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Assessment of Snow Cover Change in Uzbekistan High Mountains

○ Temur KHUJANAZAROV, Adkham MAMARAIMOV, Bakhriddin NISHONOV, Akmal GAFUROV, Kenji TANAKA

Mountain river basins in Central Asia constitute a large component of regional water security, supplying meltwater for irrigation, hydropower production, and ecosystem functioning in downstream arid and semi-arid lowlands. In Central Asia, seasonal snow accumulation in high-elevation catchments has traditionally acted as a natural reservoir, regulating runoff timing and buffering interannual climate variability (Sadyrov, 2020). However, recent warming trends and shifts in precipitation regimes have raised concerns regarding the long-term stability of snow-fed river systems and their capacity to meet growing water demands under climate change.

In this analysis we review recent basin-scale observational evidence from mountainous regions of Uzbekistan to reassess how climate-driven changes in snow accumulation, air temperature, and precipitation are reshaping river discharge regimes. The analysis is based on long-term in-situ meteorological and hydrological records spanning more than two decades (2001–2023), enabling a detailed examination of seasonal snow dynamics, temperature extremes, and discharge variability. Unlike large-scale remote sensing or modelling studies that dominate regional assessments, this synthesis emphasizes ground-based observations to provide direct insight into basin-level hydrological responses.

Observational evidence indicates a persistent decline in seasonal snow accumulation across high-elevation basins, accompanied by a reduction in the frequency of high-snow years since the early 2010s. Similar reductions in snow depth, snow cover duration, and snowfall days have been reported across the Tien Shan and Gissar–Alay mountain systems. These changes are consistent with broader regional patterns of cryospheric decline documented throughout Central Asia. The reduction in snow accumulation directly weakens the role of snowpack as a seasonal water storage mechanism, increasing sensitivity of runoff to short-term climatic fluctuations.

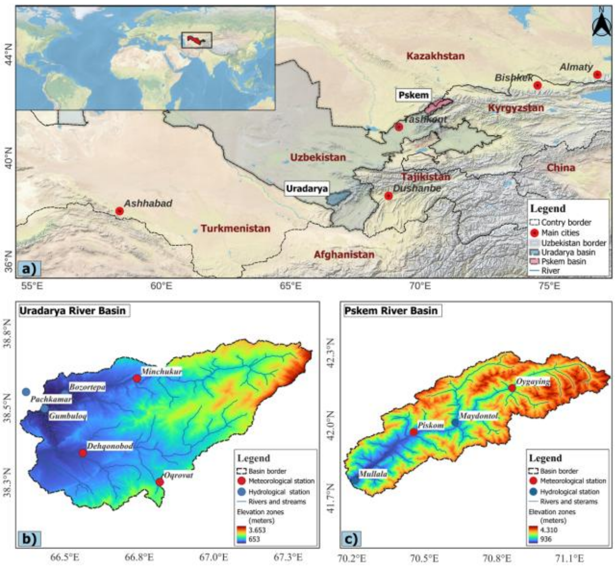

Fig. 1. Study area: (a) Geographic overview of Uzbekistan, topography and network of hydrometeorological stations in the Uradarya (b) and Pskem (c) River Basins.

Air temperature records further reveal pronounced warming trends, particularly during the spring season, when snowmelt processes are most active. Spring warming has been widely identified as a dominant driver of earlier melt onset and shortened snow cover duration across Central Asia (Kholmatjanov et al., 2020). Accelerated warming during this transitional season increases the likelihood of precipitation falling as rain rather than snow, especially in basins with lower mean elevations. This shift in precipitation phase further limits snowpack formation and reduces delayed water release into the summer period.

While winter snow accumulation remains a key control on summer discharge, the strength of the snow and runoff relationship has become increasingly moderate, indicating that temperature driven melt dynamics and precipitation variability now play a more significant role in determining seasonal flows. Peak discharge is increasingly observed earlier in the year, often during spring rather than mid-summer, reducing water availability during the vegetation period when irrigation demand is highest.

The declining alignment between water supply and demand has important implications for agriculture, hydropower, and ecosystem services in downstream regions. Irrigation systems designed around historically reliable summer flows may face increasing stress, potentially exacerbating existing challenges related to salinization and land degradation in Uzbekistan's lowlands. Hydropower operations, which depend on predictable seasonal flow patterns, may also require adaptation to earlier and more variable peak flows. Moreover, the weakening of snowpack buffering capacity increases year-to-year variability in water availability, reducing resilience to drought and extreme climate events (Mamaraimov, 2026).

From a broader perspective, the observed changes suggest a gradual transition in hydrological regime behavior in mountain basins. From snow-dominated, storage-driven systems toward more temperature controlled and climatically sensitive runoff regimes. As warming continues, the reliability of snowmelt as a predictable water source is expected to decline further, increasing uncertainty in seasonal water availability.

These findings highlight the urgent need to incorporate changing snow–runoff relationships into water resource planning and management frameworks. Strengthening observational networks, integrating ground-based data with remote sensing products, and improving seasonal forecasting capabilities will be essential for anticipating shifts in runoff timing and magnitude. Adaptive water management strategies that explicitly account for earlier snowmelt, reduced summer flows, and increased interannual variability will be critical for sustaining water security in Uzbekistan and across Central Asia under continued climate change.

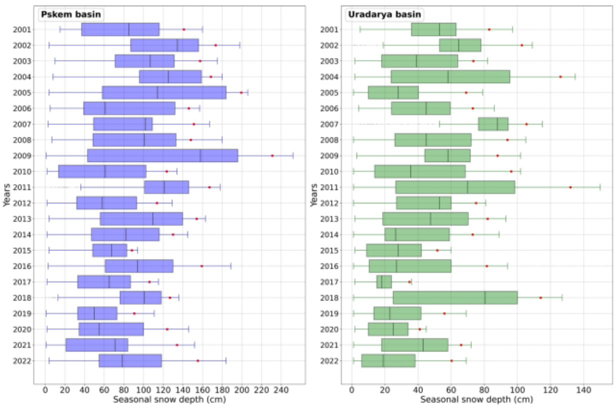

Fig. 2. Variations in the seasonal snow depth (Nov-Apr) in the Pskem and Uradarya basins in 2001-2023 hydrological years. (Mamaraimov, 2026).

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