Water Security and the Hydric Potential of Andean Cryosphere.

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November 22, 2022

Abstract

In dry regions, millions of people depend on freshwater provided by the mountain cryosphere. Its likely depletion would make productive land-use management and access to water supply an even more urgent priority. Therefore water-security-oriented policies increasingly rely on solid information feedbacks for projections provided by Earth Sciences. Nevertheless, this type of research still has a lot to understand regarding headwater catchment hydrology, the top global "water towers." For example, there are many theoretical and logistical uncertainties: "data deserts" in isolated areas, outdated legislation, or scarce research funding. Yet, one more important issue to highlight is the evolving nature of hydric resources, particularly where baselines have a large uncertainty and supply to many as in dry regions in the Andes or the Himalayas. The main concern here is the legislative inadequacy for evolving hydric resources as their baselines change. For example, groundwater within transboundary or paleowater aquifers could have unaccounted climate-sensitive recharge sources (e.g., permafrost thaw). Hence, the specific way of legislating mountain groundwater could turn ambiguous and useless. By reviewing particular legislation and landing the discussion on study cases in mountainous areas, we commit to showing the inadequacy of current legislation on hydric-potential evolution. Overall, water-security-oriented legislation will not assess and protect headwater catchments within the spectrum of different recharge processes throughout different hydroclimatic zones. First, the "evolving value" of specific catchments changes the nominal priority and purpose for protection. Secondly, a consistent failure to assess incommensurable (latent), climate-sensitive fractions of water supply structure is also found. Therefore, the policy recommendation is to use a hydric scale absorbing all nested processes necessary for hydric supply to persist, requiring defining a lifespan for legislation.

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PRESENTED AT:

AGU FALL MEETING
New Orleans, LA & Online Everywhere
13–17 December 2021
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1. CASE FOR CONCERN

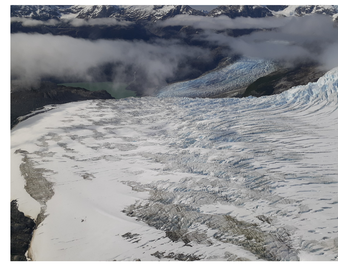
Mountain hydric resources (Fig. 1) are subject to conflicts of appropriation and economic transformations[a], having a problem of analytical incommensurability[b], as management options transform value that:

1.1 cannot be compared

1.2 lacks a particular scale, or

1.3 has suboptimal (up)scaling procedures.

Figure 1. Cryosphere in South America without clear baselines.



2. CURRENT-STATE

Assessing hydric potential (**Table 1**) should not be reduced to one measure of uncertainty, as it will irrevocably propagate the legislative inadequacy in terms of:

2.1 Evolving baselines.

2.2 Evolving priorities.

2.3 Evolving value.

The main issue is that hydric potential often grasps only one dimension of value; instrumental value.

Table 1. Evolution of hydric potential.

Hydrological sources	Hydrological connectivity	EVOLUTION OF HYDROLOGICAL STRUCTURE	HYDRIC POTENTIAL EVOLUTION	Legislative scope
Mean Transit Times				
Ecological niche				
Permafrost degradation/aggradation				
Deglacierization				
Baseline changes				

3. FEED-FORWARD

Natural value of Andean cryosphere (water supply) requires assessing both land-surface and atmospheric projections (Fig. 2) linked to:

3.1 The evolution of land-use value.

3.2 Resilience to drought and estimated time for depletion.

Hydric resilience to depletion should also be considered a proxy for either their use and non-use value.

Figure 2. Hydrological cycle above 5000 m a.s.l. in Central Andes.

4. OUTLOOK

Water security analyses should consider surplus value associated to landscapes and choose an analytical scale absorbing all processes concerning natural value.

Figure 3. Andean cryosphere: coexisting protected (National Parks, below) and non protected areas face future management issues.

References:

a. Ruiz Pereira, S., Fernandez, J., Herrera, J., & Olea, J. (2021). Environmental Impact Assessment Review, 86, 106472.

b. Adler, M. (1997). Incommensurability and cost-benefit analysis. U. Pa. L. Rev., 146, 1371.

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In dry regions, millions of people depend on freshwater provided by the mountain cryosphere. Its likely depletion would make productive land-use management and access to water supply an even more urgent priority. Therefore water-security-oriented policies increasingly rely on solid information feedbacks for projections provided by Earth Sciences.

Nevertheless, this type of research still has a lot to understand regarding headwater catchment hydrology, the top global "water towers." For example, there are many theoretical and logistical uncertainties: "data deserts" in isolated areas, outdated legislation, or scarce research funding. Yet, one more important issue to highlight is the evolving nature of hydric resources, particularly where baselines have a large uncertainty and supply to many as in dry regions in the Andes or the Himalayas.

The main concern here is the legislative inadequacy for evolving hydric resources as their baselines change. For example, groundwater within transboundary or paleowater aquifers could have unaccounted climate-sensitive recharge sources (e.g., permafrost thaw). Hence, the specific way of legislating mountain groundwater could turn ambiguous and useless. By reviewing particular legislation and landing the discussion on study cases in mountainous areas, we commit to showing the inadequacy of current legislation on hydric-potential evolution.

Overall, water-security-oriented legislation will not assess and protect headwater catchments within the spectrum of different recharge processes throughout different hydroclimatic zones. First, the "evolving value" of specific catchments changes the nominal priority and purpose for protection. Secondly, a consistent failure to assess incommensurable (latent), climate-sensitive fractions of water supply structure is also found. Therefore, the policy recommendation is to use a hydric scale absorbing all nested processes necessary for hydric supply to persist, requiring defining a lifespan for legislation.