Irrigation in high mountain Asia is creating unexpected glacier growth

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Irrigated plain in the Wakhan Valley of northeast Afghanistan, located in the mountainous Pamir region. Credit: Evgeni Sotov

A new study has demonstrated that irrigation in parts of high mountain Asia is having profound effects on some of the region's glaciers. In contrast to glaciers worldwide that are shrinking dramatically from global warming, glaciers in the Karakoram mountain range, spanning the borders of China, Pakistan and India, have long been recognized as stable and often growing. This effect, dubbed the Karakoram Anomaly, has also been observed in the western Kunlun Shan mountains of Xinjiang and Tibet in China.

In the new study, a team of glaciologists and climate modelers, lead by Remco de Kok at Utrecht University, modeled snowfall and temperature patterns and the response of glacier accumulation versus mass loss in the western Kunlun Shan and Karakoram. The results demonstrate that irrigation contributes a large part to changes in precipitation and snowfall in the region, which in turn have an effect on the glaciers. This research indicates that, in a seemingly far-fetched interplay, human activity is offsetting the negative effects of temperature increases.

The lowland valleys of high mountain Asia include some of the world's most intensely irrigated areas, such as on the Indo-Gangetic plain of north India. Rice, wheat and cotton are three water-intensive crops that are widely grown in the region commercially. Irrigation on these plains increases evaporation that adds moisture to the atmosphere. Atmospheric moisture leads to increased cloud cover and reduced incoming solar radiation, which reduces air temperatures close to the surface. Furthermore, evaporated moisture has a wetting effect by increasing precipitation and summer snowfall, which can add mass to the glaciers and provide an insulating blanket to keep the ice cool.

"We confirmed with our model that growing glaciers [in these mountains] are less sensitive to temperature changes," de Kok told GlacierHub. The computer models also indicate that this low temperature sensitivity and increase in snowfall are the main reasons

why glaciers in the region are stable and growing, suggesting that irrigation can increase glacier accumulation.

But irrigation is increasingly threatened by groundwater stress. Much of the primary source for irrigation is groundwater, which is being depleted as irrigation expands and intensifies. "The region is already stressed for water. They will get melting water from the glaciers on the other side of the Tien Shan, but this won't last forever. The region is already arid," de Kok tells GlacierHub. Once groundwater is no longer a sufficient source, irrigation may cease, which could have cascading effects for the western Kunlun Shan and Karakoram glaciers. "At some point you will hit the limit of water availability, whilst temperatures are still rising," remarks de Kok.

Increasing irrigation efficiency may be a solution to the depletion of groundwater in order to sustainably manage agricultural practices. However, trying to increase irrigation efficiency will reduce evapotranspiration and results suggest glaciers in the western Kunlun Shan and Karakoram will receive less snowfall, fueling their retreat. The connection between glaciers and irrigation creates a complex problem, whereby management of water availability can affect the local climate and glacier mass balances.

Although it has previously been hypothesized that irrigation is a potential driver of glacier growth, this study models the observed pattern of glacier mass balance directly by showing the response to precipitation and snowfall. As with many studies, there are still many unknowns that require future attention. The importance of groundwater extraction and melt from nearby regions such as the Tien Shan are not well understood, explains de Kok. "Secondary, knock-on effects for glaciers are not well modeled, this is a complex situation which still needs a lot of modeling." Scientific attention is being turned towards snowfall and the seasonal importance of snow and melt because the future evolution of these

patterns is linked to how irrigated areas will develop in the future.

De Kok is hopeful that other scientists studying high mountain Asia will strengthen his team's results and clarify the relationship between glacier mass balance and irrigation. He also suggests that a lack of ground measurements from weather stations is hindering efforts to better understand the regional weather patterns. This is a problem found in many mountain regions, as discussed in the IPCC's special report on high mountain areas.

The Karakoram Anomaly has long been puzzling scientists, offering an intriguing exploration into positive changes to glaciers in a region of the world severely impacted by climate change. The main concern is that once irrigation ceases, it can no longer drive processes of increased summer snowfall. At the same time, temperatures will still be rising, leading these anomalous glaciers to succumb to warming-induced retreat, landing them the same fate as other glaciers across high mountain Asia and the rest of the world.

More information: Remco J. de Kok et al. Towards understanding the pattern of glacier mass balances in High Mountain Asia using regional climatic modeling, *The Cryosphere* (2020). DOI: 10.5194/tc-14-3215-2020

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