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Modelling the surface water allocations and deliveries in the world's largest continuous irrigation system, Indus Basin Pakistan

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Pakistan operates the world's largest continuous irrigation system, the Indus Basin Irrigation System (IBIS), which supports food production, energy generation and stock, domestic and industrial supply for the nation. Predicting future seasonal inflows and the subsequent seasonal allocation, delivery and distribution of surface water resources throughout the IBIS is a labourious and complex process for water managers. The harmonious management of the system requires a robust, transparent and defensible understanding of the water resources and how these resources are shared between different provinces and canal systems. To enhance existing understanding, based on recommendations of the 2012 Pakistan Water Sector Task Force Report, a daily Indus River System Model (IRSM) was implemented using the eWater Source modelling framework – Australia's National Hydrological Modelling platform.

The IRSM represents the IBIS by describing both the physical and water sharing systems on a daily time step. The physical system is described by a complex node-link network that commences at rim stations and includes 2 major supply reservoirs (Tarbela and Mangla), Ghazi-Botha scheme, 16 barrages (including Chashma), 14 main link canals and 73 irrigation supply canals and associated irrigation demands and ends below Kotri barrage. The model accounts for major supply reservoir sedimentation over time, flow routing and distribution losses. The model also considers energy generation at Tarbela, Mangla, Ghazi-Botha scheme and hydro capable barrages. The water sharing system reproduces seasonal inflow forecasts at rim stations, the 1991 water apportionment accord sharing arrangements as well as provincial sharing at the command canal level. The water delivery system manages constraints and the delivery of water via multiple supply paths and storages. This IRSM is the first daily modelling framework to allow federal and provincial agencies to simulate the planning and delivery of water to the canal command level.

Model results for the period 2002-2012 show that simulated seasonal inflow forecasts match with historic forecasts resulting in provincial allocations that replicate historic water sharing and associated deliveries. The simulated total likely seasonal water availability volumes is within 6%, volumetric error of seasonal water deliveries to the Sindh and Punjab provinces is less than 1%, the average annual minimum volume error for Tarbela and Mangla is respectively within 3 and 6% or the storage capacity and daily flow nash-sutcliffe efficiency (NSE) correlations at major barrages exceeds 0.7. The IRSM provides a transparent and defensible understanding of the IBIS water resource. The IRSM can be used to identify and quantify system losses, improve delivery efficiency and explore seasonal and intra-seasonal supply reliability issues. The IRSM could also be used to investigate the potential impacts of climate change and infrastructure development on future water availability and sharing between different provinces.