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Past Water Futures: Rehabilitating Ancient Dams for Present-day Use in the Peruvian Andes

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Peru is at the forefront of climate change and concomitant water insecurity due to increasingly unstable rainfall regimes, retreating glaciers and new socioeconomic pressures on water use (Drenkhan *et al.*, 2015). Yet, climate change is not a modern phenomenon, human populations have suffered, mitigated and overcome the effects of adverse weather and environmental conditions for millennia. One such event was the Medieval Climate Anomaly (abbreviated as the MCA, see also, Lüning *et al.*, 2019). Occurring between c. AD 750-1350, with a core period during AD 1000-1200, the MCA in South America generally brought a drier and warmer climate (Figure 1).

It is likely that the MCA triggered the almost complete disappearance of glacier cover from the Pacific-facing western mountain range, precipitating a situation in which rainfall became the only annually reliable source of water. To offset this increased unpredictability of water availability, Late Prehispanic period (AD 1000-1532) communities in these highland zones adapted to the new climate regime through sustained building of hydraulic infrastructure, especially water dams, along the upper watershed basins. These features were what are known as *gravity dams*, constructed of stone and clay in which the weight and bulk of their construction is what held them in place, usually anchored onto bedrock for further stability.

This investment was considerable. Across the Cordillera Negra, covering a stretch of c. 130 km, over 290 ancient water dams have recently been identified (Pey *et al.* 2025). A limiting factor seems to have been the availability of clay near to the proposed dam: during this period the dam was invariably built where rock—ubiquitous to the highest areas of the Andes—and clay was present. In turn, this strong investment in water security led to a population explosion in the highlands, representing the highest such increase until the establishment of Spanish

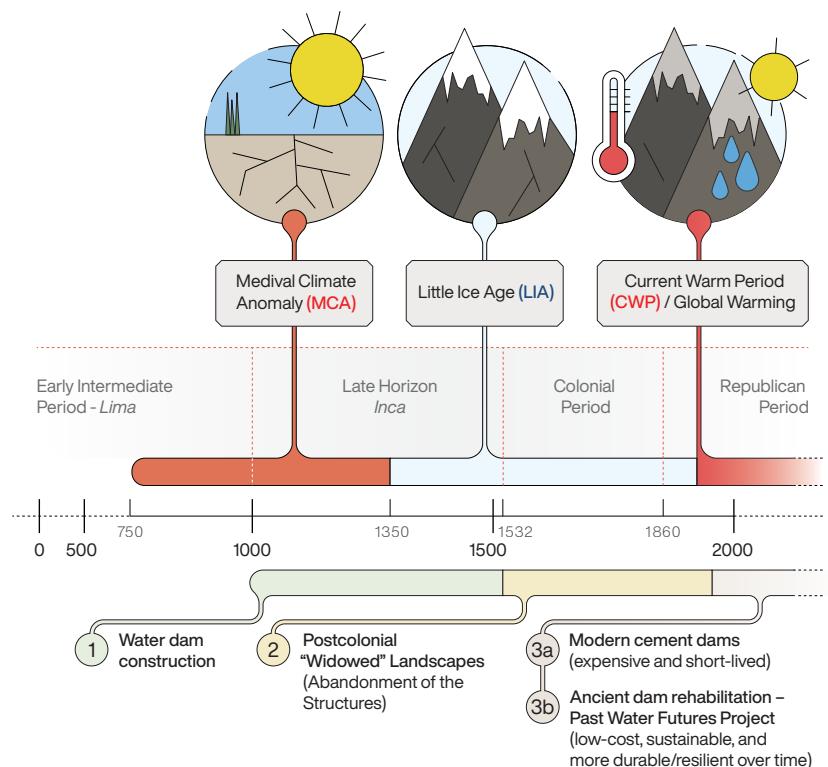


Figure 1. Timeline

imperialism across the Andes (post-AD 1532). Following this formative event, a catastrophic decline in the Indigenous People's population during the 16th and 17th Century led to the almost wholesale abandonment of these structures, heralding the establishment of *widowed landscapes* and ecologies, including derelict hydraulic infrastructure such as dams, reservoirs, *amunas*, and even terraces, among others. Nowadays, these abandoned infrastructures represent an important *installed capacity* of water-capture potential, especially as the Peruvian Andes face renewed pressure from climate induced water scarcity.



Figure 2. Ricococha Baja: pre-Hispanic dam rebuilt in 2008, failed within six months.

In these present-day circumstances where water insecurity is on the rise, the go-to solution has been the construction of modern micro-dams throughout Peru (Autoridad Nacional del Agua 2016). Invariably, in the highlands these constructions are often placed directly upon the older Prehispanic structure irrevocably destroying any record or function associated with them. While it is known that modern micro-dams are a tried-and-tested and widely accepted form of grey infrastructure that can ameliorate water scarcity, it does come with problems especially within the complex context of the Peruvian highlands.

Modern micro-dams are built from concrete and steel, and while they can hold much greater quantities of water than their more rustic Prehispanic cousins, they are also considerably more rigid and inflexible in a region where seismic events are a common occurrence.

Furthermore, modern micro-dams require expert engineering knowhow both at the design and construction level. Once the initial cost outlay has been expended in their construction few of these structures are maintained regularly, especially by rural highland communities that lack the expertise to assess a dam's condition or the financial means to redress any necessary repairs.

Another major problem is the potential for malfeasance in the modern construction of these dams. There are numerous cases of substandard materials and less quantity than the required (especially of cement bags) being employed in the construction of new micro-dams, such that the life-expectancy of these structures declines precipitously from the standard 50 years (Wieland 2010) to on average 20-30 years, in some cases considerably less so. By way of comparison, Prehispanic dams show incredible resilience, in many cases even after 500-years of negligible maintenance many of these ancient gravity dams still partially function, retaining and distributing water. The construction of the modern Ricococha Baja dam in 2008 ably demonstrated this (Figure 2). This dam functioned for just six months before it was rendered almost completely inoperable due to seismic activity compounded by bad planning and the use of limited and substandard materials (Llosa Larrabure, 2008).

Even so, state agents, NGO's, and critically, highland communities view modern micro-dams as paragons of rural development, acknowledging the use of cement and steel as progress, going so far as to term these 'noble material'. In contrast, the Prehispanic stone and clay dams are seen as defunct and inherently 'ignoble', even when in certain cases over 500 years of abandonment and negligible maintenance have not stopped these structures from still retaining and distributing water.

The *Past Water Futures* project advocates for the rehabilitation of Prehispanic dams, thereby providing a heritage-based solution grounded in the recovery of Traditional Ecological

Knowledge (TEK) and technical knowhow rooted in strong community engagement. Local buy-in is critical to these projects, as it ensures that the restored structures are effectively adopted by the target communities and maintained as an integral component of their yearlong activities (*faenas*). In essence, the restoration of ancient water dams represents a technically complex, yet low-carbon solution to water scarcity in the Andes. Additionally, there are important cost-saving implications; while a modern micro-dam budgets at a minimum of one million USD, the rehabilitation of a Prehispanic dam ranges between 100,000 and 150,000 USD apiece.

To date, the two Prehispanic dams, Ricococha Alta and the Weetacocha (Figure 2 and 3) dams, have been rehabilitated, and are both located in the Pamparomás District of the Cordillera Negra. While respecting the original construction of the dams, these rehabilitation projects incorporate certain modern materials, such as geomembrane, geotextiles and a modern sluice mechanism, thereby increasing the efficiency of the restored structures. Respectively, these two dams have a basin capacity of 18,750 m³ and 24,000 m³. Furthermore, in the first rainy season (November-April) both dams filled up at least twice, greatly boosting the available water. Some of this water then infiltrates via crack porosity through the dense Andesite geology replenishing underground aquifers that emerge as springs further downslope, creating a virtuous circle of water availability throughout the watershed. Additionally, the provision of new water at the head of the basin has incentivised the recovery of localised ecology, especially of birds which now frequent the new lakes. We have termed this positive hydraulic feedback loop with benefits to both water availability and environmental renewal a *recovered ecology*.

In regards to human benefits, the rehabilitation of these Prehispanic dams has led directly to three main outputs alongside heritage preservation of these structures, including; water provision which leads to increased water security and resilience among local communities; the growth of local economies, directly impacting monetary activity and output; and finally, protection of the environment, given that dam rehabilitation not only restores the dam itself but also protects important high-altitude wetlands which are crucial for preserving wildlife and plant environments. Of the identified 290 ancient dams in the Cordillera Negra, a conservative estimate could see at least a third of these rehabilitated. The skills honed by our research team through this process of rehabilitation can be applied on similar structures throughout the Andes and further afield. For instance, analogous technology has been observed in Africa (including the sand dams of Kenya, see Lasage *et al.*, 2008), Asia (such as the gabarbands in Pakistan and India, see Possehl, 1975) and Europe (for instance the anthropogenic fish ponds of central and eastern Europe, see Pokorný & Hauser, 2002).

Nevertheless, going forwards with this program of ancient hydraulic technology rehabilitation will require a significant paradigm shift from the current one of disregard and even contempt, towards one that embraces and promotes the restoration of these structures intimately embedded within rural communities. To this end, our research team is currently working towards deliverable policy directives at the local and state level which enshrine the rehabilitation of past hydraulic infrastructure for present-day use. We contend



Figure 3. Weetacocha: pre-Hispanic dam rehabilitated in 2024.

that in future, a hybrid approach will be best. Where old hydraulic infrastructure already exists (*installed capacity*), then these should be protected and restored; where no such infrastructure is present, then modern solutions, with the right safeguards against malpractice, should be implemented. Only by harnessing both the past and present—a combined approach—can we mitigate the risk of climate-induced water scarcity, providing resilience and reassurance to increasingly water-stressed communities throughout Andes and the world.

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Recommendations

- Recognize ancient hydraulic infrastructures as strategic climate assets, offering resilient, low-cost, and sustainable alternatives for contemporary water management and adaptation planning.
- Integrate heritage-based restoration into national water policies, promoting the rehabilitation of pre-Hispanic dams as community-driven solutions to water scarcity.
- Implement modern solutions only where such ancestral systems are absent, ensuring safeguards against unsustainable or extractive practices.
- Strengthen local capacities and community engagement through participatory restoration programs that ensure long-term maintenance and social ownership of rehabilitated dams.



Supplementary Materials



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