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USE OF GROUNDWATER FOR AGRICULTURAL PRODUCTION IN DEH DESVI OF THANO BOOLA KHAN, JAMSHORO, SINDH

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ABSTRACT

A survey was carried out to assess the crop production, available water resources, water use efficiency and economic analysis of cultivation of various crops in deh Desvi of Thano Boola Khan, district Jamshoro during year 2006. It was noted that the major crops being cultivated in the area are onion, wheat, vegetables and fodder. The onion is the most popular cash crop which is being marketed to Karachi and other parts of the country. Fodder is only being used for feeding livestock, which is the second livelihood option for farmers of the area. The net income from different crops in deh Desvi was about Rs.27.151 million by using furrow/flood irrigation method. However, on adoption of drip/trickle and sprinkler irrigation systems, the irrigation application efficiency can remarkably be increased and the income from different crops could go up to Rs.94.955 million, which will obviously increase the interest of communities in these irrigations systems and consequently the system can be more sustainable. Major portion of land is cultivated by deep wells (56.40 %), followed by dug wells (42.44 %) and Persian wheel (1.16 %). Irrigation water is being used by traditional methods as basin and furrow irrigation, which gives less irrigation efficiency about 68% and estimated water losses are up to 32%. To overcome these losses, the drip/trickle irrigation system is suggested for fruit trees, onion and other vegetables and sprinkler system is suggested for other crops which will alternately bring 90% efficiency and improve crop yield significantly. It is suggested that the rainwater harvesting techniques should be adopted which includes reservoir and groundwater recharge.

Keywords: water, resources, use, losses.

INTRODUCTION

Pakistan was a water abundant country (5300 m^3 $capita^{-1}$) during 1950s, which has turned into a water deficit country, with water availability of 1050 m^3 $capita^{-1}$ in 2002 (Ahmed, 2003). The irrigation system in the Indus Basin (Pakistan) is

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facing a number of operational problems resulting in water losses during conveyance and the application to crops. The aquifer is recharged through natural precipitation, river flow and continued seepage from the canal system and application losses from the irrigated fields. Historically, recharged groundwater has been recovered through public and private pumping systems.

The total land area of Sindh province is 14.09 mha, out of this 5.60 mha are cultivable, about 1.49 mha is culturable wastes and 1.03 mha is under forestry, 5.96 mha is not available for cultivation. Of the total cultivated areas of 5.60 mha, 2.86 mha are current fallow, and the net area sown is 2.74 mha. Hence, the total cropped area is 3.72 mha and area sown more than once is 0.98 mha. Out of the salt free (cultivated or cropped areas), which are 3.72 mha, about 2.32 mha are salt-affected. This includes 1.342 mha of highly saline, 0.673 mha of permeable saline-sodic and 0.277 mha of impermeable saline-sodic and 0.028 mha of sodic soils (GoP, 2009).

The study confines an area comprised of one deh i.e. named Desvi, Thano Boola Khan, taluka of district Jamshoro. Thano Boola Khan taluka is spread over western mountainous tracts of Sindh and is known as a part of Lower Kohistan, which is also last taluka head quarter of Kohistan region. Due to non-existence of canal irrigation system, the agricultural production is exclusively dependent on groundwater, rainfall crops mostly depend on monsoon rain. Besides low-key agriculture, the habitants involved in livestock rearing, with semi-nomadic and transhumant style and character in the heights of hills. Periodical droughts and famine afflict the tract in the freak seasons of low rainfall and run-off (SAZDA, 1991).

Thano Boola Khan taluka, exists in the arid tract of Kohistan range, where Rod/Spate dug wells and deep wells are the means to extract groundwater and rainwater harvesting depends upon the rainfall. The farming system in the area is very different from the irrigated areas. The groundwater is used on small scale because of its limited availability and mostly the farming system depends upon the Nai (Rod/Spate) irrigation system. The springs are perennial and natural source of water from the hills, which is also used to irrigate the lands. Chahi and Charkhi irrigation are also common to irrigate the crops.

The crops in Thano Boola Khan are seasonal; the tract grows sorghum and pearl millet in Kharif which is not only used as fodder but also consumed as human food. Pulses, green gram/ mungbean, gram, vegetables, onion, cluster bean (guar), cotton and wheat are also grown in this area. The study area is situated in lower Kohistan. Deh Desvi has total area reference about 48357 acres out of which 12761 acres are cultivated and 35595 acres are un-cultivable. Feeling the gravity of situation regarding the groundwater scarcity and agriculture of the area, the study was carried out to identify available water sources, water use efficiency and water losses in deh Desvi of Thano Boola Khan, district Jamshoro (Revenue Department, 2005).

A number of irrigation systems have been developed and most of them are very successful in effective water management with special reference to saving water without affecting potential crop productivity. The common water saving methods for canal irrigated areas are known as trickle irrigation, sprinkler system, pitcher irrigation system and a number of other scientific techniques developed by water management scientists. The source of irrigation in the arid zone and hilly tracts is only run-off and groundwater because of non-existence of canal water. The prevalent irrigation practices of deh Desvi Thano Boola Khan are classified as Barani (run-off), Springs, Chahi, and Charkhi. The Barani (run-off) refers to collect the run-off water in field bunds and reservoirs to irrigate the crops.

Problems identification

The existing area of Thano Boola Khan depends on groundwater and groundwater depends on rainfall. No any canal system is available in the area due to high elevation. Most of the rainfalls in monsoon season with average annual rainfall of 240mm. The quantity of receiving rainfall is less as compare to fulfill the production requirement for the existing area. Groundwater is pumped out through diesel engines, now a days it is also difficult to manage due to increase in prices day by day. The depth of dug well in the area ranges from 12.192 - 33.528 m. Most of the dug wells of less depth are operated three times a day for pumping purpose and of efficiency of pump set affected due to many times operation and it results lot of field water losses in open water courses as well as and receiving less quantity of water. Main problems in the existing area is shortage of water. The present study was carried out to assess the use of groundwater for agricultural production and crops productivities in deh Desvi of Thano Boola Khan, district Jamshoro.

Study area at glance

Deh Desvi of Thano Boola Khan is depending upon rainfed agriculture. It has population of low density with about 20 persons km^{-1} which struggles hard to earn for subsistence living. Besides low-key agriculture, they include into livestock rearing, with semi-nomadic and transhumant style and character in the heights of hills. Periodical droughts and famine afflict the tract in the freak seasons of low rainfall and run-off. The objectives of the study were to identify cultivated land on groundwater resources, cost of crops grown ha^{-1} and their income generation; and to develop strategy for sustainable agriculture with maximum land utilization under cultivation.

MATERIALS AND METHODS

A field survey was conducted to provide a broad description of the main farming activities occurring in the area and review the crops cultivated by the farmers of study area and their economic returns. Previously very little information on this topic has been published or cannot be easily accessed through the major publication databases so it was decided to use Rapid Rural Appraisal (RRA)

techniques. RRA encourages the use of a mix of study methods, many of them relatively informal in approach. This permits some triangulation of observation, accepting a lack of quantitative accuracy in favor of a better qualitative understanding of the total system, its major components and how these fit together and function.

Data collection

The survey was conducted from four major fields, total 51 interviews were conducted which included stakeholders such as farmers, landowners and field workers. In this survey a detailed data were collected which includes water resources, crops, irrigation application and methods of water extraction from the groundwater. The data also included ownership, cost and usage of water and its supply to the irrigated field, cropping pattern, acreage of land. The major land holdings were also collected on location wise. The major and minor land cultivation on each resource was also collected one by one from each farm. The collected data was analyzed to develop the scenarios in the study area for sustainable management of groundwater. The analysis mostly focuses on water available in the study area and crops cultivated.

The information regarding crop cultivation, secondary data was collected from the existing departments of Revenue and Pakistan Agricultural Research Council, Thano Boola Khan. The primary data was collected through physical field survey of existing farms of the reporting area and fill up questionnaires from each farm holder.

After the identification of groundwater in the area, the discharge was calculated using volumetric method and trajectory method.

RESULTS AND DISCUSSION

Land cultivation

The data embodied in Table 1 show the location wise land cultivation in the study area. The area is divided into 6 parts covering total area of 3707 ha, from which the dug well is available in Baro road, left side of spate Desvi and right side of spate Desvi that covers 178.47 ha of the land for cultivation purpose. The deep wells are located in Baro road, left side of the Mandir and right side of the Mandir that cover 237.154 ha of the land. Similarly, the Persian wheel (in local language Persian wheel is known as Nar, Charkhi and Chahi, the system is operated by means of donkey and camel power) covers 4.86 ha of cultivated land for the location of Nai Desvi left side and right side of the Mandir. From all sources total 420.48 ha of land is cultivated in the study area, which comes out total 11.34% during study period.

Table 1. Location wise and mode of cultivation in deh Desvi, Thano Boola Khan, 2006.

Location	Total Land (ha)	Mode of Land Cultivation (ha)		
		Dug well	Deep well	Persia Wheel (Nar/ Charkhi/ Chahi)
Baro road	430.9906	14.1640	72.84348	0
Desvi Nai left side	1045.304	92.26841	0.00	2.428116
Desvi Nai right side	973.6745	72.03411	0.00	0.00
Mandir left side	194.2493	0.00	64.74976	0.00
Mandir right side	439.0843	0.00	99.55276	2.428116
Gadooro hills	623.6211	0.00	0.00	0.00
Total	3706.924	178.4665	237.146	4.856232
Percentage (%)		42.44	56.4	1.16

The data in Table 1 shows the sources of water and its usage for agriculture and it was noted that the total land cultivated on dug well, deep well and Persian wheel are 178.4665, 237.146, and 4.856232 hectares, respectively and percentage wise 42.44%, 56.40%, and 1.16%, respectively. The contribution of deep well was remarkably higher in irrigating the land for different crops as compared to rest of the irrigation sources.

Table 2. Yield, expenditure and income ha^{-1} on groundwater resources in deh Desvi, Thano Boola Khan, 2006.

Crop	Acreage (Acre)	Yield (Kg ha^{-1})	On basis of 68.5% efficiency			Total income (m Rs.)
			Expenditure (Rs ha^{-1})	Income (Rs ha^{-1})	Net income (Rs ha^{-1})	
Onion	173.6103	24710.52	74131.55	148263.1	74131.55	12.87
Wheat	82.15126	3459.472	29652.62	38919.06	9266.444	0.76125
Vegetable	65.55913	9884.207	24710.52	98842.07	74131.55	4.86
Fodder	50.58575	24710.52	3706.577	148263.1	144556.5	7.312499
Carrots	44.51546	2471.052	6177.629	12355.26	6177.629	0.275
Cotton	1.214058	3459.472	29652.62	64865.11	35212.49	0.04275
Mango	0.809372	9884.207	61776.29	395368.3	333592	0.27
Ber	2.02343	19768.41	19768.41	395368.3	375599.8	0.76
Total	420.4688					27.1515

Table 3. Water use efficiency for various crops categorized on system applied.

Categories	Crop	System application	Efficiency (%)
1	Fodder Wheat Cotton	Sprinkler	90
2	Ber Mango	Trickle	90
3	Onion Carrots Vegetable	Drip	90

Table 4. Strategy for sustainability of agriculture on 90% efficiency on groundwater resources in deh Desvi, taluka Thano Boola Khan, 2006.

Crop	Total water requirement (mm)	Previous land cultivation (ha)	Potential land cultivation (ha)	Total volume of water (ha-m)
Onion	822.96	173.61	202.342	547.0326
Wheat	323.088	82.151	80.93	85.90437
Vegetable	499.872	65.56	64.75	106.3269
Fodder	499.872	63.131	60.702	99.68149
Carrots	350.52	44.515	0	0
Cotton	874.776	1.214	0	0
Mango	749.808	0.809	0.809	1.99363
Ber	609.6	2.023	174.015	348.48
Total	-	433.013	583.548	1189.419

Table 5. Yield, expenditure and income acre^{-1} on groundwater resources in deh Desvi, Thano Boola Khan, 2006.

Crop	Acreage (ha)	Yield (Kg ha^{-1})	On basis of 90% efficiency			Total Income (million Rs)
			Expenditure (Rs. ha^{-1})	Income (Rs. ha^{-1})	Net Income (Rs. ha^{-1})	
Onion	202.343	24710.52	74131.55	148263.1	74131.55	15.0
Wheat	80.9372	3459.472	29652.62	38919.06	9266.444	0.75
Vegetable	64.74976	9884.207	24710.52	98842.07	74131.55	4.8
Fodder	60.7029	24710.52	3706.577	148263.1	144556.5	8.775
Mango	0.809372	9884.207	61776.29	395368.3	333592	0.27
Ber	174.015	19768.41	19768.41	395368.3	375599.8	65.36001
Total	583.5572	-	-	-	-	94.95501

Table 6. Summary of net income before and after management options in deh Desvi, taluka Thano Boola Khan, 2006.

Total land (ha)	Land cultivated on efficiency (%)	Hectares	Net income on total land cultivation (million Rs)
3706.924	68.50	420.4688	27.151
	90.00	583.5572	94.95501
Net benefit	21.00	163.0885	67.80401

Economic efficiency

In Table 2, the economic analysis of crops is proposed on 68% irrigation efficiency basis. The onion was cultivated on an area of 173.6103 ha to yield 24710.52 kg ha^{-1}, and with production cost of Rs.74131.55 ha^{-1}, this generated a total income of Rs. 148263.1 ha^{-1}, showing a net income of Rs.74131.55 ha^{-1}. Thus, total incomes estimated to about Rs.12.870 million; as the share in the income generation for wheat crop was Rs.0.761 million, vegetables Rs.4.86 million and fodder crops Rs.7.312 million. Carrots were cultivated on 44.51546 ha which yielded 2471.052 kg ha^{-1} against the expenditure of Rs.6177.629 ha^{-1} that accumulated to a total income of Rs.12355.26 ha^{-1}. This indicates a net income of Rs.6177.629 ha^{-1}, while the total income generated was Rs.0.275 million in the study area. Cotton crop was cultivated on 1.214058 ha^{-1}, which produced seed cotton yield of 3459.472 kg ha^{-1}, and against production cost of Rs. 29652.62 ha^{-1}, the total income generated to Rs.64865.11 ha^{-1}, showing a net income of Rs. 35212.49 ha^{-1}; while the total net income was Rs.0.04275 million. Mango crop was cultivated on 0.8093 ha which yielded fruit yield of 9884.207 kg ha^{-1}, with production cost of Rs. 61776.29 ha^{-1}, the income generation was Rs.395368.3 ha, showing a net income of Rs.333592 ha^{-1}; while the total net income on the whole crop was Rs.0.270 million in the study area. Ber/Jujube crop was cultivated on 2.02343 ha^{-1}, which produced yield of 19768.41 kg ha^{-1}; against production cost of Rs. 19768.41 ha^{-1}, the total income generated was Rs. 395368.3 ha^{-1}, showing net income of Rs. 375599.8 ha^{-1}. The total net income from ber in the study area was Rs. 0.760 million. The results brought out that seven types of crops were grown in the area and net income generated was 27.151 million rupees on 68% irrigation application efficiency.

Strategies for sustainable water management

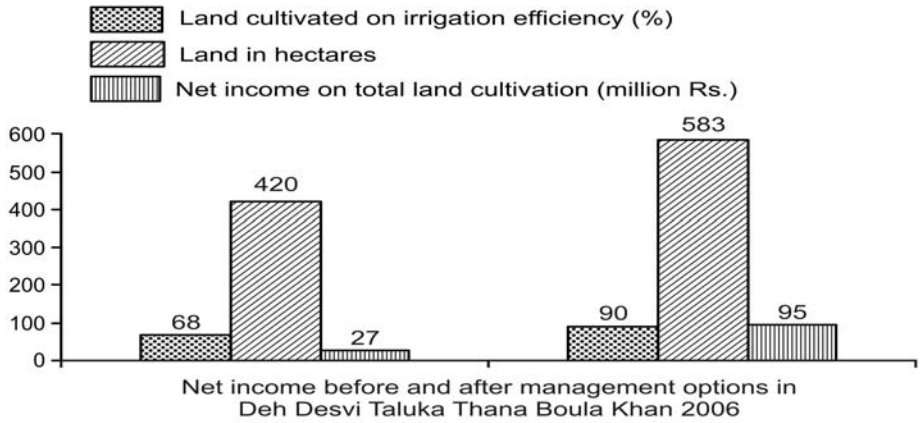
Table 3 indicates that all crops could be cultivated through sprinkler, trickle and drip system. The systems are proposed to save losses, and application efficiency could increase up to 90% as well as increased productivity with high net returns. The crops are categorized system wise, e.g. in first category fodder, wheat and cotton crops are proposed to be cultivated on Sprinkler irrigation system, that works with 90% irrigation application efficiency. In second category Ber/Jujube and mango fruits are proposed on trickle irrigation system that works 90% irrigation application efficiency. In third and final category, the onion and vegetable crops are introduced to be cultivated on Drip irrigation system that also works on 90% irrigation application efficiency. So, the efficiency performance up 90% for all crops on proposed systems is introduced.

Future strategy

The data in Table 5 shows the future strategy for sustainable agriculture in the study area. All crops are cultivated on the basis of crop water requirement; land increase over previous experience because of reduction in water losses and improved application efficiency up to 90%. The table explained that the onion crop needs 822.96 mm crop water requirement (C.W.R) for one growing season, 202.342 ha^{-1} of land could be cultivated as per planning instead of existing cultivation of 173.61 ha^{-1}. At present wheat is cultivated on 80.93 ha instead of 82.151 ha^{-1} with 323.088 mm C.W.R. Vegetables were recorded on 64.75 ha^{-1}, while this area could be increased to 65.56 ha^{-1} with 499.872 mm C.W.R. Similarly, mango orchard was found on 0.809 ha^{-1} exactly as per previous planning of 749.808 mm C.W.R. Ber/Jujube could be cultivated on 174.015 ha^{-1} instead of existing 2.023 ha with 609.6 mm C.W.R. Carrots and cotton crops are rejected for the area because only one growers cultivated cotton during last year, and the cultivation of carrots was not suitable for the area of study because it covers more area and have a low price, net returns are very low and hence uneconomical. The Ber/Jujube and fodder crops are increased due to increased demand and high economic returns. As per planning, total 583.548 ha^{-1} of land could be cultivated instead of existing cultivation of 433.013 ha^{-1}, and the application efficiency will be increased up to 90%. For this projection, 1189.419 ha of water will be required to manage cultivation of projected 583.548 ha.

Economic evaluation

The data in Table-5 explain the crop cultivation on the basis of economic returns for the future planning. The area and application efficiency is expected to increase if the planned system of Drip/ Trickle and Sprinkler is adopted on behalf of the economic returns for each crop. Yield per acre of the crop was fixed as general factor, but definitely it is expected to increase with improvement in performance of the system adoption. From the onion crop with yield of 24710.52 kg/ha^{-1}, the net returns of Rs. 74131.55 ha^{-1} are expected, and total amount Rs.15.0 million could be generated. Wheat was cultivated on 80.9372 ha, on the basis of 3459.472 kg ha^{-1} yields; the net returns could be Rs. 9266.444 ha^{-1}, while the overall income Rs. 0.75 million could be the generated. Vegetables were cultivated on 64.74976 ha^{-1} with 9884.207 kg ha^{-1} yield, a net income of Rs. 74131.55/ha^{-1} is expected, while the total income amount of Rs.4.80 million is expected. Fodders were cultivated on 60.7029 hectares and with yield of 24710.52 kg ha^{-1}, the net income of Rs.144556.5 ha^{-1} is possible, while the total income of Rs. 8.775 million rupees could be generated. Mangoes on 2 acres were growing in the study area and with a yield of 9884.207 kg ha^{-1}, net profit of Rs. 0.809372 ha^{-1} could be achieved, while the total income generation could be up to Rs. 0.270 million. Ber/Jujube was cultivated on 174.015 ha^{-1} and with 19768.41 kg ha^{-1} yields a net income of Rs. 375599.8 ha^{-1} is estimated, while the total income of Rs. 65.360 million for the year could be possible. The table shows that a total income of Rs. 94.95501 million is possibly generated from all crops cultivated round the year.



Net income before and after management options in Deh Desvi Taluka Thana Boula Khan 2006

Net returns

The Table 6 shows that the total land in the area for cultivation purpose is lying 3706.924 ha^{-1} from which 420.4688 ha^{-1} (on 68.50% irrigation application efficiency) cultivated previously during study period and generated total income of 27.51 million rupees, instead of planned 583.5572 ha of the land if cultivated on 90% irrigation application efficiency basis, the income generated will be Rs. 94.95501 million. The results brought out that from 163.0885 ha of land on 21.5% irrigation application efficiency basis the net benefit of Rs. 67.80401 million could be increased over previous experience.

CONCLUSION

The study area receives water from groundwater, which is dependent only on rainfall. The groundwater is being extracted through three modes as deep wells, dug wells and Persian wheels. Major portion of land is cultivated by deep wells (56.40 %), followed by dug wells (42.44 %) and Persian wheel (1.16 %).

Irrigation water is being used by traditional methods as basin and furrow irrigation, which gives less irrigation efficiency about 68% and looses this highly valuable water by about 32%. To overcome these losses, the drip/trickle irrigation system is suggested for fruit trees, onion and vegetables and sprinkler system is suggested for other crops which will alternately bring 90% efficiency and improve crop yield significantly.

The net income generated in the area is about Rs.27.151 million by using furrow irrigation method. It is suggested that if the irrigation is applied through drip/trickle and sprinkler systems and is managed through furrow and drip irrigation and value-added crops are grown then income generation could go up to Rs.94.955 million, which will obviously increase the interest of communities and consequently the system can be more sustainable.

The major crops being cultivated in the area are onion, wheat, vegetable and fodder. The onion is the most popular and cash crop which is being marketed to Karachi and also to other parts of the country. Fodder is used for feeding their livestock, which is the second livelihood option for the area.

It is also suggested that the rainwater harvesting techniques should be adopted which includes reservoir and groundwater recharge.

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