RESEARCH ARTICLE

From Public to Private Irrigation: Implications for Equity in Access to Water

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Abstract: This article examines changes in the irrigation economy of India in the post-Independence period by drawing upon secondary data and data from in-depth village surveys conducted by the Foundation for Agrarian Studies (FAS). Specifically, it analyses the extent of inequality in the ownership of irrigation equipment and access to irrigation across socio-economic classes. The article argues that the shift in the irrigation economy towards private groundwater irrigation is associated with greater inequality in the ownership of irrigation equipment and in access to an assured source of irrigation. The evidence from village-level data shows that while intervention by the state protects the interests of small and poor cultivators, private control over water adversely affects access to irrigation, crop choice, and profitability in agriculture.

Keywords: Irrigation economy, groundwater irrigation, inequality, PARI, cropping pattern, irrigation cost, village studies, private irrigation, public irrigation.

Introduction

At the time of Independence, agriculture in India faced a crisis of stagnation marked by low crop yield, low shares of irrigated area, large areas of cultivated land lying fallow, deterioration in soil quality, and seeds of poor quality (Nanavati and Anjaria 1965, cited in Ramakumar 2012). The expansion and improvement of irrigation facilities were thus seen as important instruments to overcome the crisis in agriculture and achieve self-sufficiency in foodgrain production. The early 1950s witnessed significant investments in public irrigation schemes and an increase in the area irrigated under these schemes. The Green Revolution of the 1960s established the importance of irrigation, among other inputs, to achieve higher productivity in agriculture (Vaidyanathan 1999). From the late 1970s onwards, there was an increase in the area under groundwater irrigation. Private investment was crucial to this expansion of groundwater irrigation through wells and pumps. With the

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liberalisation of the Indian economy in the 1990s, the area under public surface irrigation declined and there was a corresponding increase in the area under private groundwater irrigation. Private investment in groundwater irrigation has registered a rapid increase since then over the years, with groundwater irrigation accounting for about 70 per cent of the total irrigated area in 2014 (NSSO 2015).

Groundwater ownership rights in India are tied to land ownership. As the distribution of land across households of different classes and castes is extremely unequal, there is an inherent inequality in the ownership of and access to groundwater. This fact assumes significance when we consider that 85 per cent of farmers in India belong to the marginal and small categories (that is, those who own one hectare and one to two hectares of operational land respectively) but cultivate only about 50 per cent of the operational agricultural land (NSSO 2015). Inequality in land distribution and the lack of credit to invest in tubewells have reduced direct ownership of groundwater irrigation structures among small and marginal farmers. These households depend on private water markets for irrigation, which in turn increases their cost of cultivation. I discuss this later in this article by drawing on data from the village surveys conducted under the Project on Agrarian Relations in India (PARI) by the Foundation for Agrarian Studies (FAS). Inequality in access to irrigation is, I argue, a contributory factor in contemporary agrarian distress, especially among marginal and small cultivators.

Further, the unregulated expansion of groundwater irrigation has led to significant decline in the water table across the country, raising concerns of fairness and equity in the access to groundwater.[1] Unlike large farmers who have the capital to invest in water extraction machines, marginal and small farmers cannot afford such technology, and are therefore further excluded from direct ownership of groundwater structures. Many micro-level studies have shown the implications of a declining water table for equity in ownership and access to groundwater for irrigation (for example, Bhatia 1992; Moench 1992; Nagaraj and Chandrakanth 1997; Sarkar 2011).

In this context, the following questions are raised in this article:

a. What are the levels of inequality in the ownership of groundwater structures and access to irrigation?
b. How does unequal access to irrigation affect agricultural production systems, including cropping patterns, costs of irrigation, and net returns from agriculture?

The next section of the article presents the shift in India's irrigation economy in the post-Independence period. It is based on two sources of official data and a review of

[1] According to the Central Ground Water Board (CGWB), about 3 per cent of all development blocks in India are classified as critical and 16 per cent as overexploited (CGWB 2014) with respect to water resources.

the existing literature. The third section introduces the study villages surveyed under PARI at different points of time. The fourth section examines how different irrigation regimes, each associated with public or private intervention in irrigation, determine inequality in the ownership of groundwater structures, access to irrigation, cropping patterns, and the cost of irrigation in agricultural production across socio-economic classes in the study villages. The last section summarises the findings of the article.

The Development of Irrigation in India: A Brief Review

Trends in Public Investment in Irrigation

Over the decades, public policies and expenditure patterns relating to irrigation in India have undergone significant changes, and influenced irrigation systems across the country. This section briefly reviews investment patterns with reference to India's irrigation systems between 1950–51 and 2006–07.

Between 1950 and 1997, the total investment made by the central and State governments in irrigation and flood control constituted the largest single item in total public sector plan outlay on agriculture and allied activities (Vaidyanathan 1999). Table 1 shows the magnitude and composition of investment under different heads of the irrigation sector for various Five Year Plans (henceforth FYP). It is evident from the table that the period under review saw significant changes in the irrigation sector. First, investment in major and medium irrigation schemes constituted the largest share of expenditure in the irrigation sector across the FYP, though a steep rise in prices and construction costs over time might account for this.

Secondly, considerable funding was given to minor irrigation works from the Third FYP (1960–61 to 1965–66), with groundwater receiving greater attention within the category of minor irrigation works. Public investment in minor irrigation works included direct investment by the government and private investment (mostly for groundwater irrigation) attracted other institutional credit. Institutional credit from the public sector rose sharply during the Third FYP (1960–61 to 1965–66) and Fourth FYP (1969–70 to 1973–74). More than 95 per cent of groundwater structures were established by farmers' investment, with the help of credit facilities from the Government of India and other financial institutions (Shah 1993; Vaidyanathan 1994, cited in Narayanamoorthy and Deshpande 2005). This shift in the expenditure pattern of minor irrigation works, specifically for groundwater irrigation, may have helped in the expansion of the area irrigated by groundwater in the country after the 1960s.

Thirdly, from the late 1990s there has been a noticeable decline in institutional credit for minor irrigation schemes. For example, between the Fourth FYP (1969–70 to 1973–74) and the Seventh FYP (1985–86 to 1989–90), public sector institutional credit

Table 1 *Magnitude and composition of investment in the irrigation sector for different Plan periods, 1951–56 to 2002–07, at current prices* in million Rupees

Five Year Plans (FYP)	Period	Major and medium irrigation	Minor irrigation			Command Area Development	Total
			Government	Institutional credit	All		
First FYP	1950—51 to 1954—55	37.6 (85)	6.6 (15)	Neg. (—)	6.6 (—15)	—	44.2 (100)
Second FYP	1955—56 to 1959—60	38 (70)	14.2 (26)	1.9 (4)	16.2 (30)	—	54.2 (100)
Third FYP	1960—61 to 1965—66	57.6 (57)	32.6 (32)	11.5 (11)	44.2 (43)	—	101.8 (100)
Annual Plans	1966—67 to 1968—69	43 (44)	32.1 (33)	23.5 (24)	55.6 (56)	—	98.6 (100)
Fourth FYP	1969—70 to 1973—74	124.2 (52)	50.6 (21)	66.1 (27)	116.7 (48)	—	241 (100)
Fifth FYP	1974—75 to 1978—79	251.6 (62)	62.8 (15)	79.9 (20)	142.6 (35)	14.8 (4)	409 (100)
Annual Plan	1979—80	207.9 (64)	49.6 (15)	48 (15)	97.7 (30)	21.5 (7)	327.1 (100)
Sixth FYP	1980—81 to 1984—85	736.9 (64)	197.9 (17)	143.8 (12)	341.7 (30)	74.3 (6)	1,152.9 (100)
Seventh FYP	1985—86 to 1989—90	1,110.7 (59)	313.2 (17)	306.1 (16)	619.3 (33)	144.8 (8)	1,874.8 (100)
Annual Plan	1990—91	263.5 (60)	81.2 (18)	67.6 (15)	148.8 (34)	28.6 (6)	440.8 (100)
Annual Plan	1991—92	282.4 (60)	84.4 (18)	67.4 (14)	151.8 (32)	33.4 (7)	467.6 (100)
Eighth FYP	1992—93 to 1996—97	2,166.9 (64)	623.1 (18)	424.2 (12)	1,047.2 (31)	193.8 (6)	3,408 (100)
Ninth FYP	1997—98 to 2001—02	4,929.0 (78)	863.5 (14)	266.2 (4)	1,129.7 (18)	222.3 (4)	6,280.9 (100)
Tenth FYP	2002—03 to 2006—07	8,364.7 (81)	1,392.4 (13)	325.7 (3)	1,718.2 (17)	253.5 (2)	10,336.4 (100)

Notes: Figures in parentheses indicate row share.
Major irrigation schemes are those with a Culturable Command Area (CCA) of more than 10,000 hectares; medium irrigation schemes have a CCA of more than 2,000 hectares and up to 10,000 hectares; and minor irrigation schemes have a CCA of less than 2,000 hectares. The Command Area Development (CAD) programme was initiated in 1974–75 to improve utilisation of the irrigation potential, and optimise agricultural production and productivity, through an integrated and coordinated approach to efficient water management.
Source: *Water and Related Statistics*, Central Water Commission 2013.

as a proportion of the total investment in irrigation remained at around 15 per cent, and declined to 3 per cent during the Tenth FYP (2002–03 to 2006–07). In the same period, between the Fourth FYP and the Seventh FYP, the total investment in minor irrigation schemes ranged between 30 to 50 per cent; this declined to 17 per cent during the Tenth FYP (Table 1).

Jha and Acharya (2011) examined trends in policies that govern public expenditure on agricultural and rural development, including expenditure on irrigation and flood control, in the post-Independence period. Their study classifies this period into three phases. The first phase, which lasted from the early years after Independence to the late 1960s, saw the central and State governments paying greater attention to the development of irrigation. This period was characterised by large outlays on medium and minor irrigation schemes. In the second phase, from the early 1970s to the late 1980s, substantial expenditure was incurred on new water technologies to promote the Green Revolution. The third phase, which begins with liberalisation of the economy in the 1990s, is characterised by a substantial reduction in the expenditure on agricultural and rural development. Expenditure on irrigation and flood control as a share of the total public sector plan expenditure rose steadily from the First FYP (1950–51 to 1954–55) to the Sixth FYP (1980–81 to 1984–85). This share declined in subsequent plan periods, particularly from the mid-1980s. In the Eleventh FYP (2007–08 to 2011–12), the share of irrigation and flood control came down to 5.8 per cent, as compared to 10 per cent during the Sixth FYP (Table 2) (*ibid.*, pp. 141–44).

Table 2 *Plan-wise outlay on irrigation and flood control by the centre, States, and Union Territories, 1960–61 to 2011–12, at current prices* in million Rupees and per cent

Five Year Plan (FYP)	Period	Actual plan outlay (in million Rupees)	Percentage of total plan outlay
Third FYP	1960—61 to 1965—66	66.5	7.8
Annual Plans	1966—67 to 1968—69	47.1	7.1
Fourth FYP	1969—70 to 1973—74	135.4	8.6
Fifth FYP	1974—75 to 1978—79	387.7	9.8
Annual Plan	1979—80	128.8	10.6
Sixth FYP	1980—81 to 1984—85	1,093	10
Seventh FYP	1985—86 to 1989—90	1,659	7.6
Annual Plan	1990—91	397.4	6.8
Annual Plan	1991—92	423.2	6.5
Eighth FYP	1992—93 to 1996—97	3,252.5	7.5
Ninth FYP	1997—98 to 2001—02	5,542.0	6.5
Tenth FYP	2002—03 to 2006—07	10,331.5	6.8
Eleventh FYP	2007—08 to 2011—12	21,032.6	5.8

Source: "Statistical Appendix, A 40–46," *Economic Survey, 2010–11*, Government of India (cited in Jha and Acharya 2011).

Though significant attention was directed towards irrigation as a part of the development of agriculture in the early decades after Independence, public expenditure to expand irrigation has slackened since, particularly from the mid-1980s onwards. Farmers have invested in groundwater irrigation separately from the State, as a response to the stagnation in public investment in irrigation, particularly surface irrigation schemes (Ramakumar 2012). These shifts in the investment pattern may affect the trends in area irrigated by different sources over time, as shown below.

Shift in Sources of Irrigation: From Public Canals to Private Tubewells

Table 3 shows the trends in area irrigated by different sources between 1950–51 and 2013–14. The total net irrigated area in the country increased from 20.9 million hectares (mha) in 1950–51 to 68.1 mha in 2013–14. In the same period, the gross area irrigated increased over four times, from 22.6 mha in 1950–51 to 95.8 mha in 2013–14. I discuss below the major changes in the development of different sources of irrigation during the period under review.

First, in the early FYP periods, substantial investment in major and medium irrigation schemes for the construction of dams, barrages, and canal networks resulted in

Table 3 *Trends in net irrigated area, gross irrigated area, and cropping intensity in India, by source, 1950–51 to 2013–14,* in million hectares and per cent

Year	Canal	Tanks	Wells		Other sources	Total net irrigated area	Gross irrigated area	Cropping intensity (in per cent)
			Tubewells	Other wells				
1950—51	8.3	3.6	*	6	3	20.9	22.6	111.1
1955—56	9.4	4.4	*	6.7	2.2	22.8	25.6	114.1
1960—61	10.4	4.6	0.1	7.2	2.4	24.7	28	114.7
1965—66	11	4.3	1.3	7.4	2.5	26.3	30.9	114
1970—71	12.8	4.1	4.5	7.4	2.3	31.1	38.2	117.7
1975—76	13.8	4	6.8	7.6	2.4	34.6	43.4	120.9
1980—81	15.3	3.2	9.5	8.2	2.6	38.7	49.8	123.1
1985—86	16.2	2.8	11.9	8.5	2.5	41.9	54.3	126.7
1990—91	17.5	2.9	14.3	10.4	2.9	48	63.2	130
1995—96	17.1	3.1	17.9	11.8	3.5	53.4	71.4	131.8
2000—01	16	2.5	22.6	11.3	2.9	55.2	76.2	131.1
2005—06	16.7	2.1	26	10	6	60.8	84.3	136.5
2010—11	15.6	2	28.5	10.6	6.9	63.7	88.9	139.6
2013—14	16.3	1.8	31.1	11.3	7.5	68.1	95.8	142

Notes: 1. * includes under "other wells," as separate figures were not collected for these years.
2. Net irrigated area is defined as the area irrigated by any source once a year, for a particular crop. Gross irrigated area is the total area irrigated under various crops in a year, including the area irrigated under more than one crop in the same year, as many times as the number of crops grown and irrigated.
Source: Ministry of Agriculture and Farmers' Welfare, Government of India, available at https://www.indiastat.com/

an expansion of the canal-irrigated area. The net irrigated area under canals was 8.3 mha in 1950–51, which increased to 17.5 mha in 1990–91. In subsequent years, particularly after 1990, there was a sharp decline in the area irrigated by canals. Several studies have discussed the reasons for the shrinking of public irrigation systems. These include poor operation and maintenance, degraded infrastructure, low productivity and financial returns, inequity in the allocation of water, waterlogging, and salinity in the command area (Dhawan 1997; Shah 2008; Namboodiri and Gandhi 2009; Mukherji 2016).

Secondly, groundwater emerged as a major source of irrigation in India, with rapid expansion of irrigated area, after 1970. The area irrigated by groundwater was only six mha in 1950–51, which increased to 12.9 mha in 1970–72 and 42.4 mha in 2013–14. Private investment in tubewell irrigation was a major factor that contributed to the expansion of groundwater irrigation. Table 4 shows that over 90 per cent of groundwater structures in the country, namely dug wells, shallow tubewells, and deep tubewells, are under private ownership. Timely access, reliability, and ability to control the use of water played a crucial role in the massive spread of tubewell irrigation among farmers (Dhawan 1991; Shah 1993; Vaidyanathan 1999).

Thirdly, between 1950–51 and 2013–14, there was a shift in the share of area irrigated by different sources in total net area irrigated (see Figure 1). Surface water irrigation (canal and tank) accounted for 57 per cent of total net area irrigated in 1950–51, but declined to 27 per cent in 2013–14. In the same period, the share of groundwater irrigation in the total net area irrigated increased rapidly, from 28.7 per cent in 1950 to 62.3 per cent in 2013 (Figure 1). Tubewell irrigation, in particular, saw dramatic changes in this period; in 1950, there was a complete absence of tubewells, but by 2013 they constituted a share of 45.7 per cent in net area irrigated. India is now the largest user of groundwater irrigation for agriculture in the world (Shah 2009), and has 19.2 million agricultural wells and tubewells (Planning Commission 2007).

However, this shift towards groundwater irrigation occurred over different phases. In the decade after Independence, groundwater irrigation was limited to only a small section of landlord farmers. The dominant sources of groundwater at that time were traditional dug wells that were 30 feet deep at most (Shah *et al.* 2012). Till the

Table 4 *Share of public and private structures by type of groundwater structure, in 1993, 2001, and 2006*, in per cent

Year	Dug well			Shallow tubewell			Deep tubewell		
	Public	Private	All	Public	Private	All	Public	Private	All
1993	1.5	98.5	100	0.6	99.4	100	11.5	88.5	100
2001	2	98	100	0.9	99.1	100	10.5	89.5	100
2006	3.9	96.1	100	1.7	98.3	100	4.1	95.9	100

Source: Government of India (2001, 2005, 2014).

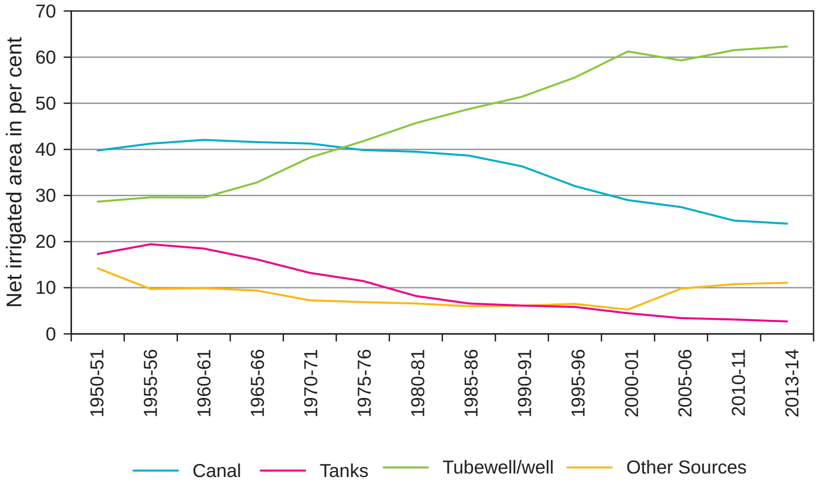

Figure 1 *Growth of net irrigated area under different sources, 1950–51 to 2013–14* in per cent
Source: Ministry of Agriculture and Farmers' Welfare, Government of India, available at https://www.indiastat.com/

mid-1960s, digging wells in the command areas of canal irrigation was either prohibited or subject to several restrictions. Once high-yielding varieties of seed were introduced, however, the restrictions on groundwater were largely relaxed, and use of groundwater was encouraged to ensure an ample and assured supply of water (Vaidyanathan 1999). Also, the government invested in public tubewells to make groundwater irrigation more affordable to small farmers. The public tubewells were managed by government-employed operators, and water rates were highly subsidised (Pant 1994). Despite these initiatives, however, groundwater irrigation failed to register a substantial increase (Shah 2012).

With the advent of the Green Revolution, private tubewells emerged as a major source of irrigation in Punjab and Haryana. The technology required to extract groundwater advanced from dug wells and borewells with centrifugal pumps in the 1970s to electric-powered, submersible pumps in the 1980s. In addition, government policies such as energy subsidies for agriculture (free electricity was supplied to Punjab, Haryana, Karnataka, Tamil Nadu, and Andhra Pradesh) and subsidised institutional credit for tubewell construction promoted the use of groundwater, and encouraged the massive spread of private tubewell irrigation across the country (Vaidyanathan 1999; Shah 2012; Mukherji 2016).

Factors Affecting Access to Groundwater Irrigation

The expansion in groundwater irrigation and private control over groundwater has led to concerns of equity in the ownership of groundwater structures and access to irrigation. This section examines some of the factors that govern ownership of and access to groundwater for irrigation.

Legal rights that govern groundwater in India do not treat groundwater as a common property or an open access resource. Access to groundwater, its regulation, and control of its use are largely derived from British laws (Cullet 2014). The right to groundwater follows from the right to ownership of land, which in turn is derived from the Indian Easement Act, 1882. In other words, "groundwater is attached, like a chattel to land property and . . . there is no limitation on how much groundwater a particular landowner may withdraw" (Singh 1991). Following from this, the unequal distribution of land across households belonging to different socio-economic classes and castes inevitably leads to inequalities in access to groundwater for irrigation. Table 5 shows the percentage of farm households of different land-size categories that owned groundwater structures. In 2013–14, in the large farmer category, 20.8 per cent owned dug wells, 22.7 per cent owned shallow tubewells, and 10.1 per cent owned deep tubewells. In contrast, only 2.4 per cent of all marginal farmers owned dug wells, 3.7 per cent owned shallow tubewells, and 0.5 per cent owned deep tubewells. Evidence from micro-level studies also indicates that inequalities in the ownership of groundwater structures are closely related to inequality in land distribution (Shah 1993; Bhatia 1992; Janakarajan 1993; Dubash 2002; Sarkar 2011; Rawal 2002).

It has been argued that the problem of unequal access to groundwater structures can be addressed by the market. Some studies propose that private water markets provide access to irrigation for small and marginal farmers, and thus promote equity in

Table 5 *Distribution of landholdings and ownership of groundwater structures by size of landholding in India, 2013–14* in number, million hectares, and per cent

Size of landholding category	Total number of holders (in millions)	Total area of holding (in million ha)	Average size of holding (ha)	Percentage of farmers that own groundwater structures		
				Dug well	Shallow tubewell	Deep tubewell
Marginal farmer	92.8	35.9	0.4	2.4	3.7	0.5
Small farmer	24.8	35.2	1.4	9.4	10.2	2.3
Semi-medium farmer	13.9	37.7	2.7	10	13	4.2
Medium farmer	5.9	33.8	5.8	9.4	11.3	6.3
Large farmer	1	16.9	17.4	20.8	22.7	10.1
All	138.3	159.6	1.2	4.9	6.2	1.5

Note: Large farmer households are those with over 10 hectares of operational land. Medium farmer households have operational land between four and 10 hectares. Semi-medium farmer households have operational land between two and four hectares. Small farmer households have operational land between one and two hectares. Marginal farmers have less than one hectare of operational land.
Source: Data on the number of holders and total holdings are from the *All-India Report on Agriculture Census*, Government of India (2015). Data on the number of tubewells are from the *Minor Irrigation Census*, Government of India (2017).

access to groundwater irrigation (Shah 1991). They also argue that a competitive groundwater market is associated with better utilisation of groundwater, and can act as an incentive in checking irrigation costs (Shah 1991; Shah and Ballabh 1997; Mukherji 2007). There are other studies, however, which show that water markets lead to exploitative relationships between tubewell owners and water buyers (Janakarajan 1993; Bhatia 1992). Sarkar (2011) points to how the water seller stands to profit from the groundwater market by gaining access to reliable irrigation through control over water. Thus, the water seller enhances output and adds to higher net returns from agriculture, as compared to the water buyer. The role of water markets is examined in a later section of this article, with data from the PARI village surveys.

Inequality in the distribution of tubewells is most pronounced in groundwater-depleted States, such as Punjab, Gujarat, Tamil Nadu, and Karnataka (Bhatia 1992; Nagaraj and Chandrakanth 1997), as compared to States with an abundance of groundwater, such as West Bengal. Falling water levels have further excluded a large number of marginal and small farmers from ownership of and access to irrigation, since lifting water from a greater depth requires new technology and substantial investment. Marginal and small farmers therefore either depend on the groundwater market for access to irrigation or change their crop combination. This has implications for equity, especially in a situation in which farmers have little opportunity for income generation (Dhawan 1982, cited in Sarkar 2011) and cannot exit agriculture. Data from the second (1993) and third (2001) Minor Irrigation Censuses (MIC) show that the water table in the country has been falling (Table 6). The share of villages where the depth of the water table was 60 metres and above increased from 3.9 per cent in 1993–94 to 7.3 per cent in 2001. The proportion of villages with a water table of less than 10 metres, however, fell from 61.9 per cent to 55.8 per cent in the same period.

To conclude, official data and the literature both confirm a shift in the irrigation economy of India from public canal irrigation in the two decades after

Table 6 *Distribution of villages in India by depth of the water table, in 1993–94 and 2000–01* in number and per cent

Depth of the water table (in metres)	1993—94		2000—01	
	Number	Percentage	Number	Percentage
Below 10 m	3,38,385	61.9	3,55,201	55.8
10—20 m	1,35,789	24.8	1,63,001	25.6
20—40 m	38,674	7.1	52,727	8.3
40—60 m	12,561	2.3	19,558	3.1
60 m and above	21,195	3.9	46,298	7.3
Total	5,46,604	100	6,36,785	100

Source: Government of India (2001, 2005).

Independence to private investment-led groundwater irrigation from the mid-1980s onwards. This shift has implications for equity in access to irrigation.

Village Surveys: An Introduction

This article uses household-level data of seven villages, collected as a part of the Project on Agrarian Relations in India (PARI) of the Foundation for Agrarian Studies (FAS) through surveys conducted in different agro-ecological regions of India (Figure 2).[2] PARI uses a consistent methodology of farm accounting to provide empirical data on production systems at the level of cultivator households. Details of the location and year of survey of each village are listed in Table 7.

In-depth census surveys were conducted between 2006 and 2010 in the seven study villages included in this article. Harevli, a canal- and groundwater-irrigated village located in the sugarcane-growing district of Bijnor in western Uttar Pradesh, was surveyed in 2006. In 2008, a census survey was conducted in Gharsondi, a village in Bhitarwar tehsil of Gwalior district in central Madhya Pradesh. In June 2009, two villages were surveyed in Karnataka State: Alabujanahalli, a canal-irrigated village in Mandya district, and Siresandra, a dry village in Kolar district. Rewasi, a dry

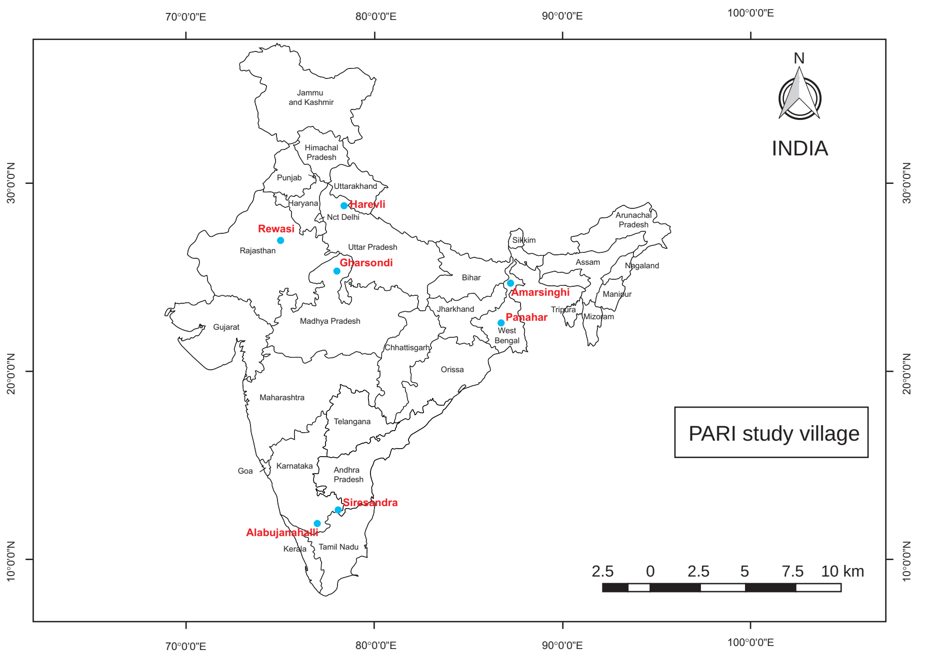

Figure 2 *Location of PARI study villages*

[2] Twenty-five villages in 11 States have been surveyed under PARI. See http://fas.org.in/category/research/project-on-agrarian-relations-in-india-pari/ for details.

Table 7 *List of study villages with location, year of survey, agro-ecological zone, and features of crop irrigation*

Village and district	State	Survey year	Agro-ecological zone	Features of irrigation and crops cultivated
Alabujanahalli (Mandya)	Karnataka	2009	Southern Dry Zone	Canal irrigation; sugarcane, paddy, finger millet, sericulture
Harevli (Bijnor)	Uttar Pradesh	2006	Bhabar and Tarai Zone	Canal and groundwater irrigation; wheat, sugarcane
Gharsondi (Gwalior)	Madhya Pradesh	2008	Gird Zone	Limited canal and groundwater irrigation; soybean, wheat, mustard
Amarsinghi (Malda)	West Bengal	2010 and 2015	New Alluvial Zone	Groundwater irrigation; monsoon (aman) rice, summer (boro) rice, jute
Panahar (Bankura)	West Bengal	2010 and 2015	Old Alluvial Zone	Groundwater irrigation; aman rice, boro rice, potato, sesame
Siresandra (Kolar)	Karnataka	2009	Eastern Dry Zone	Groundwater irrigation; finger millet, vegetables, sericulture
Rewasi (Sikar)	Rajasthan	2010	Transitional Plain Zone of Inland Drainage	Rainfed irrigation; pearl millet, wheat, mustard, fenugreek

Note: The listed agro-ecological zones are as per the National Agriculture Research Project (NARP) classification.
Source: PARI survey data.

village in the semi-arid region of Sikar district in Rajasthan, was surveyed in 2010. A census survey in 2010 and a sample survey in 2015 were conducted in Amarsinghi village (Malda district) and Panahar village (Bankura district), two groundwater-irrigated regions of West Bengal.

Socio-economic Classification

This section describes briefly the PARI classification of farm households into socio-economic classes in the study villages. The section is drawn from Ramachandran (2011).

A socio-economic classification of households was undertaken for each village, based on the three classical criteria used to differentiate the peasantry, namely, control over the means of production, relative use of family and hired labour, and the surplus that a household is able to generate within a working year. Based on these general criteria, households in the study villages were categorised broadly into the following five classes: landlords, capitalist farmers, peasants, manual workers, and households dependent on business, salaries, or other sources of income. Within each village, the peasantry was further subdivided based on the specific conditions of the village.

Landlords

These households own a large part of the land in most villages. There is a total absence of direct participation by these households in agricultural operations. Cultivation is conducted by hired labour, or by tenants to whom land is leased out by the landlord households. This class traditionally controlled all aspects of social, economic, and political hierarchies in most villages.

Capitalist Farmers

These households are similar to the landlord households in terms of their land and asset ownership and non-participation in agricultural operations. However, they are differentiated from the former in that they traditionally did not belong to the class of landlords. These households invested the surplus they gained from non-agricultural sources in land. Agriculture was not their primary source of economic power. Many of them previously belonged to the class of rich peasants or upper middle peasants, and they often belong to the dominant caste group.

Manual Workers

At the bottom of the rural class ladder are the manual workers. These households are characterised by their predominant dependence on wage incomes, either in agriculture or non-agricultural work. This category includes both agricultural and non-agricultural workers due to the increasing difficulty in separating these two groups from the pool of rural manual workers. The group of farm servants, involved in long-term work with a single employer, falls under this class. The manual worker can have diverse sources of income, such as animal husbandry, domestic work, and other low remunerative jobs in the private sector.

Peasants

The class of peasants is situated between the landlord and capitalist classes on the one hand, and the manual worker class on the other. The basic characteristic of these households is their participation in all or some agricultural operations on the land. This class is in itself differentiated, ranging from rich peasants to upper middle, lower middle, and poor peasants. The criteria used to further categorise the peasant households are broadly the extent of ownership of means of production (specifically land), the ratio of family labour and days of labouring out by members of the household (numerator) to the number of days of labour hired in (denominator), and net incomes. The exact criterion varies by village, as the specific cropping pattern, labour use pattern, caste configurations, and other socio-economic characteristics are kept in view while segregating the various classes of peasant households within a village. (Ramachandran 2011)

Only households primarily dependent on crop cultivation and allied activities in the study villages have been considered for this article. Based on the criteria listed above, specific socio-economic classes were identified for each village (Appendix Table 1).

Nature of Ownership, Access to Irrigation, and Agricultural Production

I have categorised the study villages under four distinct irrigation regimes on the basis of type of irrigation infrastructure (public investment in canals or groundwater irrigation, versus private investment in groundwater irrigation) and area irrigated by different sources of irrigation. The four categories are canal irrigation, groundwater irrigation, a combination of canal and groundwater irrigation, and dry villages with groundwater irrigation (Tables 8 and 9).

It is worth noting that combined canal and groundwater irrigation is practised in many parts of the country. For example, fields may receive water from more than one source (a public canal as well as a private tubewell) in different seasons or even in a single season. The official statistics on irrigation in India do not give information on crop lands that are irrigated by more than one source (Rawal 2001). PARI data can fill this gap by providing information on crop lands that receive water from multiple sources (Table 9).

In the following sub-sections, I examine how different types of irrigation infrastructure determine ownership and access to irrigation in the study villages, and their impact on agricultural production systems across socio-economic classes. While access to irrigation is not the sole factor determining household production decisions, it is nonetheless a vital component that influences cropping pattern and the level of productivity in agriculture, along with agro-climatic characteristics, inputs, capital, technology, and market conditions. In other words, cropping pattern choices are driven by access to resources, of which a critical resource is access to water or irrigation (Das and Swaminathan 2017).

Table 8 *Categorisation of villages by source of irrigation and type of infrastructure*

Type of infrastructure	Canal	Canal plus groundwater	Groundwater	Dry villages with groundwater irrigation
Public	Alabujanahalli	Gharsondi and Harevli	Amarsinghi	Siresandra
Private	NA	Gharsondi and Harevli	Amarsinghi and Panahar	Rewasi and Siresandra

Source: PARI survey data.

Table 9 *Proportion of gross cropped irrigated area (GCA) by different sources, selected villages* in per cent

Village	District	Canal/ river	Tubewell/ borewell	Multi-source	Pond/ Tank	Unirrigated	All
Alabujanahalli	Mandya	60.5	1.3	24.6	6.3	7.3	100
Harevli	Bijnor	8.4	47.3	37.1	0	7.2	100
Gharsondi	Gwalior	20.7	9.4	26.1	0	43.8	100
Amarsinghi	Malda	4.2	81.6	3.3	0.6	10.3	100
Panahar	Bankura	3.4	84.1	0.7	0.5	11.3	100
Rewasi	Sikar	0	63.1	0	0	36.9	100
Siresandra	Kolar	0.4	45.4	0	2	52.2	100

Source: PARI survey data.

Canal Irrigation

The public canal system is the predominant source of irrigation in Alabujanahalli village. The village is located in Maddur taluk (sub-district) of Mandya district, Karnataka State, and belongs to the Kaveri-irrigated region of south Karnataka. It receives irrigation water from a network of tanks that are fed by canals from the Krishnarajasagar dam on the Kaveri river. In 2009, two-thirds of the total crop land in the village was irrigated solely by the network of tanks, while the remaining one-third was irrigated by a combination of tanks and tubewells (Table 9).

There was no traditional landlord in this village. There were, however, two households with relatively large holdings that did not engage in any family labour, classified as "rich capitalist farmer" households. Peasant households in the village were classified as Peasant 1, Peasant 2, Peasant 3, and Peasant 4 on the basis of landholding (ownership and operational), income sources, and asset-holding (Ramachandran 2017; Appendix Table 1). According to the classification adopted, cultivator households constituted 57 per cent of all households in Alabujanahalli. Of these, 1.4 per cent were rich capitalist farmer households, 6.5 per cent were Peasant 1 households, 28.3 per cent were Peasant 2 households, 21.7 per cent were Peasant 3 households, and the remaining 42 per cent were Peasant 4 households. Table 10 shows that all the rich capitalist farmer households and Peasant 1 households owned tubewells fitted with electric pumps that were used for supplementary irrigation. The average value of the irrigation equipment of a household was Rs 12 lakhs for rich capitalist farmer and Peasant 1 households. In contrast, only 27 per cent of Peasant 3 households and 9 per cent of Peasant 4 households owned irrigation equipment, mostly diesel and electric pumps, for drawing and supplying water from tank networks to crop fields. The average value of the irrigation equipment of a household was Rs 35,492 for a Peasant 3 household and Rs 14,763 for a Peasant 4 household.

It is interesting to note that inequality in ownership of irrigation equipment among farm households did not affect access to irrigation in the survey year. The public

Table 10 *Proportion of households that owned irrigation equipment and average value of irrigation equipment by socio-economic class, Alabujanahalli, at 2015–16 prices* in per cent and Rupees

Socio-economic class	Proportion of households that owned irrigation equipment (in per cent)	Value of irrigation equipment per household (in Rupees)
Rich capitalist farmer	100	1,22,228
Peasant 1	100	1,16,661
Peasant 2	41	43,174
Peasant 3	27	35,492
Peasant 4	9	14,763

Source: PARI survey data, 2009.

canal irrigation system ensured water for cultivation across cultivator classes. Over 90 per cent of the gross cropped area belonging to all socio-economic classes was irrigated (Table 11). In years of shortage or drought, inequality in ownership of irrigation equipment among cultivator households may have an adverse effect on access to irrigation.

Secure and low-cost irrigation meant that all farm households in Alabujanahalli cultivated water-intensive crops such as paddy and sugarcane. A large extent of the cultivated land (about 80 per cent of gross cropped area) of Peasant 2, Peasant 3, and Peasant 4 households was under sugarcane and paddy (Table 12). Two rich capitalist farmers owned rice mills in the nearest market town, K. M. Doddi, which may be why 55 per cent of their total GCA was under paddy cultivation (Sarkar 2017). Irrigation cost constituted only 1.5 per cent of total paid-out cost for all socio-economic classes in Alabujanahalli, a fact that can be attributed to the low cost of canal irrigation and the almost equal average per hectare cost of irrigation across classes (Table 13).[3] Thus, in a public canal-irrigated village, despite the

Table 11 *Proportion of irrigated gross cropped area (GCA) as a share of total GCA by socio-economic class, Alabujanahalli, in 2008–9* in per cent

Socio-economic class	Irrigated GCA (in per cent)
Rich capitalist farmer	93
Peasant 1	96
Peasant 2	97
Peasant 3	90
Peasant 4	92
All	92

Source: PARI survey data, 2009.

[3] Paid-out cost was calculated using the definition of Cost A2 by the Commission for Agricultural Costs and Prices (CACP).

Table 12 *Share of different crops in gross cropped area (GCA) by socio-economic class, Alabujanahalli, 2008–9* in per cent

Socio-economic class	Sugarcane	Paddy	Finger millet	Mulberry	Fodder crops	Other crops	All
Rich capitalist farmer	35	55	5	0	0	5	100
Peasant 1	58	32	4	2	2	1	100
Peasant 2	42	44	6	7	1	0	100
Peasant 3	39	43	8	8	0	2	100
Peasant 4	30	48	9	12	1	1	100

Source: PARI survey data, 2009.

ownership of irrigation equipment being skewed towards rich capitalist farmer households, a public irrigation system ensured equitable supply of water for agriculture and reduced the cost of irrigation across farm households.

Combination of Canal and Groundwater Irrigation

Two study villages, Harevli (in Bijnor district, Uttar Pradesh) and Gharsondi (in Gwalior district, western Madhya Pradesh), were in the command area of canals. Harevli received water from a public canal that was part of the Eastern Ganga canal project and Gharsondi was irrigated by a canal on the Harsi dam. Canal irrigation, however, provided insufficient water for cultivation in both villages in the year preceding the survey. Shortage of canal water created a demand for alternative sources of irrigation and private tubewells emerged in both study villages as an alternative, particularly for rabi (winter) cultivation.

There were three landlord households in Harevli and 12 landlord/big capitalist farmer households in Gharsondi. These households had the largest extent of owned landholdings and operational holdings in the village. Their primary source of income was agriculture, apart from which they had diverse other sources of income. The peasant households of the two villages were further classified into four classes

Table 13 *Average cost of irrigation and irrigation cost as a proportion of total paid out-cost on operational holding by socio-economic class, Alabujanahalli, at 2015–16 prices,* in Rupees per hectare and per cent

Socio-economic class	Average cost of irrigation (in Rs per hectare)	Irrigation cost as a percentage of total paid-out cost
Rich capitalist farmer	1,413	1.3
Peasant 1	1,708	1.4
Peasant 2	1,926	1.9
Peasant 3	1,704	1.5
Peasant 4	1,475	1.3

Source: PARI survey data, 2009.

on the basis of landholdings (owned and operational holdings), income sources, and assets. These classes ranged from rich peasants to upper middle, lower middle, and small peasants (Ramachandran 2016). Inequality in ownership of irrigation equipment for private tubewell irrigation was very high across socio-economic classes in both villages (Table 14). All the landlord/big capitalist and Peasant 1 (rich)/capitalist farmer households owned tubewells and electric pumps, whereas only 17 per cent of Peasant 4 households in Gharsondi and 18 per cent of Peasant 4 households in Harevli owned irrigation equipment. The difference in the average value of irrigation equipment owned by households across classes was large. For example, in Harevli, the average value of irrigation equipment was Rs 1,51,982 for landlords/big capitalist farmers, Rs 65,182 for Peasant 1 (rich)/capitalist farmers, Rs 50,350 for Peasant 2 (upper middle) households, Rs 33,366 for Peasant 3 (lower middle) households, and only Rs 21,233 for Peasant 4 (small) households. Most submersible tubewells run by electric pumps were owned by the large landowning Tyagi households, while Peasant 3 and Peasant 4 households mainly owned diesel pumps. A similar pattern of unequal distribution of irrigation equipment across classes was observed in Gharsondi.

Inadequate supply of canal water on the one hand, and inequality in the ownership of private irrigation equipment on the other, led to differentiation in access to irrigation across classes. Table 15 shows that most of the land in both the villages belonged to landlords and rich capitalist farmers, and was irrigated by the public canal system

Table 14 *Proportion of households that owned irrigation equipment and average value of irrigation equipment by socio-economic class, Harevli (2006) and Gharsondi (2008), at 2015–16 prices* in per cent and Rupees

Socio-economic class	Harevli		Gharsondi	
	Proportion of households that owned irrigation equipment (in per cent)	Value of irrigation equipment (in Rs)	Proportion of households that owned irrigation equipment (in per cent)	Value of irrigation equipment (in Rs)
Landlord/big capitalist farmer	100	1,51,982	100	2,17,664
Peasant 1 (rich)/capitalist farmer	100	65,182	100	91,521
Peasant 2 (upper middle)	100	50,350	45	1,01,211
Peasant 3 (lower middle)	60	33,366	34	28,497
Peasant 4 (small)	18	21,233	17	21,561

Note: In Harevli, peasant households were classified as Peasant 1 (rich), Peasant 2 (upper middle), Peasant 3 (lower middle), and Peasant 4 (small). In Gharsondi, peasant households were classified as Peasant 1 (rich/capitalist farmer), Peasant 2 (upper middle), Peasant 3 (lower middle), and Peasant 4 (small).
Source: PARI survey data.

Table 15 *Share of gross irrigated area by source and socio-economic class, Harevli (2006) and Gharsondi (2008),* in per cent

Socio-economic class	Harevli				Gharsondi			
	Canal	Tubewell with diesel pump	Tubewell with electric pump	Multiple sources	Canal	Tubewell with diesel pump	Tubewell with electric pump	Multiple sources
Landlord/big capitalist farmer	–	–	54	46	16	0	20	64
Peasant 1 (rich)/capitalist farmer	5	15	37	43	19	0	26	55
Peasant 2 (upper middle)	6	48	13	32	35	0	14	51
Peasant 3 (lower middle)	18	22	17	42	75	0.2	11	14
Peasant 4 (small)	41	23	15	21	76	0.5	6	17

Note: In Harevli, peasant households were classified as Peasant 1 (rich), Peasant 2 (upper middle), Peasant 3 (lower middle), and Peasant 4 (small). In Gharsondi, peasant households were classified as Peasant 1 (rich/capitalist farmer), Peasant 2 (upper middle), Peasant 3 (lower middle), and Peasant 4 (small).
Source: PARI survey data.

as well as privately owned electric tubewells. Tubewells fitted with electric pumps were used for rabi cultivation and as supplementary irrigation for kharif (summer) crops. On the other hand, Peasant 4 households had very little access to tubewell irrigation and were primarily dependent on canal irrigation, which was erratic. Crop land owned by Peasant 3 and Peasant 4 households was irrigated through tubewells operated by diesel pump sets or by water purchased from other tubewell owners.

This disparity in access to irrigation had a visible impact on the cropping pattern. For example, in Harevli, the landlords, rich peasants, and middle peasants cultivated sugarcane, which requires irrigation throughout the year, on about 60 per cent of their gross cropped area (GCA) as they had greater access to tubewell irrigation (Table 16). In contrast, the Peasant 4 households in the village cultivated kharif paddy on 52 per cent of their GCA, using water for irrigation mainly from the public canal.

There was an acute shortage of water supply from the canal system in Gharsondi in the survey year, primarily on account of a bad monsoon. The main kharif crop, soybean, was completely destroyed due to lack of irrigation and pest attack. Cultivation became primarily dependent on tubewell irrigation. As a result, landlords and rich capitalist farmers who owned tubewells and had an assured source of irrigation cultivated a much higher proportion of paddy on their gross cropped areas (9 per cent) as compared to Peasant 4 households (only 0.8 per cent) (Table 17). In contrast, Peasant 3 and Peasant 4 households cultivated unirrigated crops such as black gram and

Table 16 *Proportion of different crops in gross cropped area (GCA), by socio-economic class, Harevli, 2006*, in per cent

Crop season	Crop	Landlord/ big capitalist farmer	Peasant 1 (rich)	Peasant 2 (upper middle)	Peasant 3 (lower middle)	Peasant 4 (small)
Kharif	Paddy	10	2	4	9	52
Kharif	Fodder and other crops	10	16	13	7	16
Kharif	All crops	20	18	17	17	68
Rabi	Wheat and intercrops	24	21	26	19	16
Rabi	Fodder and other crops	2	2	4	2	0
Rabi	All crops	26	23	30	21	16
Annual	Sugarcane	54	59	53	62	16
Gross cropped area	All crops	100	100	100	100	100

Source: PARI survey data, 2006.

Table 17 *Proportion of different crops in gross cropped area (GCA) by socio-economic class, Gharsondi, 2008,* in per cent

Crop season	Crop	Landlord/big capitalist farmer	Peasant 1 / rich capitalist farmer	Peasant 2 (upper middle)	Peasant 3 (lower middle)	Peasant 4 (small)
Kharif	Soybean	36	31.8	38.6	33.7	30.3
Kharif	Paddy	9	9.9	4	0.7	0.8
Kharif	Black gram	2.1	3.3	4.6	11.9	12.1
Kharif	Sesame	1.6	1.2	3.7	4.3	9
Kharif	Fodder crops	0.3	0.6	0.4	0.5	0.2
Kharif	All crops	49	46.7	51.2	51.1	52.5
Rabi	Wheat	34.8	30.3	29.6	16.2	21.6
Rabi	Wheat (intercrop)	0.2	4.6	2.6	11.3	7.3
Rabi	Chickpea and intercrop	12.8	14.5	14.3	19.2	17.7
Rabi	Fodder and other crops	2.7	3.9	2.3	2.3	0.9
Rabi	All crops	50.5	53.3	48.8	48.9	47.5
Gross cropped area	All crops	100	100	100	100	100

Source: PARI survey data, 2008.

sesame in the kharif season. In the rabi season, Peasant 3 and Peasant 4 households cultivated wheat intercropped with rapeseed, in order to reduce their losses.

As the water rates for canal irrigation were uniform for all cultivators in the villages, differences in irrigation costs across classes were mainly on account of disparities in ownership and access to tubewells. In Harevli, the average per hectare costs of irrigation for landlords, Peasant 1, and Peasant 2 households were Rs 7,620, Rs 11,190, and Rs 9,351, respectively, and constituted about 8 per cent of total paid-out cost (Table 18). Peasant 3 households undertook sugarcane cultivation (on a greater share of operated land) using water from own tubewell irrigation (usually diesel pump set-operated tubewells) or water purchased from tubewell owners. This resulted in high irrigation costs for these households, amounting to Rs 14,623 per hectare of operational holding or 16.8 per cent of total paid-out cost. Peasant 4 households had a lower area under rabi cultivation and annual crops, and limited use of groundwater irrigation, and thus a lower irrigation cost. Peasant 3 and Peasant 4 households in Gharsondi had very limited access to tubewell irrigation, and therefore had less area under water-intensive crops.

Thus outcomes were significantly different across socio-economic classes in adverse conditions, such as shortage of canal water. Landlord and rich capitalist households used their own tubewells for supplementary irrigation to avert losses. In contrast,

Table 18 *Average cost of irrigation and irrigation cost as a percentage of total paid-out cost on operational holding by socio-economic class, Harevli (2006) and Gharsondi (2008), at 2015–16 prices* in Rupees per hectare and per cent

Socio-economic class	Harevli		Gharsondi	
	Average cost of irrigation (Rs per hectare)	Irrigation cost as a percentage of total paid-out cost	Average cost of irrigation (Rs per hectare)	Irrigation cost as a percentage of total paid-out cost
Landlord/big capitalist farmer	7,620	7.6	1,448	4.5
Peasant 1 (rich)/capitalist farmer	11,190	8.1	1,588	4.8
Peasant 2 (upper middle)	9,351	7.9	1,586	3.7
Peasant 3 (lower middle)	14,623	16.8	905	2.9
Peasant 4 (small)	3,540	5.1	1,072	3

Note: In Harevli, peasant households were classified as Peasant 1 (rich), Peasant 2 (upper middle), Peasant 3 (lower middle), and Peasant 4 (small). In Gharsondi, peasant households were classified as Peasant 1 (rich/capitalist farmer), Peasant 2 (upper middle), Peasant 3 (lower middle), and Peasant 4 (small).
Source: PARI survey data.

lower middle (Peasant 3) and small peasant (Peasant 4) households had to depend on purchased water or shift their cropping pattern to unirrigated crops.

Groundwater Irrigation

Agricultural land in Panahar village (Bankura district) in West Bengal was primarily irrigated by groundwater. The village is located in the command area of the Kangsabati project but receives very little water for irrigation from it. Electricity for irrigation came to the village in the mid-1980s. About 85 per cent of the total irrigated area was under tubewell irrigation by 2010. Private tubewell irrigation was the predominant source of irrigation. Land irrigated by tubewells was triple-cropped.

There were seven landlord/capitalist farmer households in Panahar. Of these, three were Muslim households and were descendants of a Muslim *jotedar* family. The other four households were *goala* families that initially had small holdings but purchased land over time. All the other peasant households had less than two hectares of operational holdings. These households were further classified into "upper" and "lower" peasant households on the basis of a labour ratio criterion (Ramachandran 2015). In general, agricultural land in the village is characterised by small farms and fragmented landholdings. In 2010, the average size of an operational holding in Panahar was only 1.1 acres.

Expansion of electrified tubewells for irrigation in Panahar was undertaken primarily by the large landowners. Ownership of submersible tubewells was skewed in favour

Table 19 *Share of gross irrigated area by purchased water, by socio-economic class, Amarsinghi and Panahar, 2009,* in per cent

Village	Landlord/big capitalist farmer	Peasant (upper)	Peasant (lower)
Amarsinghi	NA	74	90
Panahar	13	72	96

Source: PARI survey, 2010.

of large farmer households: all seven landlord households together owned 11 out of a total of 16 electrified submersible tubewells in 2010. Despite the concentration in ownership of tubewells, all farm households had access to tubewell irrigation in all seasons. A majority of cultivators purchased water for irrigation from the water market and sale of water from tubewells predominated in the water market. About 96 per cent of gross irrigated area operated by lower peasant households was irrigated by purchased water (Table 19). Village-level data do not show a significant difference in the cropping pattern across socio-economic classes in Panahar village (Table 20). Most farm households in Panahar cultivated water-intensive crops such as summer (boro) rice. Potato was cultivated in the rabi season. The private water market ensured a regular supply of water for cultivation.

Disparities came to the fore when we studied the cost of irrigation. In general, the cost of irrigation is higher for villages that depend on groundwater irrigation as compared to canal-irrigated villages. In Panahar, all landlord/big capitalist households used their own tubewells for cultivation. As a result, the average cost of irrigation was low, at Rs 7,355 per hectare of operated land at constant prices in 2015–16, and constituted only 6.5 per cent of total paid-out cost (Table 21). In contrast, most of the lower peasant households purchased water from the private water market, paying a much higher price for irrigation. The average cost of irrigation for these households was Rs 10,684 per hectare of operated land at constant prices in 2015–16, and constituted 13.4 per cent of total paid-out cost.

Amarsinghi village is situated in Ratua I block in Malda district, in the New Alluvial Plains of West Bengal. The description given below of irrigation in Amarsinghi

Table 20 *Proportion of cultivated area in total gross cropped area (GCA), by season and socio-economic class, Amarsinghi and Panahar, 2010* in per cent

Socio-economic class	Amarsinghi			Panahar		
	Pre-kharif	Kharif	Rabi	Pre-kharif	Kharif	Rabi
Landlord/big capitalist farmer	NA	NA	NA	30	47	23
Peasant (upper)	14	40	46	25	45	30
Peasant (lower)	11	37	52	26	52	22

Source: PARI survey data, 2010.

Table 21 *Average cost of irrigation and irrigation cost as a percentage of total paid-out cost on operational holding, by socio-economic class, Amarsinghi and Panahar, at 2015–16 prices*, in Rupees per hectare and per cent

Socio-economic class	Amarsinghi		Panahar	
	Average cost of irrigation (in Rs)	Irrigation cost as a percentage of total paid-out cost	Average cost of irrigation (in Rs)	Irrigation cost as a percentage of total paid-out cost
Landlord/big capitalist farmer	NA	NA	7,355	6.5
Peasant (upper)	9,211	10.7	8,897	7.8
Peasant (lower)	12,480	16.7	10,684	13.4

Source: PARI survey data, 2010.

village is taken from Modak and Bakshi (2017). Landholdings in the village were small: the average size of operational holdings was only 0.8 acre. There were no landlord/capitalist farmer households. Peasant households were classified into "upper" and "lower" on the basis of a labour ratio criterion (Ramachandran 2015).

There were two sources of irrigation in Amarsinghi in 2010: tubewell irrigation and river lift irrigation (RLI). The RLI scheme was established in the late 1970s in a nearby village, and only some of the crop land belonging to cultivators in Amarsinghi was irrigated by water from the RLI scheme. In the early 1980s, farmers began to install self-operated, diesel-powered shallow tubewells (known as mini-tubewells). Private shallow tubewells and the RLI scheme increased the extent of boro cultivation in the village, and resulted in a change from mono-cropping to multiple cropping. In the mid-2000s, the increasing cost of diesel and the inability of diesel-powered shallow tubewells to extract water from greater depths, particularly in summer, led to diesel tubewell owners abandoning shallow tubewells. Electricity for irrigation came to the village in 2007. Shallow tubewell owners gradually shifted to electric-powered submersible tubewells. There were no diesel-powered shallow tubewells in the village in 2015. The data on the number of tubewells between 2005 and 2015 show a tendency towards concentration of ownership and control over water sources. In 2015, there were only four tubewells in the village. The richest household owned two tubewells; of the remaining two, one was owned jointly by two households.

A public deep tubewell was installed in the village in 2008 by the Irrigation Department of the Government of West Bengal in response to the continuous demands of farmers in Amarsinghi and surrounding villages. This tubewell is managed by an 18-member cooperative group. A majority of cultivators in the village bought water for irrigation. In 2010, 90 per cent of lower peasant households and 74 per cent of upper peasant households bought water (Table 19); 44 per cent of cultivator households purchased water from the cooperative-run tubewell, and 63 per cent from private water sellers.

These two state interventions, electrification and the installation of a tubewell by the government, substantially reduced the costs of irrigation for the major irrigated crops. For example, the average irrigation cost per hectare in 2010 for the primary irrigated crop, boro rice, was Rs 14,030 for households that used private diesel-powered tubewells and Rs 9,869 for households that used private electric-powered tubewells. In the same year, households that had access to the cooperative deep tubewell had a much lower irrigation cost as compared to the prevalent rates in the private water market: Rs 4,653 per hectare for boro rice. Higher rates in the private water market increased the total paid-out cost and reduced profits. To cite an example, the profitability of boro rice in Amarsinghi in 2010 was high for households that used the cooperative deep tubewell as compared to those that used private tubewells.

Dry Villages with Groundwater Irrigation

Cultivators in Rewasi village (Sikar district) in the Western Dry agroclimatic zone of Rajasthan mainly practised rainfed agriculture in the survey year. There was no public source of irrigation and cultivation was entirely dependent on private tubewell irrigation. The use of irrigation in the kharif season was limited due to high summer temperatures and sandy soil; in the rabi season, only irrigated land could be cultivated (Swaminathan and Rawal 2015). Eleven open wells were functional in Rewasi in 2010. Electric-powered submersible tubewells were fitted into the base of open wells to extract groundwater from greater depths.

Eight households that were among the richest in Rewasi were classified as "landlords and rural rich." These households wielded considerable social and political power in the village. Peasant households were further classified as Peasant 1, Peasant 2, Peasant 3, and Peasant 4 on the basis of asset ownership (see Swaminathan and Rawal 2015 for details). Survey data show that all landlord and rich peasant households had access to privately owned groundwater structures in 2010.

On account of the scarcity of rainfall and limited availability of irrigation, ownership of and access to irrigation controlled the agricultural production system in Rewasi. Table 22 shows that only about 25 per cent of operational holdings belonging to Peasant 3 and Peasant 4 households was irrigated in the kharif season. In the survey year, in the kharif season, Peasant 3 and Peasant 4 households incurred losses from crop production as 70 per cent of their crops were completely destroyed due to limited access to irrigation (*ibid.*). In the rabi season, 49 per cent and 59 per cent, respectively, of operational holdings belonging to Peasant 3 and Peasant 4 households were sown, and the rest of the land was left fallow due to lack of access to water. The average cost of irrigation for Peasant 3 and Peasant 4 households was

Table 22 *Share of irrigated, unirrigated, and fallow land in total operational holdings, by season, by socio-economic class, Rewasi, 2010* in per cent

Socio-economic class	Kharif			Rabi		
	Irrigated	Unirrigated	Fallow	Irrigated	Unirrigated	Fallow
Landlords and rural rich	44	42	14	72	0	28
Peasant 1	49	30	21	76	0	24
Peasant 2	44	36	20	80	0	20
Peasant 3	24	65	11	49	0	51
Peasant 4	26	59	15	59	0	41

Source: PARI survey data, 2010.

high, as many such households received water on payment from other tubewell owners. As shown in Table 23, the average irrigation cost per acre of operational holding incurred by Peasant 3 and Peasant 4 households was Rs 11,302 and Rs 12,706, respectively, at constant prices in 2015–16, while it was only Rs 5,486 for landlord/rich peasants, Rs 6,521 for Peasant 1 households, and Rs 7,873 for Peasant 2 households.

Siresandra village is located in the water-scarce district of Kolar, in the Eastern Dry Region of Karnataka State. Private tubewells were the primary source of irrigation in the village, although electricity for irrigation was free in the State. Siresandra was characterised by severe depletion of groundwater and falling water tables. Inequality in ownership and access to groundwater structures had further increased with groundwater depletion and was clearly evident. As installing tubewells at greater depths involved high risk and required considerable capital investment to draw water from an ever-receding water table, poor farmer households that owned tubewells could hardly access water.

There were no landlords or capitalist farmers in the village. Peasant households were classified into Peasant 1, Peasant 2, and Peasant 3 households on the basis of asset

Table 23 *Average cost of irrigation and irrigation cost as a percentage of total paid out-cost on operational holding, by socio-economic class, Rewasi, at 2015–16 prices* in Rupees per hectare and per cent

Class	Average cost of irrigation	Irrigation cost as a percentage of total paid-out cost
Landlords and rural rich	5,486	18.2
Peasant 1	6,521	21
Peasant 2	7,873	20.5
Peasant 3	11,302	19.8
Peasant 4	12,706	24.6

Source: PARI survey data, 2010.

Table 24 *Proportion of cultivated area in total gross cropped area (GCA), by season and socio-economic class, Siresandra, 2009* in per cent

Class	Annual	Kharif	Rabi	Total
Peasant 1	32	26	43	100
Peasant 2	24	63	13	100
Peasant 3	14	76	10	100

Source: PARI survey data, 2009.

ownership and value (Ramachandran 2017). Four Peasant 1 households controlled 30 per cent of all operational holdings in the village, and only 35 per cent of all operational landholdings was under irrigation in the survey year. Drip irrigation technology was used in vegetable cultivation to reduce the wastage of water (Sarkar 2017). However, the use of irrigation was limited to rich peasant households (Peasant 1) in the village In 2009, all Peasant 1 households in Siresandra owned tubewells whereas only 53 per cent of Peasant 3 households owned tubewells, many of which were not operational and could not extract water from greater depths, particularly in the summer months. In addition, the use of groundwater for irrigation was restricted among Peasant 2 and Peasant 3 households in the survey year, as tubewell owners did not have surplus water to sell to other peasants. Table 24 shows the extent of total gross cropped area that belonged to Peasant 2 and Peasant 3 households in the village, and was under cultivation in the kharif season. Cultivation in this season was primarily dependent on the monsoon rains. Only 13 per cent and 10 per cent of the gross cropped area belonging to Peasant 2 and Peasant 3 households, respectively, were under rabi cultivation, but this proportion was 43 per cent for Peasant 1 households.

Electricity for irrigation was free in Siresandra, and hence, the marginal cost of irrigation was zero. Tubewell owners, however, reported that frequent voltage fluctuations and interruptions in the supply of electricity increased the maintenance and repair costs of pumps, adding to the cost of irrigation. Table 25 shows that the average cost of irrigation per hectare of operational holding was much higher for Peasant 2 (Rs 2,804) households and Peasant 3 households (Rs 2,762), as compared to Peasant 1 households (Rs 993).

Table 25 *Average cost of irrigation and irrigation cost as a percentage of total paid-out cost on operational holding by socio-economic class, Siresandra, at 2015–16 prices* in Rupees per hectare and per cent

Class	Average cost of irrigation	Irrigation cost as a percentage of total paid-out cost
Peasant 1	993	0.7
Peasant 2	2,804	3.5
Peasant 3	2,762	2.1

Source: PARI survey data, 2009.

Importantly, survey data from Siresandra for 2009, 2014, and 2017 show a high concentration of operational tubewells in the village and a continuous depletion of groundwater. In 2017, only three rich farmer households owned operational tubewells and were able to cultivate in the rabi season. The average depth of tubewells installed in 2009 was 900 feet, which increased to 1,200 feet in 2014, and about 1,500 feet in 2017. Also, getting an operational tubewell involved high risk. To cite one example, SG, a rich peasant, owned 12 tubewells in 2015, of which only two were operational. The cost of installation of a submersible tubewell in 2015 was about Rs 1.5 lakh, which made it economically unviable for poor peasant households to bear the risk. Hence, all except three rich peasant households were excluded from ownership of and access to irrigation in 2017. Lack of access to irrigation in Siresandra raises questions on the actual benefits that large electricity subsidies provide to farmers, particularly in water-scarce regions. A study in Karnataka based on data from the 54th and 55th rounds of the National Sample Survey Organisation (NSSO) shows that the benefits of electricity subsidy for irrigation were concentrated among medium and large farmers, with 80 per cent of the subsidy accruing to farmers who owned over two hectares of agricultural land and already had access to irrigation (Howes and Murgai 2003).

Evidence from this water-scarce village shows that water markets do not develop automatically. Although the data are from a single village, they raise questions about water markets providing access to irrigation for small and marginal farmers in different agro-climatic regions. Also, markets may not develop due to the limited natural availability of groundwater. In Siresandra, despite there being a demand for irrigation water, the available groundwater was not shared or distributed through a market mechanism but was utilised only by the owners of groundwater structures. This control over groundwater further resulted in a high level of social inequality.

Conclusion

This article examines the development of the irrigation economy in India. In the early decades after Independence, significant investments were made in public surface irrigation schemes. This resulted in an increase in the area under canal irrigation schemes, from 8.3 mha in 1950–51 to 17.5 mha in 1990–91. However, public investment in irrigation slowed down from the mid-1980s, and further declined in the liberalisation era, that is, from 1991 onwards. In the Sixth Five-Year Plan (1980–85), the share of expenditure on irrigation and flood control in total public sector plan expenditure was 10 per cent. This share came down to 5.8 per cent in the Eleventh Five-Year Plan (2007–08 to 2011–12). From a predominantly public canal system the focus shifted to groundwater irrigation funded largely by private investment. The area under groundwater was only six million hectares (mha) in 1950–51, and increased to 42.4 mha in 2013–14. This rise in groundwater irrigation led to a concentration of ownership of groundwater structures in the hands of large farmers.

For this article, I examined empirical household-level data from seven villages in five States of the country, collected as part of surveys conducted by the Project on Agrarian Relations in India (PARI) of the Foundation for Agrarian Studies (FAS), to understand the levels of inequality in the ownership of groundwater structures and access to irrigation, and the effect of such inequality on agricultural production systems. The study villages were categorised into four distinct irrigation regimes on the basis of type of irrigation infrastructure (public investment in canals or groundwater irrigation versus private investment in groundwater irrigation) and area irrigated by different sources of irrigation. The four categories are canal irrigation, groundwater irrigation, a combination of canal and groundwater irrigation, and dry villages with groundwater irrigation. The major points that emerged from the analysis of each irrigation regime are as below.

First, a public canal irrigation scheme ensured water for cultivation across cultivator classes in Alabujanahalli (Mandya district in Karnataka) during the survey year. Inequality in the ownership of irrigation equipment among farmer households did not affect access to irrigation. All farmer households cultivated water-intensive crops such as sugarcane and paddy. Over 90 per cent of the gross cropped area belonging to all socio-economic classes was irrigated during the survey year. The irrigation cost was very low and was almost equal across socio-economic classes. The irrigation cost constituted only 1.5 per cent of total paid-out cost for all socio-economic classes.

Secondly, unreliable canal irrigation created a demand for alternative sources of irrigation in Harevli (Bijnor district in Uttar Pradesh) and Gharsondi (Gwalior district in western Madhya Pradesh). Farmers in these villages invested in private tubewell irrigation. However, the investments were primarily made by landlord and rich farmer households. Lower and middle peasant households in Harevli and Gharsondi mainly owned diesel pumps or had to access water through diesel pumps by making a high payment to tubewell owners. This led to differentiation in access to irrigation and had a visible impact on the cropping pattern across socio-economic classes. For example, in Harevli, landlords and rich peasant households cultivated sugarcane on about 60 per cent of their gross cropped area (GCA) as they had greater access to tubewell irrigation. By contrast, relatively poor peasant households cultivated kharif paddy on 52 per cent of the gross cropped area cultivated by them, using mainly canal irrigation. In Gharsondi, landlord and rich capitalist households were able to minimise losses from soybean cultivation by using their own tubewells as supplementary irrigation. Lower middle and small peasant households had to depend on purchased water or had to change their cropping pattern to unirrigated crops.

Thirdly, in two study villages in West Bengal, namely Panahar (Bankura district) and Amarsinghi (Malda district), tubewells were the predominant source of irrigation. In Panahar, 11 out of a total of 16 electrified submersible tubewells were owned by landlord households in 2010. Despite the concentration in ownership of tubewells, all farm households had access to tubewell irrigation in all seasons from the water market. The fragmented nature of landholdings and the high installation cost of tubewells created an informal private water market in the village. The variation in cost was significant in this village. For example, the average cost of irrigation for landlord households was comparatively low, at Rs 7,355 per hectare of operated land at constant prices in 2015–16, since they used their own tubewells. In contrast, the average cost of irrigation per hectare of operated land for lower peasant households was Rs 10,684 per hectare of operated land at constant prices in 2015–16, as most of them purchased water from the private water market.

In Amarsinghi, two state interventions in groundwater irrigation substantially reduced the cost of irrigation: one, electricity for irrigation that came to the village in 2007; and two, a public deep tubewell introduced by the Irrigation Department of the Government of West Bengal in 2008 and managed by an 18-member cooperative group. Irrigation costs differed significantly between the private water market and the public cooperative tubewell. In 2010, the average irrigation cost per hectare for summer (boro) rice in the private water market was Rs 14,030 for diesel pumps and Rs 9,869 for electric pumps. In contrast, the water charge from the cooperative tubewell for boro rice was only Rs 4,653 per hectare.

Fourthly, in the two dry villages, namely Rewasi (Sikar district in Rajasthan) and Siresandra (Kolar district in Karnataka), the extent of inequality in ownership of groundwater structures and access to irrigation was much higher. The evidence from Siresandra shows that depletion of groundwater and falling water tables has further excluded small and marginal farm households from ownership of and access to groundwater structures, as large capital costs and high risk are involved in getting an operational tubewell that can draw water from greater depths. Significantly, despite the demand for irrigation water, the available groundwater was not shared or distributed through a market mechanism but utilised only by the owners of groundwater structures. This raises questions about water markets providing access to irrigation for small and marginal farmers in different agro-climatic regions.

To sum up, the shift in the irrigation economy towards private groundwater irrigation in India is associated with higher inequality in the ownership of groundwater structures and access to assured irrigation for all cultivator households. State intervention in irrigation can protect the interests of small and poor cultivators, whereas private control over water further affects crop choices, increases risk, and lowers profitability in agriculture. Inequality in access to irrigation is an important contributory factor to contemporary agrarian distress, especially among small and poor cultivators.

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Appendix Table 1 *Distribution of cultivator households in the study villages, by socio-economic class* in number and per cent

Village	Socio-economic class	Number of households	Share of total cultivator households
Alabujanahalli	Rich capitalist farmer	2	1.4
	Peasant 1	9	6.5
	Peasant 2	39	28.3
	Peasant 3	30	21.7
	Peasant 4	58	42

Note: There was no traditional class of landlords in Alabujanahalli. Two households with relatively large holdings that did not engage in any family labour were classified as "rich capitalist farmer" households. Peasant households, whose earnings were primarily from cultivation, were classified as Peasant 1, Peasant 2, Peasant 3, and Peasant 4 on the basis of landholding (ownership and operational), income sources, and asset-holding. The value of household assets was above Rs 50 lakhs for Peasant 1 households, between Rs 20 lakhs and Rs 50 lakhs for Peasant 2 households, between Rs 10 lakhs and Rs 20 lakhs for Peasant 3 households, and below Rs 10 lakhs for Peasant 4 households.

Village	Socio-economic class	Number of households	Share of total cultivator households
Harevli	Landlord	3	4.3
	Peasant 1 (rich)	10	14.5
	Peasant 2 (upper middle)	13	18.8
	Peasant 3 (lower middle)	15	21.7
	Peasant 4 (small)	28	40.6

Note: There were three landlord households in Harevli. These households had the largest extent of owned landholdings in the village. Peasant households were further classified into four classes on the basis of landholding (owned and operational holding), income sources, and assets. These classes were Peasant 1 (rich), Peasant 2 (upper middle), Peasant 3 (lower middle), and Peasant 4 (small).

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Appendix Table 1 *(continued)* *Distribution of cultivator households in the study villages, by socio-economic class* in number and per cent

Village	Socio-economic class	Number of households	Share of total cultivator households
Gharsondi	Landlord/Big capitalist farmer	12	8.5
	Peasant 1/Rich capitalist farmer	6	4.2
	Peasant 2 (upper middle)	22	15.5
	Peasant 3 (lower middle)	44	31
	Peasant 4 (small)	58	40.8
Note: In Gharsondi, there were 12 landlord/big capitalist farmer households. Peasant households were categorised on the basis of landholding, income sources, and asset holding. Peasant 1 (rich/capitalist farmer) households owned a substantial extent of land (the average landholding was around 27.5 acres). The value of asset holding of Peasant 1 households was around Rs 56 lakhs to Rs 98 lakhs. Peasant 2 (upper middle) households had asset value ranges from Rs 24 lakhs to Rs 55 lakhs. The average landholding of this class was 12 acres. Peasant 3 (lower middle) households had an average landholding of five acres and asset values ranging between Rs 8.8 lakhs to Rs 24 lakhs. The average holding of Peasant 4 (small) households was 2.3 acres. The asset holding of this category ranged between Rs 64,000 and Rs 13 lakhs.			
Amarsinghi	Peasant (upper)	18	33.3
	Peasant (lower)	36	66.7
Note: There were no landlord/capitalist farmer households. Peasant households were classified into "upper" and "lower" on the basis of a labour ratio criterion.			
Panahar	Landlord/Big capitalist farmer	7	4.6
	Peasant (upper)	52	34.2
	Peasant (lower)	93	61.2
Note: There were seven landlord/capitalist farmer households in Panahar. Of these, three were Muslim households and were descendants of a Muslim *jotedar* family. The other four households were *goala* families that initially had small holdings but had purchased land over time. All others were peasant households with less than two hectares of operational holdings. These households were further classified into "upper" and "lower" peasant households on the basis of a labour ratio criterion.			

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Appendix Table 1 *(continued)* *Distribution of cultivator households in the study villages, by socio-economic class* in number and per cent

Village	Socio-economic class	Number of households	Share of total cultivator households
Rewasi	Landlord and rural rich	8	5
	Peasant 1	14	8.8
	Peasant 2	26	16.3
	Peasant 3	59	36.9
	Peasant 4	53	33.1

Note: Eight households that were among the richest in Rewasi were classified as "landlords and rural rich." Peasant households with means of production valued at more than Rs 20 lakhs per household were classified as Peasant 1, households with means of production between Rs 10 lakhs and Rs 20 lakhs per household were classified as Peasant 2, households with means of production valued between Rs 5 lakhs and Rs 10 lakhs per household were classified as Peasant 3, and households with means of production valued at less than Rs 5 lakhs were classified as Peasant 4.

Village	Socio-economic class	Number of households	Share of total cultivator households
Siresandra	Peasant 1	4	6.7
	Peasant 2	24	40
	Peasant 3	32	53.3

Note: There were no landlords or capitalist farmers in the village. Peasant households were classified into Peasant 1, Peasant 2, and Peasant 3 households on the basis of value of assets owned. The value of household assets was above Rs 50 lakhs for Peasant 1 households, between Rs 15 lakhs and Rs 50 lakhs for Peasant 2 households, and below Rs 15 lakhs for Peasant 3 households.

Source: PARI survey data; Ramachandran, 2015.