GROUNDWATER ISSUES IN EASTERN AND WESTERN ALLUVIUM OF GANGA BASIN

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Abstract

The eastern and western regions Utter Pradesh are marked by two contrasting features. In terms of ground water resources, the eastern region is richer than the western region. While ground water development diminishes as we move from west to east. The agricultural backwardness of the eastern region arises on account of a variety of factors covered in the paper. While it is desirable that the eastern region emulates its western counterpart in all positive agricultural practices, care needs to be taken to avoid unplanned over exploitation of ground water, which has become a menace in several areas of the western region of Utter Pradesh.

Introduction

The Ganga basin forms the major portion of the north Indian plains and occupies an area of over 0. 557 million square km. It has flat surface, fertile alluvial soil and favourable climate. Apart from millions of ground water extraction works, there is an extensive system of irrigation canals fed by perennial rivers in the basin. The lower portion of the basin in particular, receives sufficient rainfall for wet crops. The plain forming part of the basin supports one of most dense population in the world. The total population of just three states of U.P, Bihar and West Bengal which lie in the basin, stood over 293 million in 1991. The basin contains one of the best reservoirs of ground water in the world. The area has been formed out of thick alluvial deposits, which at places extend up to a depth of 3000 meters below the ground level. A considerable portion of this alluvial thickness consists of porous and granular materials, such as sand, grave and boulders, which are good water suppliers. The enormity of ground water availability from the Ganga Basin and its utilizations can be fully appreciated by an examination of Table 1. However, before it is done, it should be understood that while the title of the paper refers to the eastern and western alluvium of Ganga Basin, the examination is confined to the eastern and western plains of Uttar Pradesh. While the basin deals with hydraulic boundaries, the regions like eastern and western parts of U.P subsume districts, which have administrative boundaries. Keeping this in mind table 1 consists of two parts. The first part of the table provides basin wise data, while the second part provides Uttar Pradesh data, including that of the two regions of the state. The data in the table clearly shows that the Ganga basin is the largest basin in India. It contains 17.17mhm/yr replenishable ground water resource, which is about 38% of such resource in India. The rest of the 17 other basins together contain 62% of replenishable ground water resource. The other important point, which emerges from table is that only about 31% of ground water resources in the Ganga basin have been developed. This gives an idea of the enormity of the ground water resources and the vast potential available for its development in the basin.

However, what is important from the point of view of this paper is that whole of Uttar Pradesh constitutes a part of Ganga basin and the state contains about 47% of the basin's replenishable ground water resources. Further, the Eastern and Western regions of U.P, which are intended to be examined in this paper, contain about 72% of

TABLE 1: Ground Water Potential, Basin wise and Regionwise (UP)							
Sl.	Basin	Total replenishable G.W resource (m.h.m/yr)	Provision for drinking industrial & other uses (mhm/yr)	Utilisable G.W Resources for irrigation (mhm/yr)	Net Draft (mhm/yr)	Balance G.W. Potential available for exploitation (mhm/yr)	Level of GW Dev. (%)
1	2	3	4	5	6	7	8
1	Indus	2.5543	0.3870	2.1673	1.7186	0.4487	79.2968
2	Ganga	17.1725	2.5824	14.59	4.4931	10.097	30.7955
3	Kutch Composite & Saurashtra composite	1.3948	0.2514	1.1434	0.4545	0.6889	39.7499
4	Cambai Composite	0.7908	0.1201	0.6707	0.2026	0.4681	30.2072
5	Narmada	1.189	0.1793	1.0097	0.1552	0.0545	15.3709
6	Tapi	0.8173	0.1439	0.6734	0.1764	0.4970	26.1954
7	Subarnrekha	0.2185	0.0328	0.1857	0.0165	0.1692	8.8853
8	Brahmani with	0.5879	0.0882	0.4997	0.0258	0.4739	5.1631
	Baitarni						
9	Mahanadi	2.1293	0.3194	1.0099	0.0782	1.7317	4.3207
10	North East Composite	2.2788	0.3418	1.9370	0.2621	1.6749	13.5312
11	Godavari	4.6762	0.7342	3.9420	0.5907	3.3513	14.9848
12	krishna	2.6646	0.4342	2.2304	0.6493	1.5811	29.1114
13	Pennar	0.5047	0.0757	0.4290	0.1355	0.2935	31.5851
14	Madras Composite	2.0907	0.3137	1.7770	0.8165	0.9605	45.9482
	& Tamilnadu composite						
15	Cauvery	1.3598	0.2041	1.1557	0.5168	0.6389	44.7175
16	Western Ghat	1.8289	0.2858	1.5431	0.3027	1.2404	19.6164
	composite						
17	Brahmaputra	2.7857	0.4179	2.3678	0.0503	2.3175	2.1243
18	Meghna	0.1795	0.0269	0.1526	0.0049	0.1477	3.211
	Total	45.2233	6.9388	38.2845	10.6497	27.6348	27.8173
	UP	8.045	1.207	6.838	2.494	4.344	36.48
	Eastern UP	2.976	0.446	2.529	0.857	1.672	36.66
	Western UP	2.779	0.417	2.363	1.074	1.288	48.06
	Total	5.755	0.863	4.892	1.931	2.96	NA
Source: BHU-JAL January- March 1991 (Special Issue on Ground Water Statistics), p- 94& 98-99							

the state's replenishable ground water resources and about 34% of that the Ganga basin. This means that although our examination does not deal with the whole of the eastern and western alluvium of Ganga basin, it does cover a considerable portion of two parts (upper /western and eastern / lower) of the basin. Although the level of ground water development in Uttar Pradesh and more particularly in its western part is higher compared to the basin as a whole, there is tremendous scope for its development in its eastern part. The data also affirms that the level of ground water development is most impressive in Uttar Pradesh and more particularly in its western part.

Ground Water Resources of U.P

The state of U.P has a total geographical area of 29.4 million ha comprising of seven hydrological regimes. Bhabar, Tarai, Himalaya, Central and East Gangetic alluvial plains, Bundelkhand and Vindhyan regions. The alluvial plain areas cover about 21. 24 million ha. having fertile soils and voluminous ground water resource. The net sown area of the state is 17. 48 million ha with cropping intensity of 148.7 %. An area of about 367 thousand ha is estimated as wetlands. The critical and semi critical waterlogged areas stood at 5.39 and 4.06 millions ha respectively in October 1996 in 49 districts of the state.

The available water resources of the state are enormous with irrigation prospects. The available surface water for irrigation is estimated at about 9. 86 mhm with an ultimate irrigation potential of 15.95 mhm. The annual replenishable ground water is presently estimated to be 7.16 mhm with an ultimate irrigation potential of 15.03 mhm. In addition to this utilizable static ground water, there is further scope to utilize an additional ground water of about 7.45 mhm between water levels of 5-10 meters with an additional ultimate ground water potential of 15. 69 mhm. This means in U. P the available water for irrigation is about 24. 27 mhm (consisting of 14.61 mhm ground water and 9.86 mhm surface water). As regards ultimate irrigation potential, it is estimated to be 46.67mhm with 30. 72 mhm in respect of ground water and 15. 95mhm in respect of surface water (Rai et al 2000). This clearly means that there is tremendous scope for the utilization of ground water resources in the state.

Regional disparity

The state of Uttar Pradesh[1] like most of the large states of India presents a picture of disparities in term of agro climatic features and resource endowments. It is divided into 3 broad regions containing 83 districts. The hilly region of the north comprises of 12 districts. High mountains formed of sedimentary rocks broken by valleys and deep gorges characterize the terrain. The hill areas are sparsely populated and communication is difficult. Further, many are in accessible. The Gangetic plain consist of 64 districts. The plain stretches across the entire length of the state from west to east, flanked by Terai and Bhabar [2] areas in the north and Vindhyas plateau in the south.

[1] In this paper U.P. includes Uttaranchal, which is a separate state now. This has been done because most of the data used in the paper for U.P. includes Uttaranchal.

[2] Bhabar denotes a gravel talus with somewhat steep slope fringing the outer margins of the hills everywhere.

Table-2: Indicators of Development in the Eastern and Western Alluviums of Uttar Pradesh				
Sl.	Particulars	Western	Eastern	U.P
1	General			
1.1	Population in Million (1991)	49.5	52.7	139.1
1.2	Geographical area in sq.km.(1991)	82192	85844	2944111
1.3	Density of population- per km (1991)	603	614	473
1.4	Percent of urban population to total population (1991)	26.3	11.6	19.8
1.5	Percent of literacy (1991)	42	38.5	41.6
1.6	Percent of Schedule castes (1991)	31.5	37.3	100
1.7	Average Monsoon rain fall (in mm)	765.7	891.3	N.A.
2	Infrastructure			
2.1	Percapita electricity consumption (kwh-1997-98)	206.2	109.3	163.1
2.2	Percent of electrified villages (kwh-1998-99)	87	76.4	78.5
2.3	Post Officer per lakh population (1994-95)	11.1	13	13.5
2.4	Telegraph officer per lakh population (1995-96)	3.3	2.3	3.3
2.5	Telephone per lakh population (1995-96)	705	282	538
2.6	Length of metalled road under PWD per 1ooo sq km (1994-95)	326.2	308.7	288.0
3	Credit Facilities			
3.1	Credit deposit ratio (June 1996)	38.6	28.2	32.9
3.2	Scheduled Commercial Banks per lakh population (95-96)	5.7	5.00	5.8
3.3	Co-operative agri. marketing centres per lakh Population(94-95)	4	1.4	2.6
3.4	Co-operative marketing societies per lakh pop. (94-95)	0.19	0.13	0.18
3.5	Joint agricultural Co-operative societies (1994-95)	1.1	0.6	0.9
4	Agriculture Related			
4.1	Percent of marginal holdings (> 1 ha., 1990-91)	66.1	82.3	73.8
4.2	Average size of marginal holding (.1ha. 1990-91)	0.41	0.35	0.38
4.3	Percent of farmers against main workers (1990-91)	47.9	54.8	53.3
4.4	Percent of agricultural labours against main workers (90-91)	18.5	22.5	18.9
4.5	Consumption of electricity in Ag. As % of total con, 1997-98)	51.0	46.3	41.5
4.6	Cultivable area as% of reported area (1994-95)	82.7	77.0	70.9
4.7	Net cultivated area as% of cultivable area (1997-98)	90.6	86.0	83.3
4.8	Net irrigated area as% of net cropped area (94-95)	85.1	61.8	67.4
4.9	% of area irrigated by State tubewells (94-95)	4.2	11.2	6.6
4.10	% of area irrigated by Pvt. tubewells (94-95)	67.4	56.2	57.7
4.11	% of balance GW to total safe yield (96-97)	54.0	64.0	60.0
4.12	Cropping intensity (1997-98)	156.2	150.3	148.7
4.13	Commercial crop area as % of gross cropped area (94-95)	32.7	10.8	20.6
4.14	% of kharif area affected by floods (1997-98)	3.4	11.6	7.6
4.15	Availability of tractor per gross cropped area (in ha. 97-98)	34.4	77.4	49.7
4.16	Distribution of fertilizer per ha gross cropped area (in ha.97-98)	145.2	117.3	117.4
4.17	Value of Agr. Produce per ha on current prices (93-94)	14164	11029	11941
4.18	Productivity of food grains (q/ha 97-98)	25.2	19.4	20.3
4.19	Productivity of wheat (q/ha 97-98)	29.8	22.8	24.9
4.2	Productivity of Rice (q/ha 97-98)	25.1	20.3	21.4
4.21	Productivity oi potatoes (q/ha. 97-98)	168.3	126.7	146.7
4.22	Productivity of oil seeds (q/ha 97-98)	6.7	5.2	6.1
4.23	Productivity of sugar cane (q/ha 97-98)	654.3	516.8	610.8
4.24	Gross value of Agr. Produce per rural person on current prices (93-94)	3568	1883	2614
4.25	Income from primary sector as % of net domestic out put (96-97)	74.8	74.3	15.8
Note:	UP includes Uttranchal			
Source: GO UP, 2002 and Districtwise Indicators of Development, Economics and Statistic Division,				
	State Planning Institue, UP. 1966			

The entire alluvial plain is divided into three-sub regions- western (27districts), central (10districts) and eastern (27districts). The Gangetic plain is watered by rivers Yamuna, Ganga, and its major tributaries Ramganga, Gomti, Ghagra, and Gandale. The whole plain is alluvial and very fertile. The southern region is demarked by Vindhya hills and the plateau. It is called Bundelkhand and comprises of 7 districts. The tract is marked by scanty and erratic rainfall and scarce water resources.

It has been mentioned by us that the eastern and western parts of the Gangetic plain are most important in terms of ground water resource endowments not only in U.P but also in the whole of the Ganga basin. However, in terms of ground water development, there is lot of variations in the two regions (see table 1)

Although eastern and western region form part of the same Gangetic plain, the two regions present a picture of contrast. The eastern tract is flood prone with periodic occurrences of droughts and is least developed. The western tract although receives much less rainfall is assisted by old canal networks and high development of ground water resource. According to some, this kind of disparity is on account of historical antecedents. During the British period, nearly all the agricultural developments in the state took place in the western U. P. A major development was the construction of a network of canal system which reduced the element of risk in agriculture and gave farmers incentives to experiment with the new techniques and crops with new farm related industries. Farmers of the eastern U.P on the other hand with their high density of population resulting in high pressure on land and complete dependence on natural forces for agriculture, were not in a position to take risk and experiment in ways that if they failed, could threaten their very existence (Singh 1976)

In an effort to find out the extent of disparity between the two regions, we have put all the indicators of development in table 2, containing data in respect of two regions and the state as a whole. All the indicators have been clubbed under, four headings dealing with general features, infrastructure facilities, credit facilities and agriculture related development.

The first striking point, which emerges from the data, is that two regions together constitute the most important segment of the state. The two regions together contain 73% of the population, 57% of the state's geographical area and 72% (table1) of state's replenishable ground water resource. Although the two regions contain the same number of 27 districts each, the eastern region is larger in terms of population as well as in area than its western part. Eastern region has greater density of population, greater percentage of scheduled castes and higher monsoon rainfall. Western part on the other hand has higher rate of literacy and urbanization, greater per capita consumption of electricity, higher proportion of electrified villages, higher proportion of telegraph offices, telephones and higher length of metalled roads. It is obvious from this examination that eastern region lags behind the western region in respect of all the indicators of development but is ahead in respect of indicators, which lead to backwardness. In respect of credit facilities, it is found that western region is more favorably disposed in comparison to the eastern tract. Western region forges ahead in all respects, such as credit deposit ratio, number of banks cooperative agricultural marketing centers and cooperative societies etc.

The forth and the largest section of the table deals with agriculture related indicators. Here also the same trend continues which was found to be in respect of first three sections. Eastern U.P lags behind western U.P in respect of all such indicators which are positively related to modern / advance agriculture. On the other hand, the region is ahead of the western region in respect of indicators which hinder modern / advance agriculture. An important point, which emerges on the basis of the table, is that the eastern region not only lags behind western region but is also behind the state as a whole. In all, 43 indicators have been used in the table and only in respect of one indicator, i.e. number of post offices (2.3) eastern U.P scores higher than western U.P. Here also, it is possible that the post offices are established keeping in mind population norms. In all other respects, the eastern region lags behind the western region. In comparison to the state as a whole in respect of first 18 indicators, only in case of length of metalled roads, eastern region's position is better than U.P as a whole. However, in agriculture related indicators, eastern region's position is better than the state as a whole and in respect of 9 indicators out of 25 indicators. On the basis of table 2, the picture that emerges presents the eastern region in very poor light. It is a region, which abounds with small and poor farmers with a preponderance of marginal holdings and socially and economically backward area. A large part of the area is affected by floods. In the absence of adequate credit facilities, the resource base of farmers remains poor and small area is covered with commercial crops. This is further aggravated by lower cropping intensity and low fields of crops, which ultimately leads to reduction of gross value of agriculture produce.

Ground water development

As early as in late 1970's, Dhawan had highlighted the wide differences in the agricultural development of eastern and western U.P on account of extent of ground water irrigation in two regions. On further examination, he found that tube well irrigation in the alluvial Gangetic plains diminishes in force as one moves from west to east (including Bihar and Bengal). This downward trend according to him coincides with a like pattern in the matter of agricultural growth. The downward trend as we move from west to east in the Gangetic plain is on account of several factors such as progress in land consolidation, spread of rural electrification, institutional support and finance (Dhawan 1982). Under exploitation of available ground water in Eastern U.P is regarded as the main cause of this region's agricultural backwardness. Even today it utilizes only 36% of its available ground water resource. It is pointed out that excepting parts of the erstwhile Mirzapur district, the rest of the region, have large groundwater resources. It is felt that if the same are exploited intensively in a planned manner, they can help improve crop intensity, promote crop diversification and increase productivity of crops. Therefore, exploitation of ground water is given highest priority (RBI 1984).

A general impression that still prevails among the policy makers and researchers is that the development of ground water is quite slow in Eastern U.P. Table 3 discounts this kind of thinking. No doubt Eastern U.P lags behind Western U.P in the development of ground water as it utilizes only 36% of ground water resource compared to western region's 46% utilization. However, the pace of development has been more rapid in the east compared to the west. Data in table 3 reveals that in 1964 –65 in Eastern U.P only about 11% area was irrigated by tube wells which went up to about 62% in 1983-84 and about 73% in 1999-2000. As against this in case of

Western U.P, the tube well irrigated area in 1964-65 was about 20% and went up to 62% in 1983-84 and about 79% in 1999-2000. This means the pace of ground water development was heavily in favor of Western U.P in the mid 1960's but Eastern U.P matched Western U.P by mid 1980's. This means that growth of ground water in Eastern U.P is faster until mid 1980's. No doubt presently the pace of development is marginally in favor of Western U.P.

Agricultural productivity

It is interesting to note that the pace of ground water development has affected the productivity of main crops of rice and wheat to a great extent during this period in the eastern region. In 1964-65, the productivity of rice was 7.97 ql / ha in the west and 7. 16 ql / ha in the east. In 1983-84, the same was 14.61 ql / ha in the west. In 1997-98, the productivity of rice went up to 25. 1 ql / ha for west and 20.3 ql / ha for the east. In respect of wheat, the productivity in 1964-65 was 9.26 ql / ha for west and 7.31 ql / ha for the east. It went up to 21.55 ql / ha for the west and 15. 94 ql / ha for the east. In 1983-84, again it went up to 29.8 ql / ha for the west and 22.8 ql / ha for the east. An interesting trend emerges on the basis of this data. In 1964-65, the productivity of Western U.P was marginally higher compared to Eastern U.P. A dramatic change, however, is noticed in 1983-84. In 1983-84, western region registers a tremendous growth in the two crops, more particularly, in case of wheat. While incase of Eastern region, although there are marginal gains in the productivity of rice, even wheat productivity has doubled here. But what is important is that large variations in productivity of two crop occurred in the two regions in 1983-84. This is in spite of the fact that during this period ground water utilization in eastern region had reached at par with the western region.

Table-3: Source wise Irrigated area (in thousand ha)									
Sl.	Source	Eastern			Western			State		
		64-65	83-84	99-2000	64-65	83-84	99-2000	64-65	83-84	99-2000
1	Canals	303	856	1025	1149	1267	721	2225	3330	2988
	%	14.56	27.79	24.95	49.51	27.57	14.74	40.53	33.71	23.97
2	Tubewells	225	1899	2980	467	2839	3885	715	5467	8700
	%	10.81	61.66	72.52	20.12	61.77	79.42	13.06	55.34	69.77
3	Others	1553	325	104	705	490	286	2548	1082	781
	%	74.63	10.55	2.53	30.37	10.66	5.84	46.41	10.95	6.26
4	Net Irrigated area	2081	3080	4109	2321	4596	4892	5490	9879	12469
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: Adapted from : A study of agricultural development in Eastern UP Director Agricultural Statistics and Crop Insurance UP Lucknow, Publication No.112 Sept. 1986, page 8 and Directorate of agriculture, UP Lucknow, December-2000

Another interesting feature is noticeable in 1997-98. During this period, the productivity of rice in the eastern region has doubled in comparison to rice productivity in 1983-84. In respect of wheat, productivity is doubled in 1983-84 and trebled in 1997-98. This means that productivity gains are maximum in respect of both the crops in eastern region in 1997- 98

In fact the field level data collected by us during our reconnaissance visits in Jaunpur and Moradabad districts during October- November 2001 indicates a much higher productivity. However, it should be noted that the village in Jaunpur and the village in Moradabad represent agriculturally most advanced villages. In case of Jaunpur (Eastern U.P), the village was Chakra in Dhobi block. It was a high caste (Thakur) dominated village. Irrigation in the village was done mainly by private shallow tube wells, which were 40 in number and all were electrical. Most of them were of 5 hp. The availability of power in the village was reported to be 12-18 hours per day, which is quite exceptional in the eastern region. Water charges on sale of water were around Rs. 10 per hour. The ground water level in the village was around 10 ft (post monsoon).

The village from Moradabad was Singhpur Saini, forming part of the Sambhal block, which remains to be a dark block of the district. It was a Jat dominated village. The enormity of ground water utilization can be gauged by the fact that there are 500 electric and 200 diesel pump sets in the village. Although electricity was available for 10-15 hours per day, farmers kept pump sets as an insurance against electricity failure. The water level in the village was reported to be 4o-45 feet (post monsoon). Sale of ground water by tube well was Rs. 40-45 per hour, while it was Rs. 20 per hour for electric tube well. The productivity of important crops in the two villages was reported to be as follows.

Crops	**Productivity ql / ha**	
	Jaunpur (Chakra)	**Moradabad** (Singhapur Saini)
1. Rice	35 –40	25 – 30
2.Wheat	40 – 45	30 – 35
3.Sugarcane	750 – 800	700 – 750
4. Potato	250 – 300	N.A
5. Gram / Peas / Pigeon pee	25 – 30	N.A

Although the above data is not indicative of the general productivity levels in Eastern U.P, it does show that there are areas in the Eastern U.P where productivity is as high as anywhere in the western U.P

Flooding and Water logging

Frequent occurrence of floods is a common feature of the eastern region. According to 1997 – 98 estimates, while 11.6% kharif area in the eastern region is affected by floods, only 3.4% of the kharif area is affected by floods in the western region (table 2,item 4.14). The east west differences are most conspicuous if we examine the data for the districts of Jaunpur and Moradabad. While Jaunpur contains 56183 ha of area, which is flood prone, there is no such area in Moradabad (GOUP 1999). Ghagra,

Rapti and Gandak are notoriously flood-creating rivers. Even smaller rivers like Rohni, Burhi, Rapti, Arni, Kuwano, Gurra, Tons, Kunhra, Ghongi, Burhi Gandak deluge in flooding the region. It is estimated that Rapti alone inundates 350,000 ha of area every year in Bahraich, Gonda, Basti, Siddhartha Nagar and Deoria districts (Shah. 2001)

The problem in the eastern region has been further enhanced due to unplanned and haphazard use of water resources in the state. As a result, large areas suffer from miseries of rising water table. It would not be out of context to mention a field visit the author had carried out fifteen years ago with Tushar Shah and Robert Chambers through the commands of Sharda Sahayak and Gandak. We had moved by road from Lucknow to Deoria via Barabanki, Gonda and Gorakhpur. After the visit Robert Chambers had circulated a note, and his comments in respect of water logging remain relevant even today after a lapse of 15 years. He had written, "All canals we saw on Sharda Sahayak and also on Gandak were running full, although it had recently rained and it is doubtfull whether anyone was taking water. One wonders whether there is any attempt at all to throttle back on water deliveries. It seems crazy to send more water into these areas when they are already in such trouble. There are difficulties over travel time, but I would have thought long term weather fore castes could enable managers, without any one losing, to reduce flows at times like that of our visit"(Chambers 1987)

The magnitude of water logging can be gauged if the following figures recently worked out by the State Ground Water Investigation Department are taken into consideration. These figures are based on the data collected from 3173 hydrograph monitoring stations, which have been set up by the GOUP. The waterlogged area has been divided in two groups. The one is "critical area" which refers to the areas where ground water level is between 0 to 2 meters. The other is "semi critical" area, which relates to the areas where ground water level is between 2 to 3 meters.

	U.P	**west**	**east**
Critical area in thousand ha.	4803	1090	2360
Percentage of such area against the reporting area in thousand ha.	23. 89	13. 50	31. 45
Semi critical area in thousand ha.	3911	1188	1731
Percentage of such area as against reporting area	19. 45	14. 71	23. 07
Critical and semi critical area in thousand ha.	8714	2278	4091
Percentage of such area against reporting area.	43. 34	28. 21	54. 52
Reporting area (in thousand ha)	20107	8077	7502

Although the preceding data sets alarm bells for the Western U.P also, the villages visited by us in the districts of Jaunpur and Moradabad showed a picture in contrast. While in Jaunpur, we witnessed a number of villages with accumulated water, in Moradabad a number of villages had very deep ground water table. In Moradabad 16 out of 19 blocks were critical, semi critical or over exploited. In Jaunpur only 2 out of 20 blocks were having critical water levels. The growing menace of water logging in the eastern region is mainly on account of impeded drainage caused by historical antecedents, high ground water recharge and frequent flooding. One more reason that came to our notice during the recent field visits (October- November 2001) was the construction of rural roads under MPLADS and MLALADS by departments and organizations which do not have the full technical know how [3] In the absence of the close scrutiny of the quality of work, lack of resources and absence of technical expertise no attention is being paid to drainage. In some cases even the existing drainage passages are being blocked to meet the district level targets.

Evolution of public policy

Tube well technology got it's first shot as a public funded programme in the early1930s when two public tube wells were installed in Moradabad district. At the beginning of the first five-year plan, the number of state tube wells stood at 2000.By the end of first five-year plan, another 3000 state tube wells were added (GOUP 1971). In the wake of developmental planning, tube well indivisibility witnessed substantial reduction, which induced many farmers to invest in their own tube wells. This inducement was reinforced by the advent HYV seeds and progress in land consolidation, rural electrification, institutional credit etc. However, public policy for a long time continued to encourage state owned tube wells for the rural poor. During the 1980s new design public tube wells were devised with intended beneficiary participation in the operation, water distribution and maintenance of tube well system. However, the performance of such tube wells was found to be far below the expectations. The poor performance of such tube wells had been on both technical and organizational grounds (Pant 1993).

In respect of private tube well, the growth was stupendous and the stock of private tube- well rose in U.P from about 3 thousand in 1951 to 600 thousand in 1977 (Dhawan 1982). By mid 1970s, tube-well irrigation had overtaken canal irrigation, which was the dominant mode of irrigation earlier to that. The rapid growth of private tube-wells had its repercussions on the power point. Historically, as the ground water development was building up in the state, the demand on the power was not significant since there was surplus power available in most areas until the 1970s. However, after that and in early 1980s, the large-scale ground water development in the private sector had led to a situation where the rural demand for electricity always exceeded power availability. It was around this time, power generation and transmission capacity became the constraint to the rate at which electrical connection to tube-well points could be made. In table 4 we are able to put together data from 1980 onwards in respect of various modes of ground water extraction prevalent in the two regions of U.P. Looking at the table, it is found that the traditional modes of

[3] Under the schemes members of the Parliament and the State Legislature are allocated Rs. 2 crore and Rs. 50 lakhs respectively for the development of the areas they represent. In U.P most of the money coming from these sources is being spent on the construction of roads under the overall supervision of the district administration.

ground water irrigation, i.e. dug-wells and Persian wheels seemed to be quite popular in both the regions until mid 1980s. In fact, in case of dug-wells the decline had started by mid 1980s. In respect of Persian wheel, the popularity had continued even during 1980s. Between the two regions, dug-well seemed to be more popular in the eastern region compared to the western region. Persian wheel seemed to be equally popular in the two regions although marginally more popular in the western region.

Table –4: No. of Ground Water Works in Eastern & Western Alluvium

At the end of year	Dugwell			Persian Wheel			Diesel Pumping set			Electric Tubewell		
	East	West.	UP	East	West.	UP	East	West.	UP	East	West.	UP
1979-80	271151 (53.60)	258583 (46.64)	679443 (46.14)	15338 (41.06)	179410 (41.65)	239671 (36.36)	128954 (16.30)	317028 (11.73)	581998 (9.38)	183083 (24.94)	217432 (21.17)	465969 (23.08)
1984-85	228655 (45.20)	222371 (40.11)	586119 (39.80)	15500 (41.11)	179786 (41.74)	245022 (37.18)	258727 (12.61)	526343 (19.46)	1030488 (16.61)	285902 (38.95)	290068 (28.24)	674753 (33.43)
1993-94	N.A	N.A	N.A	N.A	N.A	N.A	525389 (25.61)	710862 (26.29)	1624923 (26.20)	81431 (11.09)	194027 (18.89)	306978 (15.21)
1998-99	6110 (11.20)	73430 (13.25)	207042 (14.06)	50147 (17.85)	71540 (16.61)	174371 (26.46)	1138065 (55.48)	1149837 (42.52)	2965357 (47.81)	183623 (25.02)	325743 (31.71)	570748 (28.28)
Total	505916	554384	1472604	280985	430736	659064	2051135	2704070	6202766	734039	1027270	2018448
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

, Source: Updated Minor Irrigation Censuses GOUP

In respect of diesel pump-sets, it is found that there is a progressive increase in their numbers in the two regions. But the growth of diesel pump tube-wells is more pronounced after the mid 1980s in case of the eastern region. In fact, after 1993, the growth of diesel pumping sets is higher in the Eastern U.P in comparison to the Western region. The reverse is noticed, however, in case of electric tube-wells. Here, up to 1984-85, the growth is greater in Eastern U.P while after that period; growth is higher in Western U.P. However, what is noteworthy, there is a decline in the growth of electric tube-wells between mid 1980s and mid 1990s in both the regions and the decline is more severe in case of eastern region. However, there is a growth again after the mid 1990s and the growth is higher for the eastern region.

The total number of pump-sets (both E&D) is always higher in the western region compared to the eastern region. However, the proportion of increase goes on declining over the years. While in 1980, the proportion of the total pumps (in the two regions) was 63% for the western region, the same declined by 52% in 1998-99.

The proportion of diesel pumps in relation to electric pumps was always higher in the western region and the proportion went on increasing from 59. 3 % in 1980 to 64. 5% in 1985 and then 78. 6% in 1994 after which it registers a marginal decline of 0. 7%. In case of eastern region, the picture is quite different. Here, the proportion of electric pumps was more than diesel in 1980 and 1985 where their proportion was 58.7% and 52.5% respectively. Here a dramatic decline in the number of electric tube-wells occurs between mid 1980s and mid 1990s when the proportion of electric pumps