized electricity for farm use, unsustainable and economically unviable pumping of fossil groundwater is likely to continue. In recent years, new states like Chhattisgarh and Telangana have also announced free farm power policies.

The introduction of solar irrigation pumps – especially with high capital subsidies from union and state governments – coupled with the rapid decline in their unit costs is likely to have a significant impact on the minor irrigation economy. Once installed, solar irrigation pumps offer high quality, zero-marginal cost, day-time energy to farmers without the possibility of rationing. Mindless promotion of off-grid solar pumping systems will mimic a free farm power regime and the inability of utilities and government agencies to limit pumping hours will further accentuate the precarious groundwater situation.

The expansion of efficient irrigation technologies in recent year is a positive sign but even with the recent rise, drip and sprinkler technologies cover only about 5% of minor irrigation schemes and cover less than 10% of the area irrigated by them.

References

CGWB (2011): Dynamic Groundwater Resources of India (As on 31st March 2011). Central Groundwater Board (CGWB), Government of India. Available Online: http://www.cgwb.gov.in/documents/Dynamic-GW-Resources-2011.pdf

CSO (2017): Energy Statistics: 2017. Central Statistics Office (CSO), Ministry of Statistics and Programme Implementation, Government of India. Available Online: http://www.mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2017r.pdf.pdf

GoI (1993): First Minor Irrigation Census, 1986-87. New Delhi: Minor Irrigation Division, Ministry of Water Resources, Government of India. Available Online: http://micensus.gov.in/ mi1census/mi 1census.html

GoI (2001): Report on census of minor irrigation schemes (1993-94). New Delhi: Ministry of Water Resources, Minor Irrigation Division, Government of India. Available Online: http://micensus.gov .in/mi2census/default.htm

GoI (2005): Report on third census of minor irrigation schemes (2000-01). New Delhi: Ministry of Water Resources, Minor Irrigation Division, Government of India. Available Online: http://micensus .gov. in/mi3census/index.htm

GoI (2014): 4th census of minor irrigation schemes report. New Delhi: Ministry of Water Resources, River Development and Ganga Rejuvenation, Minor Irrigation (Statistics) Wing, Government of India. Available Online: http://micensus.gov.in/stateRep.html

GoI (2017): Report of 5th census of minor irrigation schemes. November, New Delhi: Ministry of Water Resources, River Development and Ganga Rejuvenation, Minor Irrigation (Statistics) Wing, Government of India. Available online: http://mowr.gov.in/report-5th-minor-irrigation-census-has-been-released

ITP (2017): *Fifth census of minor irrigation schemes*, 2013-14. Unpublished report. Anand: IWMI-Tata Water Policy Program (ITP).

MoA (2012): 8th Agricultural Census 2005-06. Agriculture Census Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. Available Online: http://agcensus.dacnet.nic.in/

MoA (2015): 9th Agricultural Census 2010-11. Agriculture Census Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. Available Online: http://agcensus.dacnet.nic.in/

Mukherji, A., Rawal, S. and Shah, T. (2013): Major Insights from India's Minor Irrigation Censuses: 1986-87 to 2006-07. *Economic and Political Weekly*, 48(26 & 27): 115-124.

Shah, T. (2009): Taming the Anarchy: Groundwater Governance in South Asia. Washington D.C.: RFF Press.

About the IWMI-Tata Program and Water Policy Highlights

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations. Through this program, IWMI collaborates with a range of partners across India to identify, analyze and document relevant water management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from International Water Management Institute (IWMI), Tata Trusts, CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or any of its funding partners.

IWMI Headquarters
127 Sunil Mawatha
Pelawatte, Battaramulla
Mailing Address
P. O. Box 2075, Colombo, Sri Lanka
Tel: +94 11 2880000, 2784080 **Fax:** +94 11 2786854
Email: iwmi@cgiar.org **Website:** www.iwmi.org

IWMI-Tata Water Policy Program
"Jal Tarang"
Near Smruti Apartments, Behind IRMA Gate
Mangalpura, Anand 388001, Gujarat, India
Tel: +91 2692 263816, 263817
Email: iwmi-tata@cgiar.org

IWMI International Water Management Institute

IWMI is a CGIAR Research Center and leads the: CGIAR

RESEARCH PROGRAM ON Water, Land and Ecosystems