Journal of Agricultural Development and Policy, 2021
Volume 31, No. 1, 111-117

Scenario of Groundwater Exploitation in Punjab: Recent Trends

Yogita Sharma and Baljinder Kaur Sidana

Department of Economics and Sociology, Punjab Agricultural University, Ludhiana, Punjab, India

Abstract

Punjab's depleting water table is a cause of grave concern as it has caused water quality problems in Punjab. The study revealed the water table in all the districts of Punjab has been declining. The state has witnessed a fall in water table @ 0.43 metres per year during the last 22 years. The percentages of wells falling in the range of below 10 m showed a drastic decrease whereas the wells in range of above 10 m showed a tremendous increase for both the pre-monsoon and post-monsoon period. The districts where the scenario of high groundwater depletion is prominent are Sangrur, Patiala, Jalandhar, Moga and Barnala. The groundwater balance has decreased, turning the net groundwater availability to -14.58 bcm in 2017. The present stage of groundwater development has reached 166 per cent in the state. The percentage of over-exploited blocks has increased to 79 per cent with major districts of the state having 100 per cent fully over-exploited blocks. The total annual draft for Punjab has reached 35 bcm, which is higher than the sustainable limit of 20 bcm. The change in cropping pattern towards rice is primarily responsible for fall and over-exploitation of ground water in Punjab. Water-saving techniques like drip and sprinkler irrigation, construction of ponds, harvesting of rainwater, its management and efficient utilization can resolve the water scarcity problem to a greater extend in these exploited districts.

Keywords: Groundwater, Critical stage, Groundwater balance, Over-exploitation

JEL Classification: Q25, Q15, Q56

Introduction

Water is the core of economic and social growth: it is essential for maintaining health, producing food, generating energy, managing the environment, and creating jobs. Estimates indicate that the world will face a 40 per cent shortfall between forecast demand and accessible supply of water by 2030 with present practices of water management and population development. Agriculture currently accounts for 70 per cent of worldwide water withdrawals (World Bank, 2018). Groundwater plays a major role in the supply of water, the functioning of the ecosystem and the well-being of people. The country's green revolution was based upon groundwater resource development. Presently there are approx. 20 million wells that pump water using free electricity supply given by the Government. This has been depleting groundwater while encouraging wastage of water in many states. As a result, the water table in the country is dipping every year by 0.4 m (CWC, 2017).

Water is the only available natural resource, and no other mineral or natural resources are accessible to the state of Punjab. Being highly intensive, Punjab's agriculture relies on massive water requirements. The current cropping pattern and the efforts to increase the food grain production has resulted in a tremendous strain on irrigation system because of inadequate surface water, which is insufficient to meet requirements resulting in stress on groundwater. In Punjab, through well-organized canal irrigation, the surface water resources are completely utilized. The dominance of paddy-wheat crop rotation has transformed the state of Punjab from a water-surplus into a water-scarce state (Kaur *et al.* 2010). The agrarian sector accounts for 85 per cent of the state's water consumption. The region irrigated by tube wells has increased over the years because of an upsurge in the demand for water and

Corresponding author email: sharmayogita35@gmail.com

reduced canal capacity. Tube well irrigation maintains a constant water flow, and electricity subsidies (Nelson *et al*, 2013), easy credit services increased the use of centrifugal tube wells as the chief source of irrigation. Groundwater is, therefore, being overexploited in this state for irrigation purposes. Punjab is confronting a severe decline in the water table (Gulati *et al,* 2017).

Out of the total water demand of 4.40 m ham, the water supply falls by 1.27 m ham of the total supply of 3.13 m ha m. The scarcity is met by overuse of groundwater reserves by wells and tube-wells (Singh and Bhangoo, 2013). Falling water levels not only reflect constraints on the capacity to increase future groundwater use, but also suggest that a percentage of the current food supply of the world relies on unsustainable water. In its effort to provide the country with the required food security, Punjab has ruthlessly mined the surface and groundwater, with prolonged consequences for the region's environment and the ecology. Due to exploitation above the recharge capacity, Punjab has lost a major part of groundwater resources. In recent times, the overdependence of groundwater supplies has also influenced the quality of groundwater. Punjab is emerging as a major groundwater pollution hot spot, and there are many sources of such pollution, such as agriculture, industry and distilleries. In recent years, both the Government of India and the State Governments have implemented a range of projects focused on groundwater recharge; replenishable use of water for agriculture; and the use of technology.

Data Sources and Methodology

The present study was carried out in the state of Punjab. As the rate of fall in water table has reached 40 cms/year; hence, the behaviour of groundwater in Punjab state was studied for the period 1996 to 2018. To fulfil the objectives of the study secondary data was collected from various sources. All the data were collected at the district level. The study is based on the data monitored and collected by Central Ground Water Board. Ground water levels are being measured by Central Ground Water Board four times a year. The data were analyzed using tabular methods and simple statistical techniques such as averages and percentages were used to study the exploitation of groundwater in Punjab.

Results and Discussion

Declining water table depths of Punjab

A tremendous increase was seen in the percentage of wells falling in the range of 20-40 m for both pre-monsoon and post-monsoon periods respectively (Table 1). Only 2.62 per cent of wells were in the range of 20-40 m depth in the state in the year 1996, which increased to 41.88 per cent for pre-monsoon period; thereby showing an increase of 16 times. Similarly, for the post-monsoon period the water table depth increased from 2.65 per cent in 1996 to 66.67 per cent in 2018 showing an increase of 25 times. A decrease was seen in the per cent of wells in the range of 10-20 m from 42.15 per cent to 17.05 per cent for the pre-monsoon whereas; for post-monsoon the decrease was from 39.5per cent to 19.9 per cent. There was a complete swap over the wells under water table depth from non-critical stage to critical stage. The percentage of wells below 10 m depth were 28 per cent which become 72 per cent having water table depth more than 10 m in year 2018.

Over the years, the decreasing rainfall has adversely affected the flow of water in major rivers and the natural recharge of groundwater resources. The inadequate amount of canal water for irrigation and use of groundwater in excess of recharge has led to over-exploitation of groundwater resources in the state. As a result, every year, the water table in Punjab has been deteriorating over time (Table 2). The decline in water table was highest in Sangrur from 10.45 m in 1996 to 33.08 m in 2018, with a decline of 22.63 m therefore indicating the per cent decline of 216.55 for the last 22 years. Barnala, Patiala, Moga and Jalandhar showed a decline of more than 14 m. The decline was least for Gurdaspur with 35.62 per cent decline in water table from 1996 to 2018 with an absolute change of 1.97 metres. A 2.1 per cent rise was observed in Muktsar district during 1996-2018.

Increasing over-exploitation of groundwater in Punjab

A perusal of district-wise groundwater balance is presented in Table 3. The net annual draft has increased more as compared to the net annual recharge over the year in the most of the districts of Punjab. The

Table 1. Percentage of Wells under different water table depths in Punjab, 1996 to 2018

(per cent)

Years	0-2 m	2-5 m	5-10 m	10-20 m	20-40 m	>40 m
Pre Monsoon						
1996	4.94	25.58	42.15	24.42	2.62	0.29
2000	5.43	27.91	38.37	26.36	1.94	-
2005	1.49	22.77	29.7	38.61	7.43	-
2010	1.56	19.27	24.48	39.58	14.06	1.04
2015	2.04	13.72	21.20	35.19	27.72	0.14
2018	1.50	9.82	17.05	28.38	41.88	1.36
Post Monsoon						
1996	10.32	25.66	39.53	21.53	2.65	0.29
2000	6.32	28.62	38.29	25.28	1.49	-
2005	5.24	22.51	31.41	31.94	8.9	-
2010	7.69	20.33	21.98	36.26	13.19	0.55
2015	2.82	11.89	19.91	30.91	34.32	0.15
2018	-	-	-	33.33	66.67	-

Source: Central Ground Water Board

Table 2. District wise, fall in annual water table (in metres) in Punjab, 1996-2018

(metres)

Districts	1996	2018	Absolute change	% decline (1996-2018)
Gurdaspur	5.53	7.5	-1.97	35.62
Hoshiarpur	9.23	18.19	-8.96	97.07
SAS Nagar	7.77	19.05	-11.28	145.17
Rupnagar	6.72	13.47	-6.75	100.44
SBS Nagar	9.99	19.82	-9.83	98.39
Patiala	10.44	29.99	-19.55	187.26
Kapurthala	8.34	18.4	-10.06	120.62
Ludhiana	10.66	19.84	-9.18	86.12
TarnTaran	9.3	18.59	-9.29	99.89
F. Sahib	9.56	23.17	-13.61	142.36
Amritsar	6.99	14.67	-7.68	109.87
Jalandhar	10.4	24.54	-14.14	135.96
Sangrur	10.45	33.08	-22.63	216.55
Barnala	12.88	33.99	-21.11	163.89
Moga	9.84	24.45	-14.61	148.47
Bathinda	8.88	16.54	-7.66	86.26
Mansa	4.68	14.35	-9.67	206.62
Faridkot	4.64	9.12	-4.48	96.55
Ferozepur	4.97	10.08	-5.11	102.82
Muktsar	3.86	3.78	0.08	-2.07

Source: CGWB; author have prepared this table from water table depths collected from the mentioned source

Table 3. District wise groundwater balance estimates, Punjab, 1997-2017

(million hectare metre)

Districts	Net Annual Recharge			Net Annual Draft			Groundwater Balance		
	1997	2011	2017	1997	2011	2017	1997	2011	2017
Gurdaspur	0.154	0.196	0.204	0.109	0.219	0.221	0.045	-0.023	-0.017
Hoshiarpur	0.097	0.098	0.094	0.043	0.087	0.084	0.054	0.011	0.010
SAS Nagar	0.022	0.03	0.283	0.015	0.023	0.023	0.006	0.007	0.260
Rupnagar	0.042	0.045	0.045	0.018	0.043	0.044	0.023	0.002	0.001
SBS Nagar	0.039	0.069	0.070	0.038	0.07	0.071	0.001	-0.001	-0.001
Ludhiana	0.149	0.231	0.215	0.204	0.336	0.338	-0.054	-0.105	-0.123
Sangrur	0.091	0.145	0.160	0.155	0.336	0.368	-0.063	-0.191	-0.208
Jalandhar	0.065	0.130	0.130	0.128	0.267	0.268	-0.063	-0.137	-0.138
Patiala	0.107	0.166	0.152	0.138	0.288	0.290	-0.031	-0.122	-0.138
F. Sahib	0.038	0.059	0.061	0.054	0.111	0.112	-0.016	-0.052	-0.051
Amritsar	0.081	0.137	0.171	0.089	0.217	0.217	-0.008	-0.08	-0.046
Taran Tarn	0.079	0.116	0.140	0.089	0.187	0.188	-0.009	-0.071	-0.048
Moga	0.043	0.133	0.119	0.107	0.242	0.243	-0.065	-0.109	-0.124
Kapurthala	0.032	0.073	0.077	0.081	0.150	0.151	-0.048	-0.077	-0.074
Barnala	0.046	0.065	0.064	0.057	0.118	0.119	-0.012	-0.053	-0.055
Bathinda	0.050	0.111	0.153	0.036	0.118	0.132	0.014	-0.007	0.021
Mansa	0.073	0.077	0.114	0.028	0.144	0.145	0.045	-0.067	-0.031
Faridkot	0.053	0.067	0.067	0.026	0.095	0.096	0.026	-0.028	-0.029
Ferozepur	0.272	0.21	0.240	0.175	0.275	0.287	0.097	-0.065	-0.047
Muktsar	0.099	0.086	0.081	0.014	0.051	0.051	0.085	0.035	0.030
Punjab	1.637	2.253	2.393	1.610	3.417	3.456	0.027	-1.164	-1.063

Source: Dynamic Ground Water Resources of India, various issues

net annual recharge and draft of Punjab in the year 1997 was 1.64 m ha m and 1.61 m ha m respectively, which in 2017 increased to 2.39 m ha m and 3.45 m ha m respectively. The result of this high increase in draft in comparison to recharge resulted in a negative groundwater balance of 1.06 m ha m in 2017 from 0.03 m ha m in the period 1997. Only five districts (out of 20) are having a positive groundwater balance in the state namely, Hoshiarpur, SAS Nagar, Rupnagar, Bathinda and Muktsar. Higher annual draft (Srivastava *et al,* 2015) in excess to recharge has resulted in a negative groundwater balance and fall in water table in the state thus, putting a huge pressure on groundwater resources of Punjab.

Though, the green revolution in Punjab and Haryana brought prosperity to the state, but water and soil degradation problems emerged and have grown important as these states contribute significantly to national food security (Singh, 2001). The cultivation of rice, which is a water-intensive crop and the increase of industrialization and urbanization have led to an increase in reliance on groundwater, which has widened the demand and supply gap of groundwater over time.

The stage of groundwater development has always been high for Punjab. Stage of Groundwater Development is the ratio of groundwater draft to the net annual groundwater availability. If the value of the groundwater development of the assessment unit is less than 70 per cent, it is considered “safe” from the viewpoint of groundwater extraction. The stage of groundwater development has increased (Table 4) from 98 per cent to 166 per cent from 1997 to 2017. This shows that the annual groundwater recharge is less than the annual water consumption in the state.

Table 4. District wise comparison of stage of groundwater development, Punjab (draft as a percentage to recharge)

Districts	1997	2004	2009	2011	2013	2017
Gurdaspur	71	107	126	127	114	125
Hoshiarpur	44	85	104	102	99	107
SAS Nagar	-	-	102	103	98	120
Rupnagar	52	93	110	110	110	117
SBS Nagar	-	175	112	115	107	116
Jalandhar	197	254	229	231	209	239
Ludhiana	136	144	170	167	162	183
Sangrur	155	183	264	283	211	260
Patiala	128	165	195	196	189	217
F. Sahib	141	161	210	210	191	208
Amritsar	111	152	179	180	126	148
Tarn Taran	-	-	181	182	133	153
Barnala	-	-	197	204	194	211
Kapurthala	251	204	235	234	205	224
Moga	-	178	203	202	207	229
Bathinda	52	93	124	119	93	98
Mansa	-	175	214	208	138	141
Faridkot	76	106	159	160	160	167
Ferozepur	64	105	141	147	124	136
Mukstar	-	62	70	69	70	74
Punjab	98	145	170	172	149	166

Source : Dynamic Groundwater Resources of India, various issues
Mansa is included in Bathinda, Moga and Muktsar in Faridkot and Nawan Shehar in Jalandhar and Hoshiarpur for the year 1997
Pathankot and Fazilka are included in Gurdaspur and Ferozepur districts respectively
SAS Nagar is included in Rupnagar and Patiala, Tarn Taran in Amritsar and Barnala in Sangrur for the period 1997 and 2004

The groundwater development for all the districts has increased overtime. Almost all the districts have groundwater development (Kaur *et al*, 2015) above 100 per cent. In Sangrur and Jalandhar, the stage of development for 2017 was observed to be 260 and 239 per cent, respectively. The districts having a groundwater development of less than 100 per cent in the state are Muktsar and Bathinda with 74 and 98 per cent respectively. The reason for over-exploitation is indiscriminate groundwater extraction both for agricultural, industrial and domestic uses etc. as well but mainly for irrigation purpose.

Over the period, the rate of over-exploitation has increased in the state. In 1997 the percentage of over-exploited blocks was 53 per cent which increased to 79 per cent in 2017 (Table 5). The number of over-exploited blocks has increased sharply during the period 1997 to 2004. The district-wise scenario depicts that by the year 2017, more than 50 per cent of districts in the state have turned dark (100 per cent of the blocks are under over-exploited category). For the period of 1997 to 2004, only few blocks were fully over-exploited. The prominent districts with fully over-exploited blocks are Patiala, Kapurthala, Ludhiana, Tarn Taran, F. Sahib, Amritsar, Jalandhar, Sangrur, Barnala, Moga, Faridkot and Ferozepur. In 1997, the percentage of over-exploited blocks was 22 which rose to 54 per cent in 2017. In Rupnagar a drastic change in the per cent of over-exploited blocks was shown from 28.6 per cent in 1997 to 60 per cent in 2017. An opposite trend was observed in Mansa district, where the per cent of over-exploited blocks decreased over time.

This over-exploitation scenario depicts the fact that limited surface water supply and a reduction in their

Table 5. District wise change in number of Over-exploited blocks in Punjab, 1997-2017 (Number)

Districts	1997	2004	2009	2011	2013	2017
Rupnagar	2(28.57)	2(28.57)	3(60)	3(60)	2(40)	3(60)
Hoshiarpur	2(20)	2(20)	4(40)	4(40)	4(40)	4(40)
SAS Nagar	-	-	2(66.67)	2(66.67)	2(66.67)	2(66.67)
Gurdaspur	4(28.57)	7(50)	8(80)	8(80)	8(80)	8(80)
SBS Nagar	-	3(60)	3(60)	3(60)	2(40)	3(60)
Patiala	8(88.89)	8(88.89)	8(100)	8(100)	8(100)	8(100)
Kapurthala	5(100)	5(100)	5(100)	5(100)	5(100)	5(100)
Ludhiana	8(72.73)	10(91)	11(91.67)	11(91.67)	11(91.67)	12(100)
Tarn Taran	-	-	8(100)	8(100)	8(100)	8(100)
F. Sahib	3(60)	5(100)	5(100)	5(100)	5(100)	5(100)
Amritsar	11(68.75)	16(100)	8(100)	8(100)	7(87.5)	8(100)
Jalandhar	10(100)	10(100)	10(100)	10(100)	10(100)	10(100)
Sangrur	12(100)	12(100)	9(100)	9(100)	9(100)	9(100)
Barnala	-	-	3(100)	3(100)	3(100)	3(100)
Moga	2(40)	5(100)	5(100)	5(100)	5(100)	5(100)
Faridkot	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)
Mansa	-	5(100)	5(100)	5(100)	4(80)	4(80)
Ferozepur	3(30)	7(70)	8(100)	8(100)	5(83)	6(100)
Bathinda	1(14.28)	4(57)	3(42.85)	3(42.85)	3(42.85)	3(42.85)
Fazilka	-	-	-	-	2(50)	1(25)
Punjab	73(52.89)	103(75.18)	110(79.71)	110(79.71)	105(76.09)	109(78.99)

Source: Dynamic Groundwater Resources of India, various issues
**Figures in parantheses indicate percentage to the total number of blocks in corresponding district*
**SAS Nagar was newly made from districts Rupnagar and Patiala in 2006, so data was not available for this district.*
**Tarn Taran, Barnala are included in districts Amritsar and Sangrur while Fazilka is included in Ferozepur district till 2011*

quantity over time have put tremendous pressure on groundwater resources due to ever increasing demand for water. There is an immediate need to recharge groundwater in the over-exploited blocks and improve the available shallow groundwater in the safe blocks to prevent water logging in the near future.

Conclusion and Policy Implications

The water level in Punjab is getting deteriorated. The percentages of wells falling in the range of below 10 m have decreased drastically. The net groundwater availability in the state is decreasing with an availability of -14.58 bcm in 2017. Thus, putting pressure on the groundwater resources and leading to over-exploitation of groundwater. The prominent districts with serious fall in water levels are Sangrur, Patiala, Jalandhar, Moga and Barnala of Central zone. In South West zone, Muktsar showed an increasing trend in water level depth. Rainfall has decreased over the years affecting the flow of water in major rivers and natural recharge of the groundwater resources. The net annual draft was always higher than the net annual recharge thus creating a negative ground water balance in almost 70 per cent of the state. Almost all the districts have groundwater development above 100 per cent. The districts having a groundwater development of less than 100 per cent in the state are Muktsar and Bathinda with 74 and 98 per cent respectively. In Sangrur and Jalandhar, the stage of development has reached 260 and 239 per cent respectively. The percentage of over-exploited blocks has increased to 79 per cent, while for safe blocks, it has decreased drastically. The districts with fully over-exploited blocks are Patiala, Kapurthala, Ludhiana, Tarn Taran, F. Sahib, Amritsar, Jalandhar, Sangrur, Barnala,

Moga, Faridkot and Ferozepur. The decrease of water table can be arrested by either limiting the groundwater draft or increasing the recharge of groundwater. Construction of artificial ponds/tanks may be done to store water into it, which will help percolation of water to subsoil. The state government should adopt a well-defined policy on artificial recharge of groundwater, exclusively in areas with high declining water levels. The state government should adopt a well-defined policy on artificial recharge of groundwater, exclusively in areas with high declining water levels. The harvesting of rainwater, its management and efficient utilization can resolve the water scarcity problem to a greater extend.

References

Central Water Commission 2017. Annual Report: Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India. http://cwc.gov.in/sites/default/files/finalcwcar2017-18_1.pdf

Government of India. Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation. http://cgwb.gov.in/

Government of India, *Dynamic Ground Water Resources of India* (various issues), Ministry of Water Resources, CGWB (Central Ground Water Board), New Delhi. http://cgwb.gov.in/Dynamic-GW-Resources.html

Gulati A, Roy R and Hussain S. 2017. Getting Punjab agriculture back on high growth path: sources, drivers and policy lessons. https://icrier.org/pdf/Punjab%20Agriculture%20Report.pdf

Kaur B, Sidhu R S and Vatta K. 2010. Optimal Crop Plans for Sustainable Water Use in Punjab. *Agric Econ Res Review***23**:273-84. https://doi.org/10.22004/ag.econ.96936

Kaur B, Vatta K and Sidhu R S. 2015.Optimising irrigation water use in Punjab agriculture: role of crop diversification and technology. *Indian J Agric Econ* **70**:307–318. https://doi.org/10.22004/ag.econ.230064

Nelson H, Roe T, Smith R, de Leon Barido D P and Georgiou E F. 2013. The Shadow Value of Groundwater in Punjab, India: An analysis in an Economy-Wide Context. *The University of Minnesota, Institute of the Environment* (Original not seen. cited by Grant D). http://dleonb.com/wp-content/uploads/2013/12/Discovery-Grant-White-Paper-2_Oct2013.pdf

Singh I and Bhangoo K S. 2013. Irrigation system in Indian Punjab. *Punjabi University*, Patiala, India. https://mpra.ub.uni-muenchen.de/50270/1/MPRA_paper_50270.pdf

Singh J M, Kaur B, Chopra S, Singh J, Sachdeva J and Kumar H .2019. Existing status of groundwater resources in Punjab – an overview, in: Chand P, Jain R, Kumar D S, Singh J M and Badal PS (Eds.), Natural Resource Use Planning for Sustainable Agriculture. ICAR-NAIP publication, National Printers,NewDelhi,pp.61-78. http://www.ncap.res.in/upload_files/workshop/book2020.pdf#page=73

Singh R B. 2001. Impact of land-use change on groundwater in the Punjab-Haryana plains, India. *IAHS PUBLICATION*, pp.117-122. http://hydrologie.org/redbooks/a269/iahs_269_0117.pdf

Srivastava S K, Chand R, Raju S S, Jain R, Kingsly I, Sachdeva J, Singh J and Kaur A P. 2015. Unsustainable groundwater use in Punjab agriculture: insights from cost of cultivation survey. *Ind J Agri Econ***70**:365-378. https://doi.org/10.22004/ag.econ.230215 http://www.worldbank.org

Received: April 7, 2021 Accepted: June 8, 2021