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Adaptation of a pattern-scaling approach for assessment of local (village/valley) scale water resources and related vulnerabilities in the Upper Indus Basin

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The water resources of the Upper Indus Basin (UIB) are of the utmost importance to the economic wellbeing of Pakistan. The irrigated agriculture made possible by Indus river runoff underpins the food security for Pakistan's nearly 200 million people. Contributions from hydropower account for more than one fifth of peak installed electrical generating capacity in a country where widespread, prolonged load-shedding handicaps business activity and industrial development. Pakistan's further socio-economic development thus depends largely on optimisation of its precious water resources. Confident, accurate seasonal predictions of water resource availability coupled with sound understanding of interannual variability are urgent insights needed by development planners and infrastructure managers at all levels.

This study focuses on the challenge of providing meaningful quantitative information at the village/valley scale in the upper reaches of the UIB. Proceeding by progressive reductions in scale, the typology of the observed UIB hydrological regimes – glacial, nival and pluvial – are examined with special emphasis on interannual variability for individual seasons. Variations in discharge (runoff) are compared to observations of climate parameters (temperature, precipitation) and available spatial data (elevation, snow cover and snow-water-equivalent).

The first scale presented is composed of the large-scale, long-record gauged UIB tributary basins. The Pakistan Water and Power Development Authority (WAPDA) has maintained these stations for several decades in order to monitor seasonal flows and accumulate data for design of further infrastructure. Data from basins defined by five gauging stations on the Indus, Hunza, Gilgit and Astore rivers are examined.

The second scale presented is a set of smaller gauged headwater catchments with short records. These gauges were installed by WAPDA and its partners amongst the international development agencies to assess potential sites for medium-scale infrastructure projects. These catchments are placed in their context within the hydrological regime classification using the spatial data and (remote sensing) observations as well as river gauging measurements. The study assesses the degree of similarity with the larger basins of the same hydrological regime. This assessment focuses on the measured response to observed climate variable anomalies.

The smallest scale considered is comprised of a number of case studies at the ungauged village/valley scale. These examples are based on the delineation of areas to which specific communities (villages) have customary (riparian) water rights. These examples were suggested by non-governmental organisations working on grassroots economic development initiatives and small-scale infrastructure projects in the region. The direct observations available for these subcatchments are limited to spatial data (elevation, snow parameters). The challenge at this level is to accurately extrapolate areal values (precipitation, temperature, runoff) from point observations at the basin scale. The study assesses both the degree of similarity in the distribution of spatial parameters to the larger gauged basins and the interannual variability (spatial heterogeneity) of remotely-sensed snow cover and snow-water-equivalent at this subcatchment scale.

Based upon the characterisation of spatial and interannual variability at these three spatial scales, the challenges facing local water resource managers and infrastructure operators are enumerated. Local vulnerabilities include, but are not limited to, varying thresholds in irrigation water requirements based on crop-type, minimum base flows for micro-hydropower generation during winter (high load) months and relatively small but growing demand for domestic water usage. In conclusion the study posits potential strategies for managing interannual variability and potential emerging trends. Suggested strategies are guided by the principles of low-risk adaptation, participative decision making and local capacity building.