

Original Research Article
**Potential and Determinants of Groundwater Use
in Coimbatore District of Tamil Nadu**

ABSTRACT

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Aims: To study the potential and determinants of groundwater use

Study design: Purposive random sampling.

Place and Duration of Study: The study was conducted in the Coimbatore district of Tamil Nadu and the survey was conducted during July 2021 and September 2021.

Methodology: The sample size selected for the study is 480 which includes 160 sample farmers from each region. Mean and simple regression analysis with regional dummy was used for the study.

Results: The groundwater was highly developed in the overexploited region. Among the farmers, it was highly developed among the medium farmers. The determinants of groundwater use on the farm are the overexploited region, farm size and cultivating water-loving crops of expecting higher income.

Conclusion: The groundwater is highly tapped in the overexploited region and mostly by the large farmers of the region. Sustainable groundwater management is essential for addressing the developing water scarcity problems. The optimal extraction of groundwater could be the solution for the groundwater depletion particularly in the overexploited regions of the district. It could be made possible by regulatory institutions. One could conclude that our policy focus may be tilted towards the water management practices and particularly in the regions of overexploited area.

Keywords: groundwater, wells, groundwater development, groundwater use, groundwater over-extraction, regional dummy

1. INTRODUCTION

Groundwater is an important source of freshwater that supplies nearly half of the household needs of the world's population [16]. Groundwater meets around 38 per cent of global consumptive irrigation water demand [12]. Groundwater depletion is a major issue in most of the world's irrigated regions, where millions of people live [8]. [2,13] report that groundwater abstraction accounts for 33 per cent of total withdrawals globally and provides water for agricultural (42 per cent), domestic (36 per cent), and industrial (27 per cent) demands. The rapid growth of irrigated farmland to fulfil the needs of the growing population has resulted in the exploitation of groundwater [4,15]. More than half of the population relies on groundwater for food production [3,12]. According to [5], the current global groundwater footprint is 3.5 times the actual aquifer area, posing a threat to about 1.7 billion people, even though 80 per cent of aquifers have footprints smaller than their area, implying that only a few overexploited aquifers are responsible for the net global footprint. Groundwater depletion is primarily concentrated in isolated overexploited aquifer systems, such as those in Northern India [11,15].

Irrigated agriculture is suited more in the water scarce region than rainfed agriculture [1,9,10]. Even in rainy regions, mismanagement of water resources can lead to a greater dependency on groundwater due to uneven rainfall distribution [11]. India mostly reliant on the Indian summer monsoon rain, and lower monsoon rain might lead to drought [6]. During such dry periods, water extracted from groundwater causes a drop in groundwater level, worsening drought conditions even more [14].

The availability of groundwater is a boon to agriculture. The resource's fugitive character necessitates caution in its management. Due to the policy, the resource's marginal cost is zero, it takes farmers a long time to recognize the importance of economic and use efficiency. Though groundwater is a renewable resource, the time it takes to replenish it may be longer and more uncertain, similar to the pattern of depositing and withdrawing funds from a bank account with the option of saving for the future or spending now. A groundwater resource overdraft occurs when withdrawal or draught exceeds recharge. As the water table drops, resulted in raising the short- and long-term costs of groundwater

development. The depth and density of wells are uncontrollable. The productivity of farms and the equality and sustainability of resources over time and space impact high social costs.

As a result, groundwater is a critical resource for the sustainability of ecosystems and lives in the world's second-most populous country. Groundwater can also help to mitigate the negative effects of climate change on water availability. Rapid groundwater depletion is still one of the most serious for long-term sustainability issues. In the present and expected future climates, groundwater sustainability is critical for satisfying food and water needs. It is hypothesised that ground water is depleting at a higher rate and the large farmers of overexploited region exploits more. The study discussed about the depleting factors at the farm level.

2. METHODOLOGY

2.1 Selection of study area and sampling design

The study was carried out in the Coimbatore district, which is located in the western part of Tamil Nadu, between the latitudes of 10° 10' N and 11° 30' N, and the longitudes of 76° 40' E and 77° 30' E, with an annual average rainfall of 1215 mm. The southwest and northeast monsoons cater to rain to the district. The northeast monsoon brings the most rain to the area, and summer showers are rare. The Palghat Gap on the Eastern side of the Western Ghats had a profound impact on the climate and agriculture of the district. This gap delivers a huge amount of rain to Pollachi Taluk during the southwest monsoon. The district's temperature ranges from 18.6° to 35.7° Celsius. The district is the hard rock type which is composed of rocks such as charnockite, sillimanite, genesis, granite, pyroxenite calc. granulites quartzite and alluvium.

As per the recent GO Dynamic groundwater resources assessment for Tamil Nadu dated 23.10.2019 categorization, the regions are classified into firkas. There are 38 firkas in the district. Firkas are classified into over-exploited, critical, semi-critical, safe, and saline, or poor quality firkas based on their percentage of exploitation. The firkas which are exploited more than 100 per cent are overexploited firkas, between 90 to 100 per cent are critical firkas, between 70 to 90 per cent are semi-critical firkas, and less than 70 per cent are safe firkas. Over-exploited, critical, semi-critical, and safe firkas were purposively selected for the study since it critically shows the negative externalities of the groundwater. Of the 38 firkas, 26 firkas are overexploited five firkas are in critical, six firkas are in semi-critical, and one falls in safe firka.

Among 38 firkas in the district, two firkas from each category that critically shows the externality were purposively selected for the study. Four villages from each firka were purposively selected for the study, which is shown in the figure 1. The villages selected for the study from the overexploited firka were Kunnathur, Pachapalayam, Naranapuram, and Kattampatti from Annur firka, Thondamuthur, Narasipuram, Alandurai, and Booluvampatti from Thondamuthur firka. From critical firka, the villages selected were Madukkarai, Ettimadai, Seerapalayam, and Pichanur from madukkarai firka and the villages from saravanampatti firka were Kalapatti, Vilankurichi, Vellaikinaru and Chinnavedampatti. The two firka selected from semi-critical firka were Kuniyamuthur firka and Karamadai firka. The villages were Kurinchi, Kulathupalayam, Pulakadu, and Kuniyamuthur from Kuniyamuthur firka and the villages under Karamadai firka were Sikkarampalayam, Bellathi, Kemmarampalayam and Maruthur. The total sample size was 480 which constitute twenty members from each village. The table shows the detailed distribution of samples in the study area.

Primary data was collected from the sampled respondents through personal interviews with the aid of a pre-tested interview schedule designed specifically for the purpose. The personal interview method was adopted to ensure that the data obtained from the respondents were relevant, comprehensive reasonably correct, and precise. Detailed information of the respondents like the number of open wells or bore wells and their usage in their farm. The data collected were tabulated, processed, and subjected to statistical analysis.

Table 1 Distribution of sample respondents in each region

Over exploited region	No. of samples	Critical region	No. of samples	Semi critical region	No. of samples
Annur region	80	Madukkarai region	80	Kuniyamuthur region	80
Kunnathur	20	Madukkarai	20	Kurichi	20
Pachapalayam	20	Ettimadai	20	Kulathupalayam	20
Naranapuram	20	Seerapalayam	20	Pulakadu	20
Kattampatti	20	Pichanur	20	Kuniyamuthur	20
Thondamuthur	80	Saravanampatti	80	Karamadai region	80

region		region			
Thondamuthur	20	Kalapatti	20	Sikkarampalayam	20
Narasipuram	20	Villankurichi	20	Bellathi	20
Alandurai	20	Vellaikinaru	20	Kemmarampalayam	20
Booluvampatti	20	Chinnavedampatti	20	Maruthur	20
Total respondents	160		160		160

Source: Primary data collection (2021)

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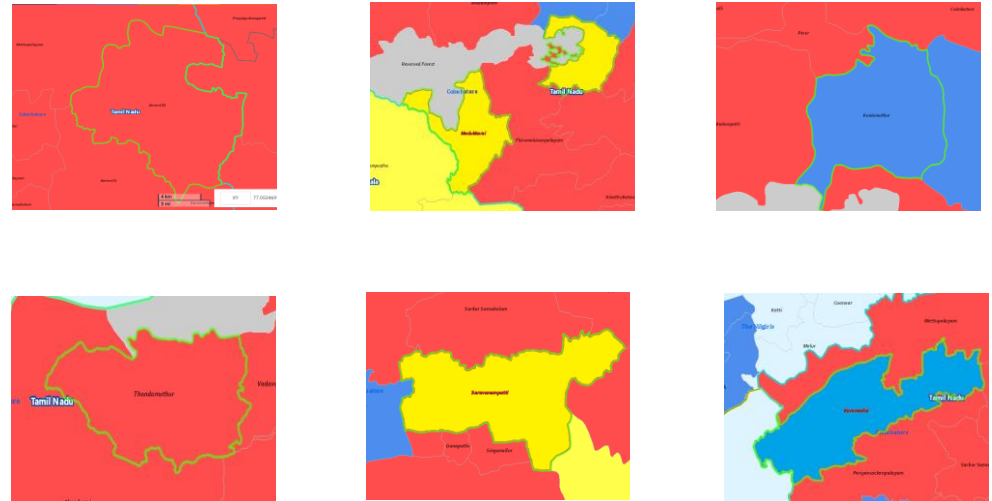
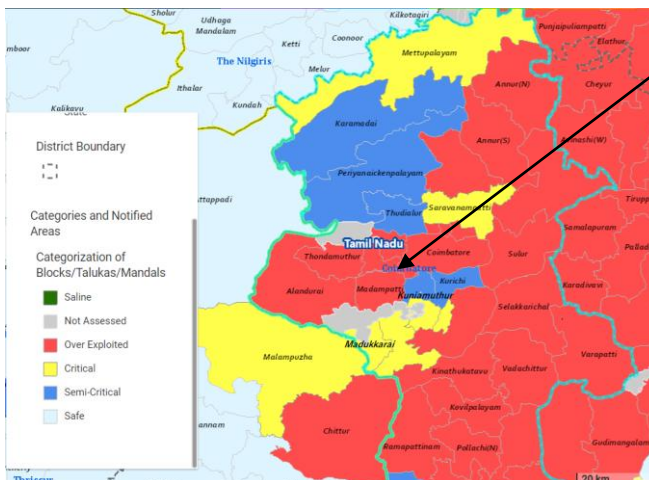
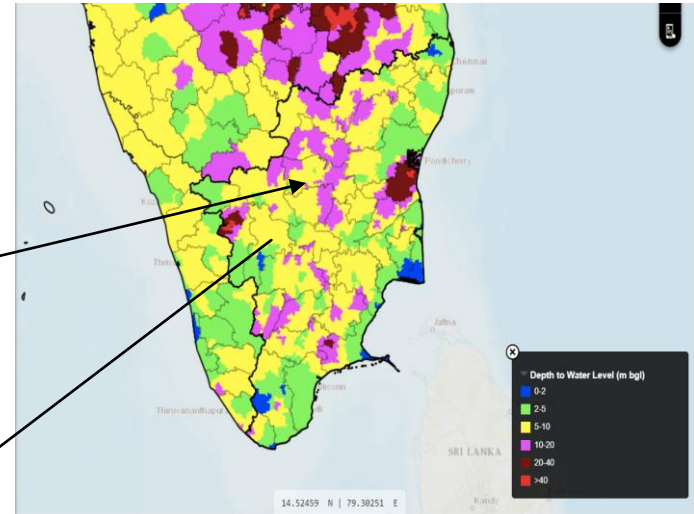
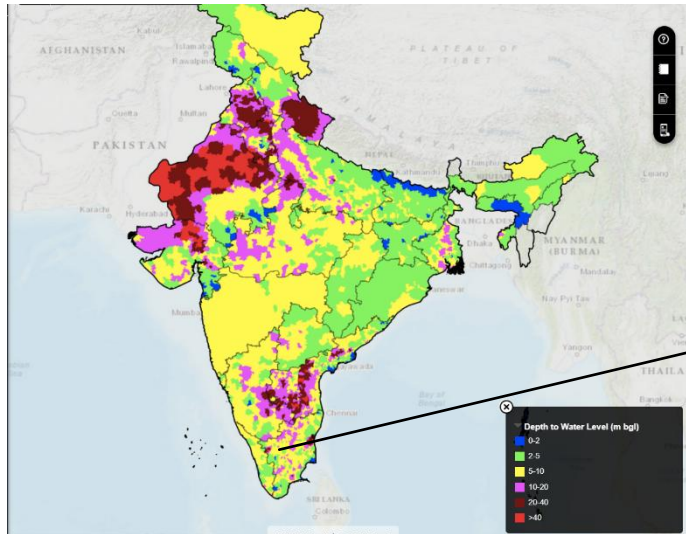


Fig 1 Selection of study area

2.2 Analytical framework

2.2.1 Determinants of groundwater use on the farm

Groundwater is highly developed in the Coimbatore district of Tamil Nadu. The groundwater use on the farm was determined by the factors such as depth to the water table, farm size, the area under water-loving crops, non-farm income and adopter or non-adopter of water management practice. The adoption of drip irrigation is mentioned in the study.

The linear regression model was used for analysis. Water pumped per hectare is a dependent variable and depends on the factors such as regional dummy which are overexploited region, critical region and semi-critical region, depth to water table, farm size, area under water-loving crops and adoption of water management practices.

The linear regression model used is,

$$W = \beta_0 + \beta_1 R2 + \beta_2 R3 + \beta_3 D + \beta_4 FSIZE + \beta_5 AWLC + \beta_6 NFI + \beta_7 ADOPT$$

Brief accounts of a priori of the explanatory variables are discussed hereunder:

FIRKA : It is expected that overexploited region may have a positive influence on the volume of water pumped since groundwater has highly developed in the overexploited region and the other firkas may have a negative influence on the dependent variable. The groundwater has less development in the other regions.

D : Depth to water is the distance between the surface of groundwater and the water availability in the well. Depth to the water level in feet may negatively influence the dependent variable. As the distance increases the volume of water pumped may decrease.

FSIZE : The increase in farm size increases the volume of water pumped. The increase in farm size forces the farmer to extract more water. It is expected that it may positively influence the volume of water pumped.

AWLC : Area under water-loving crops may have a positive sign on the dependent variable. If the farmer has a larger area under a water-loving crop, there is a need for a large volume of water.

NFI : It is expected that non-income may have a negative influence on the dependent variable (volume of water pumped). The increase in non-income will decrease the interest of the farmers to cultivate more areas simultaneously decreasing the volume of water pumped per hectare.

ADOPT : Adoption or non-adoption of water management activities may negatively influence the volume of water pumped. Installation of drip irrigation in the farm may decrease the volume of water pumped.

Table 2. Variables and units of measurement

Variable	Definition	Expected sign
Dependent variable		
W	The volume of water pumped (in m ³)	
Independent variable		
R1, R2, R3	Dummy for different firkas such as overexploited, critical and semi-critical firkas	+/-
D	Depth to water table (in feet)	-
FSIZE	Farm size (in hectares)	+
AWLC	The area under water-loving crops (in hectares)	+
NFI	Non-farm income (in rupees)	-
ADOPT	Adoption of water management practices; 0 for non-adopter and 1 for an adopter	-

3. RESULTS AND DISCUSSION

3.1 Groundwater depletion in the district

Groundwater is the major source of irrigation in the Coimbatore district. According to the Ground Water Potential Assessment conducted in March 2009, six blocks in the Coimbatore District are classified as overexploited and critical, while the remaining six blocks are classified as semi-critical and safe.

The State's next Ground Water Resources Assessment was completed in March 2011 with Firka as the assessment unit was shown in the table 3. There are 33 Firkas in the Coimbatore District, 22 of which are classified as Over Exploited, and the remaining 11 are classified as Semi Critical and Safe blocks. Instead of using Block as an assessment unit, Firka can be used to concentrate the assessment at the micro-level. A block with more than three to four Firkas, for example. Two Firkas in this block may have better groundwater potential than the other two Firkas, although they may be classified as Overexploited. To avoid this, assessments based on Firkas are conducted for the benefit of farmers in the implementation of irrigation schemes. By switching from a Block to a Firka assessment, the ratio of overexploited and critical Firkas has grown. In the Coimbatore District, the total percentage of overexploited and critical Blocks was 50 per cent in 2009, but the total percentage of overexploited and critical Firkas was 66.66 per cent in March 2011.

Long-term changes in water levels in several parts of the Coimbatore District range from ground level to 14.0 m. The water level in the north, west, and central areas of the Coimbatore District has decreased, according to the analysis. The lack of rainfall, which influences the groundwater levels in the phreatic aquifer, is inferred from the annual fluctuations. The seasonal fluctuation investigation demonstrates that the water level has decreased as a result of the requirement to develop groundwater for various sectoral purposes and the failure of the monsoons.

The groundwater level is high in July followed by August and it was very low in the cold month of December. The groundwater is highly correlated with groundwater availability [7]. The yearly average groundwater availability is 12.35 meters. The month-wise groundwater fluctuation is shown in figure1.

Figure 2 shows that the groundwater level has decreased over the years. The meter below ground level (mbgl) is the distance between ground level and the water level. If the value was low, the distance is shallow, higher water availability. If the value is high, the distance is high and low water availability. The difference is very high during July followed by August. The difference is low during the cold month of December. It could be inferred from the figure that groundwater is highly depleted over the years and it may increase widely in near future.

Table 3. Development of groundwater resources in the district

Categorization	Number of firkas		
	2011	2013	2017
Over Exploited	21	21	26
Critical	1	2	5
Semi Critical	9	8	6
Safe	2	2	1
Saline	..	..	..
Total	33	33	38

Sources: India Water Resource Information System, 2020

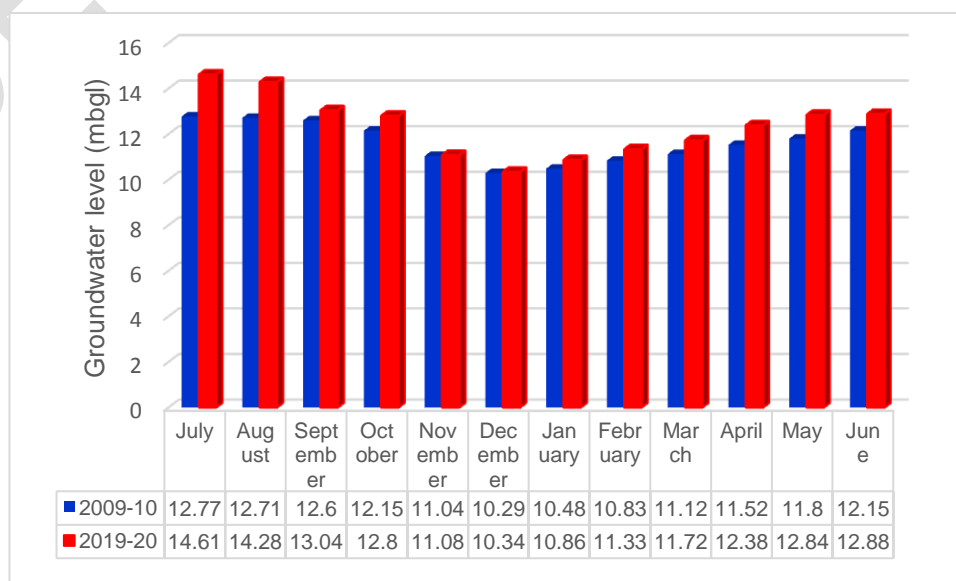


Fig 2 Seasonal fluctuation of groundwater in Coimbatore district

3.2 Distribution of electric pumps

The distribution of electric pumps among the different classifications of farmers answers the question of who owns multiple numbers of pumps and who invests more in irrigation well. It is argued that large landowners have the potential to own electric pumps and multiple pumps and pumps of higher horsepower, they consume more electricity than the others.

The analysis of the pump ownership pattern indicates that the majority of the farmers in the overexploited region own 2 pumps on their farms followed by 3 pump sets. The large farmers of the overexploited region own 41.30 per cent of the 3 pump sets on the farm. Mostly all the categories of the farmers own 3 pumpsets on the farm. The marginal and small farmers (50 per cent) of the overexploited region have only one electric pump set on their farm.

In the case of the critical regions, most of the large farmers own 3 pump sets on the farm followed by medium farmers (62.71 per cent). Half of the small farmers own 2 pump sets on the farm followed by medium farmers (27.94 per cent). Only marginal and small farmers own 1 pump on the farm.

In the semi-critical region, 68.97 per cent of the medium farmers own 3 pump sets on the farm followed by large farmers (31.03 per cent). The majority of the farmers of the semi-critical region own only 1 pump on the farm. Table 4 shows that a large number of pumps is due large the area of the farm.

Table 4. Distribution of farmers based on number of pumps

(Numbers)

Regions/ Landholding size in ha	Over exploited region			Critical region			Semi-critical region		
	1 Pump	2 Pump	3 Pump	1 Pump	2 Pump	3 Pump	1 Pump	2 Pump	3 Pump
Marginal (<1 ha)	7 (50.00)	13 (14.44)	4 (8.70)	18 (54.55)	15 (22.06)	..	52 (73.24)	38 (63.33)	..
Small (1-2 ha)	7 (50.00)	30 (55.56)	8 (17.39)	15 (45.45)	34 (50.00)	..	19 (26.76)	7 (11.67)	..
Medium (2- 4 ha)	..	37 (30.00)	15 (32.60)	..	19 (27.94)	37 (62.71)	..	15 (25.00)	20 (68.97)
Large (>4 ha)	..	..	39 (41.30)	..	..	22 (37.29)	..	..	9 (31.03)
All categories	14 (100)	80 (100)	66 (100)	33 (100)	68 (100)	59 (100)	71 (100)	60 (100)	29 (100)

Source: Primary data collection (2021)

Note: Figures in the parentheses indicate the percentage of farmers.

3.3 Distribution of pump horsepower

The power of an electric pump is usually determined by two factors: the amount of horsepower available (the minimum pump size is 3 HP) and the amount of groundwater that needs to be drawn to the surface. For instance, marginal and small farmers may be obliged to install a larger pump than is economically warranted by the land they do crop, while in locations where the water table is too deep, larger horsepower pumps may be required.

Table 5 shows that a large number of farmers own 10 HP motors in the overexploited area, particularly by large farmers (56.52 per cent) followed by medium farmers (43.48 per cent). The 3 HP pump set is owned by a very small proportion of small and marginal farmers.

In the critical region, the majority of the farmers own 5 HP motors followed by 3 HP motors. More than half of the farmers who own 7.5 HP pumps are large farmers, 49.81 per cent of the 5 HP pump owners are small farmers and more than 60 per cent of the 3 HP pump owners are medium farmers.

All the large farmers in the semi-critical region have 7.5 HP pumps, whereas the majority of the 7.5 HP pumps are owned by medium farmers (32.50 per cent). Nearly half of the farmers who own 5 HP pumps are marginal farmers. Large farmers have 3 HP pumps followed by 5 HP pumps and 7.5 HP pumps.

The frequency distribution of using different horsepower electric motor in the study area indicate that in general the farmers in all the regions, irrespective of size group, go for relatively higher horsepower electric motors. This is evidenced from the analysis that 5 HP indicates the severity of the problem of groundwater depletion.

Table 5. Frequency distribution of horse pump electric motors

Regions/ Landholding size in ha	Over exploited region				Critical region				Semi-critical region			
	3 HP	5 HP	7.5 HP	10 HP	3 HP	5 HP	7.5 HP	10 HP	3 HP	5 HP	7.5 HP	10 HP
Marginal (<1 ha)	2 (20.00)	18 (45.00)	4 (9.76)	..	10 (16.67)	12 (19.67)	11 (28.21)	..	52 (71.23)	27 (47.37)	11 (27.50)	..
Small (1-2 ha)	8 (80.00)	12 (30.00)	25 (60.97)	..	13 (21.67)	30 (49.18)	6 (15.39)	..	11 (15.07)	8 (31.58)	7 (17.50)	..
Medium (2-4 ha)	..	10 (25.00)	12 (29.27)	30 (43.48)	37 (61.66)	19 (31.15)	..	..	10 (13.70)	12 (21.05)	13 (32.50)	..
Large (>4 ha)	..	..	..	39 (56.52)	..	..	22 (56.41)	..	..	..	9 (22.50)	..
All categories	10 (100)	40 (100)	41 (100)	69 (100)	60 (100)	61 (100)	39 (100)	..	73 (100)	47 (100)	40 (100)	..

Source: Primary data collection (2021)

Note: Figures in the parentheses indicate the percentage of farmers.

3.5 Number of functioning wells and failed wells

The number of wells in the study area critically shows the groundwater development, exploitation and interferences. The increase in number results in increased exploitation. The increased dried wells critically show the externality in the sense of increased well investment.

The total number of wells (37.35 per cent) and dried wells (37.85 per cent) are higher in the overexploited regions. The per cent of open wells (36.34 per cent) are higher in critical regions followed by semi-critical regions (32.14 per cent). The proportion is more or less similar. The dried wells are also high in the overexploited regions because of over-abstraction due to larger cropped areas of water-loving crops. The bore wells dug cum bore wells are higher compared to the other regions. The borewells and open wells are more compared to the dug cum borewells because the probability of water is less in the case of the dug cum bore well. The farmers prefer a new bore well than to dug the dried open well. The number of open wells is more in critical and semi-critical regions because of less groundwater development in the study area.

Table 6. Total number of wells and failed wells

Firkas	Open wells	Borewells	Dug cum bore wells	Total	Dried wells
Over exploited	150	168	54	372	260
Critical	173	121	51	346	232
Semi critical	153	83	42	278	195

Total wells	476	372	147	996	687
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Source: Primary data collection (2021)

3.6 Distribution of wells across the different categories of farmers

The frequency distribution of wells among the different categories of farmers answers the question of who own more wells. Medium and large farmers (32.00 per cent) of the overexploited region own a large number of open wells followed by small farmers. Medium farmers (32.14 per cent) own a large number of the dug wells followed by large farmers (31.55 per cent). Medium farmers (31.99 per cent) own a large number of total wells. The proportion of dried wells is largely owned by large farmers (40 per cent). Mostly medium and large numbers have the highest groundwater development.

In the critical region, medium farmers (42.77 per cent) own a large number of open wells followed by small farmers (24.28 per cent). The dug wells are largely owned by the medium farmers (43.80 per cent) followed by small farmers (23.97 per cent). The proportion of wells dried is high in the case of large farmers (45 per cent).

The farmers of the semi-critical region own a large number of open wells than dug wells. The groundwater is highly developed by the medium farmers in the semi-critical region. The study indicated that medium and large farmers own a large number of wells. The number of dried wells typically shows the groundwater depletion in the study area.

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Table 7. Distribution of wells across landholding sizes

Regions/ Landholding size in ha	(numbers)														
	Over exploited region					Critical region					Semi-critical region				
	No. of open wells	No. of dug wells	No. of dug cum bore wells	Total wells	% of wells dried up	No. of open wells	No. of dug wells	No. of dug cum bore wells	Total wells	% of wells dried up	No. of open wells	No. of dug wells	No. of dug cum bore wells	Total wells	% of wells dried up
Marginal (< 1 ha)	18 (12.00)	20 (11.90)	7 (12.96)	45 (12.10)	15	24 (13.87)	16 (13.22)	8 (15.38)	48 (13.87)	25	70 (45.75)	38 (45.78)	20 (47.62)	128 (46.04)	15
Small (1-2 ha)	36 (24.00)	41 (24.40)	14 (25.93)	91 (24.46)	10	42 (24.28)	29 (23.97)	12 (23.08)	83 (23.99)	15	18 (11.76)	10 (12.05)	5 (11.90)	33 (11.90)	12
Medium (2-4 ha)	48 (32.00)	54 (32.14)	17 (3.48)	119 (31.99)	35	74 (42.77)	53 (43.80)	22 (42.31)	149 (43.06)	15	50 (32.68)	27 (32.53)	13 (30.95)	90 (30.95)	33
Large (>4 ha)	48 (32.00)	53 (31.55)	16 (29.63)	117 (31.45)	40	33 (19.08)	23 (19.01)	10 (19.23)	66 (19.08)	45	15 (9.80)	8 (9.64)	4 (9.52)	27 (9.52)	40
All categories	150 (100)	168 (100)	54 (100)	372 (100)	260 (37.85)	173 (100)	121 (100)	52 (100)	346 (100)	232 (33.77)	153 (100)	83 (100)	42 (100)	278 (100)	195 (28.38)

Source: Primary data collection (2021)

3.7 Distribution of ownership of wells

The distribution of ownership of wells explains clearly the wells of different classes of farmers. The total and average extent of irrigated area from well explains the relationship between irrigation and well investment. The more the area, the more water is needed which forces more well investment across different farmers of the study area.

It could be seen from table 8 that large farmers of overexploited firka, owns 117 wells and irrigate 282.35 ha of land. The average extent of irrigated area per well is 2 ha which is due to the higher extraction of 10 HP motor pumps. The marginal farmers have 119 wells with a total irrigated area of 162.03 ha and the average extent of irrigated area per well is 1.50 ha. Marginal and small farmers have 45 and 91 wells respectively with a total irrigated area of 16.87 ha and 66.19 ha. The average extent of irrigated well is 0.75 and 1.50 ha per well which may be due installation of 3 and 5 HP motor pumps which abstract a low volume of water. The average extent of irrigated area per well of semi-critical firka is 1 ha for large farmers which is very low compared to other regions.

Table 8. Ownership of wells across the size of landholding farmers

Landholding size in ha	Over exploited firka					Critical firka					Semi-critical firka				
	No. of wells owned	Total no. of wells	Functioning wells	Total irrigated land in ha	Average extent of irrigated area per well	No. of wells owned	Total no. of wells	Functioning wells	Total irrigated land in ha	Average extent of irrigated area per well	No. of wells owned	Total no. of wells	Functioning wells	Total irrigated land in ha	Average extent of irrigated area per well
Marginal	24	39	45	16.87	0.75	33	58	48	20.48	0.75	90	29	128	38.51	0.50
Small	45	26	91	66.19	1.50	49	35	83	71.56	1.00	26	23	33	29.24	0.75
Medium	52	91	119	162.03	1.50	56	35	149	136.11	1.00	35	64	90	79.84	0.75
Large	39	104	117	282.35	2.00	22	104	66	109.08	1.50	9	79	27	48.45	1.00
All categories	160	260	372	527.44	1.43	160	232	346	337.23	1.06	160	195	278	196.04	0.75

Source: Primary data collection (2021)

3.8 Determinants of groundwater use on the farm

3.8.1 Groundwater use on the farm

A simple regression model with regional dummies was used to capture the factors involved in groundwater use on the farm. The factors responsible for groundwater extraction were the different regions, depth of the wells, farm size, the area under water-loving crops, non-farm income and adopter or non-adopter of water management practices. Regional dummies were used to differentiate different regions. R1 is the regional dummy for the overexploited area, R2 is the dummy for critical firka and R3 is the dummy for the semi-critical firka. To avoid the dummy variable trap, two dummies (R2 and R3) were used for estimation with all other factors.

Table 9 reveals groundwater use on the farm with the volume of groundwater extracted. R square is 0.63 which means 63 proportion of variance in the dependent variable is explained by the independent variables. The farm size (FSIZE) and the area under water-loving crops (AWLC) significantly influence the groundwater use on the farm. The increase in farm size and the area under water-loving crops increases groundwater extraction. The negative sign of the regional dummies implies less dependence of the regions on groundwater use compared to the overexploited firka. The sign of depth to water level is negative as expected which shows as the depth to water level increases groundwater use increases and vice versa but the influence is very negligible (0.003). The water table near the surface motivates the

farmer to cultivate more crops which in turn consumes more water. The income from a non-farm source drives the farmers to participate in non-farm income activities than agriculture which is the reason for the negative sign of non-farm income source. The dummy variable is used for the qualitative variable adopter or non-adopter of water management practices like drip irrigation and sprinkler irrigation. The adoption of water management practices forces to bring the larger area under cultivation which in turn consumes more water.

It could be concluded that groundwater is highly developed in the overexploited region. The farm size of the farmers and area under water-loving crops significantly influence the groundwater use on the farm.

Table 9. Parameter estimates of groundwater use on the farm

Variables	Co-efficient
Constant	-4.21 (10.82)
R2	-1.89 (1.65)
R3	-0.66 (2.46)
D	-0.003 (0.012)
FSIZE	1.62*** (0.40)
AWLC	5.98*** (0.95)
NONFARM	-0.000011 (0.00003)
ADOPT	0.59 (0.72)
R square	0.63
No. of observations	480

Note: Figures in the parenthesis indicates standard error

*** indicates a 1 per cent significance level.

4. Conclusion

The study revealed that the groundwater has highly depleted in the Coimbatore district particularly overexploited regions compared to other regions of the district. Large farmers are the major depletors of groundwater in the district. It is evident from the pump ownership of the farm and HP of the pump sets they own. Most of the large farmers had 3 pump sets in the farm which may be due the large farm size. Farm size and area under water-loving crops significantly influence the groundwater use on the farm. The increased farm size forces the farmer to extract more water. Cultivation of large area under water loving crops forces the farmer to deplete more. The other factor positively influences the groundwater extracted on the farm is the adoption of water management practices like drip and sprinkler irrigation. The adoption of water management practices makes the farmer to crop more and irrigate more and extract more.

The optimal extraction of groundwater could be the solution for the groundwater depletion particularly in the overexploited regions of the district. It could be made possible my regulatory institutions. One could conclude that our policy focus may be tilted towards the water management practices and particularly in the regions of overexploited firka.

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