CHAPTER I

INTRODUCTION

Efficient and effective planning of water resources for the purpose of irrigation occupies a high priority on the economic development agenda in almost all countries, as food continues to be among the most pressing needs in the world. The water resources include the entire range of natural water resources regardless of their state (solid, liquid, or gas) and may be classified as surface water and subsurface or groundwater. Groundwater plays a significant role in so far as agricultural, municipal and industrial water supplies are concerned. Specially groundwater for irrigation is available to the crops in desired quantity at the required time and as a result it is a dependable source for crop production. Exploitation of groundwater through shallow tubewells is receiving more and more attention for the last one decade. It is essential to tap more groundwater efficiently.

1.1 Groundwater

Groundwater is one of the major sources of irrigation and its chief advantage lies in its availability at many places where other sources of water are not feasible. It is also less prone to seasonal fluctuation and its extraction can be continued even long after the droughts.) The amount of groundwater storage upto a depth of 300 m is estimated at 37,000 Mcu-m which is equal to about 10 times the annual rain fall. In India, the average annual precipitation, excluding evapotranspiration and soil moisture storage is 179 Mha-m, resulting in surface runoff and groundwater recharge (Times of India Directory, 1971).

1.2 Development of Irrigation in India

The development of irrigation potential has been progressing rapidly in India since the initiation of the Five Year Plans. Out of the total geographical area of 328.7782 Mha of the country an area of 170.995 Mha is put under crops (Patel, 1979). The total irrigation potential of the country increased from 22.60 Mha in 1950-51 to about 59 Mha in 1980-81. The Government of India has set a target of extending irrigation facility to the entire gross potential area of 113 Mha by the year 2000 A.D. The target for irrigation by groundwater in the sixth Five Year Plan is 7 Mha and the ultimate potential is estimated at 40 Mha (Michael, 1982).

1.3 Future Water Requirements

The quantitative increase of world population and long range prospects of economic developments are to be considered for evaluating the quantity of future water consumptions. According to studies conducted by the UN experts (Siddiqui et al., 1981) the world population will touch a mark of 6,000 million by the year 2,000 A.D. More than 50 per cent of this population will live in cities and will require a considerable quantity of water for domestic and industrial purposes. The water consumption for industrial purposes has aquired alarming magnitudes and added to this would be the agricultural requirement. The problem of water supply is becoming alarming because the need for water is increasing several times more rapidly than population growth. According to UN Experts (Siddiqui et al., 1981) in the early 21st century water consumption will increase by several times in comparison with the year 2000 and will be close in magnitude to the total annual runoff from land areas which is about 41,500 km^2/year.

Considering the great increase in water consumption and the paucity of fresh water resources, it is of utmost importance to exploit the groundwater. This becomes all the more important because, at present, water supply to hydroelectric power stations is mostly non-returnable.

1.4 Irrigation Development and Agricultural Production

Irrigation development is considered as the best insurance against weather-induced fluctuations in agricultural production. When the production of food grains in India during the period 1950-51 to 1960-61 was considered it was found that there was an increase of 3 million tonnes of food grain production for every million hectares of additional area brought under irrigation (Michael, 1982). Irrigation has been one of the chief factors responsible for the spectacular increase in the food grain production in India during the past three decades. (Weather-induced fluctuations are still persistent in our total food grain production. To overcome the malady, it is necessary to launch a nation-wide drive to increase the efficiency of our irrigation systems and to emphasise more on groundwater potential.)

1.5 Energy Requirements

The groundwater resources are being exploited for irrigation purposes mostly through sinking of various types of wells and pumping water out by application of power (human, animal, mechanical and electrical). The total estimated requirement of the various forms of power during the period 1968-69 to 1998-99 for lifting water is presented in the Table 1.1.

Table 1.1 Estimated annual requirements of energy for irrigation pumping in India (Patel and Madalia, 1979)

Source	Energy consumption in million kilowatts/hour						
	1968-69	1973-74	1978-79	1983-84	1988-89	1993-94	1998-99
1	2	3	4	5	6	7	8
Human and animal power	2,746.6	2,365.9	2,178.1	1,937.1	1,642.9	1,294.0	893.2
Diesel Engines	1,004.5	1,813.2	2,905.2	3,264.5	2,627.5	3,099.5	3,620.9
Elec-tric Motor	1,543.9	4,241.9	6,778.4	7,573.4	10,234.2	12,153.5	14,207.9
Total	5,295.0	8,421.0	11,861.7	12,775.1	14,504.6	16,547.4	18,722.0

The above projections are based on a reasonable level of efficiency in pumping. Due to the present day inefficiency in pumping, the actual values of energy consumptions are higher than the projected values.

1.6 Research Need with Reference to the Shallow Tubewells

Shallow tubewells are being used in large numbers in India to supply water for irrigation. They are the only source of water in some areas for raising a second crop which is raised from January to April. These wells have a depth of 30 to 50 m and diameter of 7.5 cm or 10 cm. They usually tap a confined or semi-confined aquifer of about 10 to 12 m thickness lying at a depth of 20 to 30 m below ground level. These wells became popular among farmers because of less fabrication and installation cost as compared to deep tubewells and they could be drilled manually without any heavy drilling equipment. They also give satisfactory amount of water required by small farmers if properly designed and constructed. In India the farmers are aware of the advantage of well irrigation system and the number of private tubewells is increasing rapidly as can be seen from the Table 1.2.

Table 1.2 Development of groundwater structures (in 1000 Nos.) (Rao, 1980)

Period	Dug wells	Private shallow tube-wells	Public deep tube-wells	Electric pump-sets	Diesel pump-sets
Pre-plan (1950-51)	3,860	3	2.4	21	66
End of 2nd Plan (1960-61)	4,540	20	8.9	200	230
End of Annual Plan (1968-69)	6,110	360	14.7	1,090	720
End of 4th Plan (1973-74)	6,700	1,140	22.0	2,430	1,750
End of 5th Plan (1977-78)	7,425	1,700	30.0	3,300	2,500
During (1978-79)	210	200	3.4	300	200
Target (1979-80)	280	250	3.9	400	200
Target 6th Plan	1,200	1,200	10.0	2,000	1,000
Ultimate Feasible	12,000	4,000	60.0	12,000	5,000

A deep tubewell of 300 m depth having a discharge of about 30 l/s costs approximately Rs.2,00,000 and commands an area of 40 to 70 ha. A shallow tubewell of 30 m depth having a discharge of 4 to 10 l/s costs Rs.15,000 and commands an area of 3 to 5 ha. A medium farmer with a small holding of 3 to 5 ha of land cannot afford to invest a large sum of money on a deep tubewell and would prefer to have his own shallow tubewell. In India 30.40% of the area (Table 1.3) is owned by medium farmers. Thus a large number of shallow tubewells have been in use and many more are being constructed every year.

Table 1.3 Number of operational holdings (1976-77) (Swaminathan, 1981)

Size class	No. of holdings		Area	
	In million	Percentage	In million hectare	Percentage
(1)	(2)	(3)	(4)	(5)
Marginal (below 1 ha)	44.53	54.60	17.50	10.70
Small (between 1 to 2 ha)	14.70	18.00	20.86	12.80
Semi-medium (between 2 to 4 ha)	11.64	14.30	32.36	19.80
Medium (between 4 to 10 ha)	8.21	10.10	49.60	30.40
Large (10 ha and above)	2.44	3.00	42.82	26.30
Total	81.52	100.00	163.14	100.00

One of the most important devices used for lifting water is centrifugal pump. This is because of its simplicity, low cost and ability to operate under varying conditions. Generally shallow tubewells are operated by centrifugal pumps installed at ground level and they work satisfactorily at places where the water level in the well is within the suction lift of the centrifugal pump. As the cropping season advances the piezometric surface gradually falls and the discharge of the well decreases. Particularly during the critical months of March and April when the evapotranspiration requirements are high the discharge of the well is low and farmers find it difficult to meet the water requirements of the cropped area even by running the pump sets for 16 to 21 hours a day. Their problem is aggravated if more farmers drill wells through the same aquifer.

In spite of the spectacular progress made in groundwater utilization by shallow tubewells, deciding the position of pump during installation is still done by trial and error method and on the basis of local experience. Suitable methods have not yet been developed for deciding the position of pump during installation by taking into consideration the fluctuation of groundwater table and the characteristics of pump. For determining the command area of a shallow tubewell, it is necessary to know the discharge expected to be delivered by the well depending upon the position of the groundwater table at different times during the crop period.

If the total drawdown in a shallow tubewell is to be within the allowable limits considering the suction lift of the centrifugal pump, it is necessary to know the well losses that occur in addition to the drawdown in the aquifer. It will be useful for irrigation planning if a reasonable estimate can be made about the discharge expected at different crop stages, the area each tubewell can command and the effect of operating a certain number of wells simultaneously on the discharge of each well. In order to plan the number of tubewells that an aquifer can sustain, it is necessary to have a knowledge of potential recharge into the aquifer. It is also necessary to know the response of the aquifer to inflows and withdrawals. The discharge of a shallow tubewell is generally very low in the dry season when the water requirements of crop are high. If a method for increasing the yield of the shallow tubewells can be deviced, it will certainly have an impact on agricultural production of the country.

1.7 Objectives

Considering the need to increase the food production in the country by bringing more and more areas under irrigation research was initiated at Agricultural Engineering Department, IIT, Kharagpur, India with the following specific objectives.

1. To develop a method for predicting the discharge of a shallow tubewell on the basis of the position of the piezometric surface at any particular time during the year.

2. To determine the effect of the net positive suction head required by the pump on discharge of shallow tubewell.

3. To determine the effect of operating a number of wells at a time in an area on the discharge of a shallow tubewell.

4. To develop a method for determining the location of the pump of each well so that all the wells in an area give equal discharges.

5. To determine the effect of the recharge into the aquifer on the drawdown and discharge of shallow tubewells.