Ind.Jn.of Agri.Econ.
Vol.53, No.3, July-Sept. 1998

An Assessment of Institutional Management's Impact on the Use of Groundwater Resource for Sustainable Agriculture Development in Uttar Pradesh

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I

INTRODUCTION

Amongst the renewable natural resources. groundwater commands a pre-eminent position. However, its excessive withdrawal for irrigation raises the issue of sustainability of irrigation-based agriculture. Being a common pool resource it is generally used by all the farmers. In fact the groundwater structure is quite cheap and its availability gives the farmers a sense of ownership. Uttar Pradesh is the most populous state of the country and most of the geographical area is fertile alluvium plains, sustaining wells and tubewells. It has a maximum groundwater potential of 18 million hectares out of 80 million hectares for the country as per the revised assessment of Central Ground Water Board. In several areas of the state, there is tremendous decline in the water table because of over-exploitation and non-availability of recharge from canals. Excessive decline in the water table due to over-exploitation has resulted in drying up of open wells. The wells depend on increase in the water availability. Similarly, the cost also increases in the case of borewells/tubewells, pumps are to be further lowered because of decline in the water table. Due to decrease in the availability of water, the area under irrigation decreases leading to decline in agricultural production.

Keeping in view the above facts, the specific objectives of this study are: (i) to examine the role of various organisations/institutions engaged in groundwater management in terms of assessment of groundwater, its development and measures adopted to check the over-exploitation and depletion of groundwater resources; and (ii) to examine the impact of groundwater organisation in terms of changes in groundwater use structure, level of water table, depletion and over-exploitation of groundwater and normative demand for water by various crops over a period in the four regions of Uttar Pradesh.

Methodology

The study is based on secondary data collected from different bulletins and published agricultural statistics for the years 1977-78 to 1993-94. The net draft groundwater (supply of water) and net balance estimated by Water Commission and evapo-transpiration (ET) for major crops were used for the estimation of gap between supply and annual normative demand for groundwater in Central, Eastern, Western and Bundelkhand regions of Uttar Pradesh (Saxena, 1992).

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The data used in the paper are from the M.Sc. Thesis of the second author, submitted to G.B. Pant University of Agriculture and Technology.

Estimation of Requirements of Water

The annual normative demand of water for irrigation purpose has been estimated by using the following formula (see, Singh and Sankhayan, 1991):

$$AND = \sum ETiAjg$$

where AND = Annual normative demand for irrigation purposes with groundwater resource in hundred hectare-meters (hem),

ETi = Evapo-transpiration demand for i-th crop in hectare-metres with groundwater resources in 100 hectares.

Aig = Irrigated area with groundwater under the i-th crop in million hectares.

The estimate of AND so obtained was raised by 25 per cent to take care of water requirements of fodder, vegetables and other crops. The difference between water requirement and availability of water (net draft of water) was worked out to arrive at the water balance estimates for all the regions.

II

ROLE OF GROUNDWATER ORGANISATION/INSTITUTIONS IN GROUNDWATER MANAGEMENT

Role of Groundwater Organisation

To examine the efficiency and sustainability effects of various organisations set up by the government to develop the groundwater resources, the role and various activities of Central Ground Water Board (CGWB) and other organisations involved in the management of groundwater resources are presented below (see Saxena, 1992).

Groundwater surveys and assessment:- A systematic programme of groundwater surveys and investigation started in the country in 1954 with the launching of all-India exploration project under the technical co-operation programme of U.S.A. Another institution, Exploratory Tubewells Organisation (ETO) was set up under the Ministry of Agriculture, Government of India along with the creation of an exclusive wing in the Geological Survey of India (GSI) for groundwater surveys and investigations. These two organisations started preparatory work in opening out groundwater worthy areas for the use of groundwater for irrigation purposes. However, when the programme of groundwater development gained momentum around 1965, it was noted that there were many shortcomings in the groundwater surveys and planning. Therefore, these two organisations were merged in 1970 to form a unified organisation at the central level called the Central Ground Water Board (CGWB) which is basically a field organisation. With 40 field offices located in different states of the country, it is carrying out the following activities: (i) systematic hydrological survey including reappraisal surveys; (ii) observation of groundwater table several times during the year in 12,477 wells spread all over the country including water quality testing; (iii) exploratory tubewells drilling including construction of production wells; and (iv) other scientific studies like geophysical, artificial recharge, water balance, etc.

The CGWB has covered 91 per cent of the country's total geographical area. Studies to assess the complete water resources in an area are being undertaken by adopting the

multi-disciplinary approach. These studies are primarily directed towards evolving methodologies of investigations and empirical norms for the assessment of the resource potential under the various hydrological and hydro-climatic set-ups in the country. In addition, the studies aim at evolving economic and scientific designs of groundwater extraction structures and preparation of detailed development plans of the areas/river basins.

Groundwater Assessment by State Groundwater Organisation (SGWO)

In addition to CGWB, each state has its own groundwater survey organisation. The SGWO carries out all the above activities for the state in a detailed manner. For example, it estimates the water balance for each development block in the state, and works out the various recharge and draft parameters as per guidelines given in the Report of the Groundwater Estimate Committee Report (1984) of the Government of India.

The concept of net water balance is used for the clearance of minor irrigation works by National Bank for Agriculture and Rural Development (NABARD). This implies that : (i) Future works should be cleared against net water balance available for development. (ii) The unit draft of each category of work should first be estimated as gross draft based upon field survey. Thereafter, the future number of works that can be cleared against the available net water balance should be based upon their net draft as 70 per cent of the gross draft. (iii) Stage of groundwater development is taken as the ratio of the net draft to the net recoverable recharge. For clearance of the scheme by NABARD, the stage of development has to be estimated after five years of interval. The following parameters are followed for the level of groundwater development in a block:

(a) If the projected net extraction in scheme area in five years is less than 65 per cent of recoverable recharge, technical approval by the SGWO and appraisal by NABARD would be made on the basis of block level water balance (white areas).

(b) If the projected net extraction in a scheme area in five years is between 65 and 85 per cent of the recoverable recharge, the scheme will be subjected to special scrutiny by NABARD appraisal and the SGWO would be requested to provide a block level balance during a period of ten years (grey areas).

(c) If the projected net extraction in scheme area in five years is in excess of 85 per cent of the recoverable recharge, the SGWO would be required to support its evaluation of resource adequacy with detailed hydrological maps showing extraction and recharge distribution together with projected extraction for a planning period of 15 years and an evaluation of the probable effects of draught period on water availability and farmers' repayment capacity (dark areas).

So far all the planning for groundwater development is being done on the following basis: (i) volumetric availability of groundwater for irrigation and (ii) gross cropped area that can be irrigated taking an average applicable water depth of 0.65 cm.

Over-exploitation of groundwater:- The Central Ground Water Board is generally monitoring the groundwater table in different places in India. The states have a more bigger network. This helps in spotting the areas where there is a constant trend of decline. In several areas of Uttar Pradesh, serious decline in the water table is taking place because of over-exploitation and non-availability of recharge from canals.

In the Western region Ghaziabad, Bulandshahr and Saharanpur and in Eastern region Allahabad; in Bundelkhand region Jalaun and Jhansi and in the Central region Barabanki, Lucknow and Kanpur are the most adversely affected districts. According to groundwater assessment (1990) in Uttar Pradesh, out of 57 districts 17 blocks are identified as dark areas, 77 blocks as grey areas and 801 blocks as white areas (Government of India, 1990).

Groundwater management and conservation:- The National Water Policy laid down the following guidelines for systematic development and management of groundwater resources in the country. There should be a periodical re-assessment on a scientific basis of the groundwater potential, taking into consideration the quality of water available and its economic viability. Exploitation of groundwater resources should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity. Groundwater recharge projects should be developed and implemented for augmenting the available supplies. Integrated and co-ordinated development of surface water and groundwater and their conjunctive use should be envisaged right from the project planning stage and this should form an essential part of the project. Over-exploitation of groundwater should be avoided near the coast to prevent ingress of sea water into sweet water aquifers.

Measures to check and prevent Over-exploitation of Groundwater Resources

The following measures have been taken to check and prevent over-exploitation of groundwater resources:

(a) Restriction of loan:- The loan from the banks is given only when the availability of groundwater resource in a block has been certified by SGWO. For this purpose, the SGWO prepares and submits annually the blockwise groundwater assessment. Based on this the blocks are put into three categories, i.e., white blocks, where unrestricted loan is advanced. Grey blocks where loan is given with caution and dark blocks where the SGWO are required to carry out detailed survey based on which loans may be advanced in some areas.

(b) Restriction of subsidy:- As government subsidy is linked with loan, no subsidy is available for dark blocks.

(c) Energisation is done only when groundwater availability is certified by SGWO.

(d) Spacing criteria is such that there is no interference between two wells/tubewells while pumping, NABARD has decided the statewise minimum spacing.

Artificial recharge of groundwater:- It is necessary to augment groundwater storage and resource potential in areas where due to activities of men, a high stage of development of resource has reached in such areas. Experiments have been conducted to evolve methods and assess their economic viability. These studies have been undertaken in certain areas of the country.

Regulation of Groundwater Development

During the past three decades, groundwater development has witnessed a massive acceleration. Though on a national scale, there is still considerable potential for future development but when viewed at the micro level, a critical stage appears to have been reached

in certain pockets with very high level of development. Such areas require careful consideration before additional withdrawals are effected. To prevent situations leading to over-withdrawals and to maintain sustainability of the system and social equity it is necessary that groundwater development is regulated on scientific lines to permit optimal development. The following measures have been taken in this regard:

(a) *Administrative measures:-* The method of control followed presently for regulating the groundwater development to some extent is in the form of administrative measures, namely, restriction on flow of institutional finance for groundwater development in areas with high stages of development. Institutional financing agencies require technical clearance for proposed programmes in such areas. However, in the absence of any law, these measures do not necessarily permit the groundwater development on scientific lines to control over-exploitation/indiscriminate exploitation of groundwater. There is also no restriction on private investment.

(b) *Model bill for regulating groundwater development:-* With a view to protecting the groundwater regime, taking safeguard measures against hazards of over-exploitation and ensuring equitable distribution of this vital and finite resource, enactment of suitable legislation to regulate the exploitation of this resource is necessary and helpful. In 1970, the Government of India had circulated a Model Bill to the state for adoption of suitable legislation keeping in view the prevailing groundwater situation in the states. However, this model bill is enforced by only some states in the country.

Groundwater Development Programme for the Weaker Sections

The groundwater is used by the farmers to increase food production, but for equitable and judicious distribution of common pool resources, the government as well as financing agencies are providing incentives to the small and marginal farmers. In general, the small farmers tend to depend on the groundwater markets. And possibly the performance of the buyers is better than farmers using other sources of irrigation. Thus groundwater markets have a tendency to improve the equity in sharing the groundwater as well as the income generated thereof.

The following types of subsidies are given by the government for groundwater development for the weaker sections of the farmers.

1. Under the Integrated Rural Development Programme (IRDP), the subsidy to the extent of 25 per cent for small farmers (1-2 hectare land holdings), 33.33 per cent for marginal farmers (upto 1 hectare of land holdings) and 50 per cent for tribal beneficiaries is available. The subsidy percentage is on the unit cost of the groundwater structure as approved by NABARD, and there is no ceiling on upper limit of subsidy. Enhanced subsidy is available to co-operative societies of IRDP beneficiaries.

2. Under Jawahar Rozgar Yojna, open wells are given free of cost to the small and marginal farmers belonging to the scheduled castes and scheduled tribes who are below the poverty line.

3. Boring of wells is also done on the farms of small, marginal and tribal categories of farmers free of cost with financial ceiling of Rs.3,000, Rs.4,000 and Rs. 5,000 respectively.

4. Under the Command Area Development Programme in the commands of major and medium irrigation schemes, subsidy on IRDP pattern is provided for conjunctive use of

groundwater.

5. For installation of solar and wind pumps, subsidy to the extent of 80 per cent of unit cost is provided.

III

IMPACT OF GROUNDWATER ORGANISATION ON GROUNDWATER USE

The impact of groundwater organisation is examined in terms of change in groundwater use structure (tubewells), the level of water table, and depletion and over-exploitation of groundwater. An attempt has been made to estimate the normative demand of water by various crops over the period in the four study regions of the state.

Development of Groundwater Use Structure

It is evident from Table 1 that there was significant increase in the number of private and government tubewells ranging from 195 per cent in the central region to 318.6 per cent in the eastern region and from 33 per cent in the western region to 246 per cent in the Bundelkhand region, respectively. However, there was a drastic reduction in the number of wells in all the regions ranging from 40 per cent in the Bundelkhand region to about 87 per cent in the eastern region. In absolute terms the number of private tubewells was the highest in the western region as compared to other regions in 1992-93. This showed that in the western region of the state, the groundwater use structure was much developed as compared to the other regions.

TABLE 1. GROUNDWATER STRUCTURE IN DIFFERENT REGIONS OF UTTAR PRADESH

Particulars	Number of			
	Private tubewells	Government wells	Wells	Total
(1)	(2)	(3)	(4)	(5)
Eastern region				
1979-80	2,44,641	7,325	4,46,551	6,98,517
1992-93	10,24,036	11,988	59,042	10,95,066
Per cent change in 1992-93 over 1979-80	318.59	63.66	-86.78	56.77
Western region				
1979-80	3,34,958	7,891	3,95,735	7,38,584
1992-93	12,51,564	10,518	73,430	13,35,512
Per cent change in 1992-93 over 1979-80	273.65	33.29	-81.44	80.82
Central region				
1979-80	1,59,060	1,707	1,35,315	2,96,082
1992-93	4,69,931	4,180	20,468	4,94,579
Per cent change in 1992-93 over 1979-80	195.44	144.87	-84.87	67.04
Bundelkhand region				
1979-80	18,750	402	78,697	97,849
1992-93	76,393	1,393	46,789	1,24,575
Per cent change in 1992-93 over 1979-80	307.43	246.52	-40.55	27.31

As a result of the increase in the number of tubewells, the irrigated area through tubewells has increased considerably. The irrigated area in Bundelkhand has increased by about 4 times in 1993-94 over the period 1977-78 as compared to the western region, followed by the central region (three times). (Table 2). However, the western region registered an increase of only 96.47 per cent, in the area irrigated, the reason being that the area irrigated was already the highest in 1977-78 as compared to the other regions.

TABLE 2. TOTAL AREA IRRIGATED WITH GROUNDWATER (TUBEWELLS AND WELLS) IN DIFFERENT REGIONS

Region	Area irrigated with groundwater (ha)		Per cent change in 1993-94 over 1977-78
	1977-78	1993-94	
(1)	(2)	(3)	(4)
Eastern region	16,39,097	23,91,589	45.90
Western region	26,93,445	38,80,256	44.06
Central region	5,01,370	12,12,400	141.82
Bundelkhand region	73,012	2,17,888	198.43

Estimates of Gap between Annual Normative Demand for Crops and Actual Supply of Groundwater (Net Draft Water)

Due to the increase in the irrigated area of major crops and change in cropping pattern, the annual normative demand also increased in 1993-94 over the period 1982-83. Rice and sugarcane crops require more water due to higher evapotranspiration (ET) rate (ET 0.72 and 1.80 respectively) as compared to other crops. Therefore, in absolute terms the annual normative demand was higher in these crops in all the regions.

The difference between the total net draft water and the total annual normative demand constitutes the estimated water balance (Table 3). The estimate of difference was observed to be negative ranging from -220.61 per cent in the Bundelkhand region to 297.66 per cent in the central region. It is due to the fact that the change in annual normative demand was higher as compared to net draft groundwater in all the regions except Bundelkhand in 1993-94 over 1982-83. However, the situation in terms of water balance in Bundelkhand region was better as compared to other regions of the state.

In the case of net balance (i.e., availability of groundwater) as estimated by the CGWO, there was a decline in all the regions in 1993-94 over the period 1982-83. It ranged from (-) 3.66 per cent in the western region to (-) 56.41 per cent in the Bundelkhand region. In absolute terms, the availability of water as estimated by the CGWO was the highest in the western and eastern regions and the lowest in the Bundelkhand region.

Due to reduction in the net balance of groundwater, the levels of water table has declined in all the regions. The percentage of decline ranged between 107.6 in the central region to 331 in the Bundelkhand region in 1993-94 over 1982-83. If we compare the level of groundwater table, it is observed that in the Bundelkhand region the water strata was at the lowest as compared to the other regions of the state. It is because of the higher magnitude of increase in the number of tubewells in this region as compared to the other regions in 1993-94 over 1982-83.

TABLE 3. WATER BALANCE ESTIMATE AND LEVELS OF GROUNDWATER IN DIFFERENT REGIONS OF UTTAR PRADESH

(hectare-metres)

Particulars (1)	Total annual normative demand for crops irrigated through tubewells and wells (2)	Balance (availability) of groundwater as estimated by CGWO (3)	Net draft groundwater(supply) (4)	Balance (gap between the normative demand and net draft(supply) (5)	Groundwater level (metres) (6)
Eastern region					
1982-83	14,41,390.29	17,20,800	7,98,800	-6,42,590.29	2.53
1993-94	21,90,434.84	15,30,300	11,28,500	-10,61,934.84	5.64
Per cent change in 1993-94 over 1982-83	51.97	-11.07	41.27	65.26	122.92
Western region					
1982-83	25,68,801.84	15,88,500	10,36,900	-15,31,901.84	3.73
1993-94	44,39,713.98	15,30,300	11,28,500	-33,11,213.98	9.12
Per cent change in 1993-94 over 1982-83	72.83	-3.66	8.83	116.15	144.50
Central region					
1982-83	4,77,910.20	12,15,200	4,15,900	-62,010.20	3.17
1993-94	7,89,192.33	10,11,400	5,42,600	-2,46,592.33	6.58
Per cent change in 1993-94 over 1982-83	65.13	-16.77	30.46	297.66	107.57
Bundelkhand region					
1982-83	66,830.20	5,59,100	1,00,200	33,369.80	2.15
1993-94	1,27,447.74	2,43,700	87,200	-40,247.74	9.27
Per cent change in 1993-94 over 1982-83	90.70	-56.41	-12.97	220.61	331.16

IV

CONCLUSIONS AND SUGGESTIONS

The Central Ground Water Board, State Groundwater Organisation and NABARD have played an important role in groundwater development. These organisations/institutions have also performed the monitoring role to check the over-exploitation of groundwater resources. The organisation is engaged in assessing the groundwater availability and identified the white, grey and dark zones of the common pool groundwater resource. The National Water Policy has laid down certain guidelines for systematic development and management of groundwater resources. The NABARD has restricted the advancing of the loan for the installation of tubewells in areas where the SGWO has declared that the availability of groundwater in terms of net balance is declining (declared as dark zone). But to provide an opportunity of availing the use of common pool resources, the government encouraged the installation of tubewells on small and marginal farms. However, major efforts have to be made by the farmers themselves as the organisation has no control on the private investment and no effective organisational structure has been so far developed to monitor the private investor and the installation of tubewells on the farms.

The data presented in Section III, shows that there has been substantial increase in the number of private tubewells ranging from about 200 per cent to more than 300 per cent in all the regions of the state. Though the increase in the number of government tubewells was also significant, the magnitude of the increase was less than that of the private tubewells. As a result of the increase in the number of tubewells (both private and government tubewells)

the irrigated area through tubewells has increased significantly. The data show that not only the water balance estimates in terms of gap between normative demand and actual net draft in all the regions are negative but it also showed a declining trend over the period. This meant that the net draft water was not enough to meet the annual normative requirements. Hence less and less water would be available over time for crop growth in future. If the present trend continues, the situation would become still worse.

Another problem arises due to the decline in the water table in that the reduction in tubewells discharge affects the command area of a tubewell and hence the cost of irrigation.

Administrative measures are presently adopted for regulating the groundwater development in areas with high stages of development. In the absence of any law, these measures are not effective to control over-exploitation and depletion of groundwater.

Keeping in view the above facts, the following measures should be adopted: (1) Groundwater resources should be used in conjunction with surface water so that over-exploitation of groundwater resource is minimised. (2) All losses in conveyance of water from the groundwater structure to the fields should be reduced to the minimum by way of pipeline distribution system. (3) To minimise the wastage of water, sprinkler/drip irrigation system should be used extensively. (4) In areas where declining trend is more pronounced, artificial measures should be taken up. (5) Effective groundwater legislation should be introduced to control the over-exploitation of common pool resources. (6) Higher water requirement crops, particularly rice is preferred because of land suitability and profitability. To replace rice, the production technology of competing crops which require less amount of water will have to be upgraded. (7) Besides, the agricultural price policy should be such that it induces suitably changes in the cropping pattern in the state so as to ensure the sustainability of water resources.

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