INTEGRATION OF CANAL AND GROUNDWATER TO IMPROVE COST AND QUALITY EQUITY OF IRRIGATION WATER IN A CANAL COMMAND

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ABSTARCT

Climate in Pakistan gradually increases in severity in north-south direction; this is also the general flow direction of Indus Basin Irrigation System (IBIS) and canal commands. Thus, in general crop water demand increases and rainfall decreases in head-tail end direction of the canal commands. Insufficient delivery of canal water in comparison to increasing cropping intensities and water demands has lead share of groundwater irrigation to be at par with canal supplies. This has given birth to groundwater mining problems and increasing irrigation costs in tail ends of the canal systems. The research was conducted in Lower Bari Doab Canal (LBDC) irrigation system to explore way out to curtail and reverse abnormal groundwater lowering trends at tail ends of canal systems and ensure equity of irrigation costs.

Data regarding canal water, groundwater depth and quality, spatial climate variability and crop water requirement was analysed. Groundwater model of the area was developed using Groundwater Vistas software. Groundwater pumping by the farmers was the most complex parameter; crop water deficit approach was adopted to estimate it on Kharif and Rabi season basis. Different canal water reallocation scenarios encompassing 50 years time were developed and simulated. Most plausible reallocation pattern from head to tail end of the command was found for achieving the combined cost and quality equity of canal and groundwater use in the command.

At prevailing pattern and average cropping intensity of 159.7%, the annual crop consumptive use requirements increases from 1051 to 1152 mm from head to tail end respectively, with 9.6% increase. Annual normal rainfall decreases from 472 mm at head to 212 mm at tail end, with 55.1% reduction. Net crop consumptive use requirement (after accounting rainfall contribution) is 725 mm at head end and 908 mm at tail end (distributed over CCA), thus 25.2% larger at tail end of the command. Canal supply is fairly uniform at distributary head, with out any trend in head tail end perspectives. Balance of crop water requirement is largely met by groundwater

pumping to the tune of 492 mm at head to 518 mm at tail. Groundwater recharge from canal supplies and rainfall reduces from 430 mm at head end to 285 mm at tail end.

Groundwater depth varies from 4-8 m at head end to 14-20 m at tail end. Groundwater mining is taking place at tail end @ 0.34-0.60 m/year, whereas in head end areas groundwater levels are stable. About 49.35% area, mostly between LBDC canal and Ravi River is fresh. The areas on left side of the LBDC command i.e. head reach, upper part of the middle reach and a small patch in tail reach near Jhanian town fall under saline to marginal quality. In general groundwater quality improves towards the tail end. Excessive lowering of watertable has made groundwater pumping 2.37 times and overall irrigation cost 2.19 times expensive in tail reach areas of the command. With continued equitable canal water supply, after 50 years from now, tail end farmers will be bearing 3.17 and 3.92 times of irrigation costs than at head end, in case of Stochastic (S) and Post LBDCIP (P) flow series, respectively.

With 25% reallocation from head towards tail end (with linear variation in between and comparatively less reallocation form saline head end areas) improves the standard deviation of cost inequity from 1905 to 323 and 1607 to 241 for S and P flow series, respectively. There is also net saving in groundwater pumping cost of 7.24 to 18.9% for the area in comparison to existing equitable canal water distribution. With this approach, at least no or minimal waterlogging in the head end area even during wet years and at the same time, no groundwater mining in the tail end can be expected. It is recommended that canal water duty may be re-established in consideration of spatial variability of climatic parameters (rainfall and ET) within and amongst the canal systems in the region.

Temporal and spatial analysis of groundwater quality, travel time calculations, solute transport simulation and MODPATH run do not show much vulnerability of lateral saline intrusion, due to very slow movement of groundwater, except salts up-coning from deep saline water in Shergarh sub-area is posing the threat.