Revisiting Ancestral Groundwater Techniques as Nature Based Solutions for Managing Water

Luís Ribeiro

Abstract

To achieve water sustainability and a more efficient use of water we should base on the ancestral water and territory management knowledge and grained in the culture of the people, This work is inspired in Nature Based Solutions (NBS) for managing water availability, particularly groundwater and aquifer-related NBS that hold major unrealized potential for alleviating adverse impacts of progressive climate change, namely to increase water security/drought resilience. In some cases, more ecosystem-friendly forms of water storage, such as natural wetlands, improvements in soil moisture and more efficient recharge of groundwater, could be more sustainable and cost-effective than traditional grey infrastructure such as dams. The core of this study is centred in the pre-Inca and Inca civilizations and how these communities have developed ingenious NBS solutions to adapt to extreme climate scenarios such as prolonged droughts, managing water resources in a holistic way and how they understand clearly the global water cycle in all the components specially groundwater. The work is divided in three interlinked phases: to sow water, by implementing ancestral aquifer recharge solutions, to retain water by improve hydraulic efficiency in terms of infiltration and drainage and to collect water by improve the performance of extraction in the subterranean aqueducts in arid regions.

Keywords

Groundwater • Sustainability • Nature-based solutions • Recharge • Climate change

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1 Introduction

For some decades, the world has shown its concern for a better use of water, ending with the paradigm that it is an unlimited natural resource and almost worthless. The management of water resources requires new solutions to counteract the growing challenges of water security arising from population growth and climate change. Today more than ever we must work with nature, rather than against it. The challenge we must all face is to meet this demand in a way that does not exacerbate negative impacts on ecosystems. These trends pose broader challenges, stemming from the increased risk of floods and droughts, which in turn has an impact on our ability to adapt to climate change. The great challenge is to take full advantage of nature's potential to contribute to the achievement of the three main objectives of water management—increase the availability of water resources, improve their quality, and reduce water-related risks.

The key global problem nowadays persists: the need to achieve a sustainable balance between water availability and demand especially in these times of the threats of the effects of climate change on the water resources of the planet.

The water sustainability can be advantageously achieved based on culturally anchored local knowledge and practices, by revaluating the ancestral wisdom in the management of water and territory how they have been able to overcome water problems throughout their histories, and on that basis build processes for a more efficient use of water (Vargas 2006; Yapa 2013).

This article is inspired in Nature Based Solutions (NBS) for managing water availability. The option of building more reservoirs is increasingly limited by silting, decrease of available runoff, environmental concerns, and restrictions. In many cases, more ecosystem-friendly forms of water storage, such as natural wetlands, improvements in soil moisture and more efficient recharge of groundwater, could be more sustainable and cost-effective than traditional grey infrastructure such as dams (WWAP 2018).

M. Abrunhosa et al. (eds.), *Advances in Geoethics and Groundwater Management: Theory and Practice for a Sustainable Development*, Advances in Science, Technology & Innovation,
https://doi.org/10.1007/978-3-030-59320-9_103

As the largest liquid freshwater reservoir on earth, groundwater has both a huge environmental and economic value, and will be an essential resource for adaptation to climate change and reduction of socio-economic vulnerability, particularly in regions where freshwater availability is highly variable and frequently limited.

Groundwater and aquifer related NBS hold major unrealized potential for alleviating adverse impacts of both floods and droughts in the same region/basin and impacts of progressive climate change overall.

Groundwater is less vulnerable to impacts of climate change, such as increasing temperatures (WWAP 2018). A related aspect is the role of improved soil management (a NBS) for managing infiltration, and therefore both runoff and groundwater recharge, as well as soil moisture retention, which is a particularly important factor regarding water security for crop production.

Aquifer-centric NBS, such as large-scale MAR interventions, may be applied in certain physiographic conditions to alleviate the risks of both floods and droughts in the same river basin in order to (a) increase water security/drought resilience; (b) increase food security, agricultural production, employment and farmer income; and (c) increased dry-season base flows to rivers and wetlands. Water storage is far from being realized. For example, trees can increase or decrease groundwater recharge according to their type, density, location, size, and age (Borg et al. 1988; Ilstedt et al. 2016).

The core of this contribution is centred in the pre-Inca and Inca civilizations and how these communities have developed ingenious NBS solutions to adapt to extreme climate scenarios such as prolonged droughts, managing water resources in a holistic way and how they understood clearly the global water cycle in all the components specially groundwater.

Why Peru? Among the most vulnerable areas to the catastrophic effects of climate change is Peru (Vuille et al. 2007). These effects include severe droughts, which affect everything from Peru's agricultural output to the resilience of the surrounding lands. Another prominent Peru effect is glacial melt. Peru has nearly 70% of the world's tropical glaciers. Both tropical glaciers and arctic glaciers are in peril, as rising air temperatures are causing them to lose ice more quickly than they acquire new snow. In 8 years (from 1989 to 1997), 447 km^2 of glaciers (21.85%) were lost corresponding to 12.3 billion cubic meters of water reserves (Vuille et al. 2007).

In the past, the ancestral civilizations of Peru have developed extraordinary solutions to adapt to adverse climate scenarios such as very prolonged droughts or the periodically El Niño events (Yapa 2013). Hence, Peru is a living laboratory where we can use the wisdom of the ancestor cultures to solve the present and the future of water management not only in this country, but also the problems that arise in another areas of Planet where the impact of climate change is also critical such as the Mediterranean region.

This article is divided in three interlinked phases: (1) To sow water by implementing ancestral aquifer recharge solutions, (2) To retain water by improve hydraulic efficiency in terms of infiltration and drainage and (3) To collect water by improving the performance of extraction in the subterranean aqueducts in arid regions.

2 To Sow Water

In Peru, the pre-Inca populations observed that the melting of the snows disappeared among the fissures of the Rocky Mountains feeding an aquifer or connecting directly to springs some kilometres further. The long fissures in the rocks that feed the springs in Peru are known as *amunas* (Fig. 1) The *amunas* constitute a complex hydro-geo-cultural system of artificial recharge of the aquifers, which begins with the rainy season and lasts in active state throughout the agricultural cycle. They are part of the inheritance of the pre-Hispanic times, reproduced and managed by three Huarochiran communities, in order to increase the volume of water from the springs that are used in their different economic and social activities, and mainly to productive purposes. The *amunas* currently in operation are located within the Huarochiran communities: San Andrés de Tupicocha, Santiago de Tuna and La Merced de Chaute (Apaza et al. 2006).

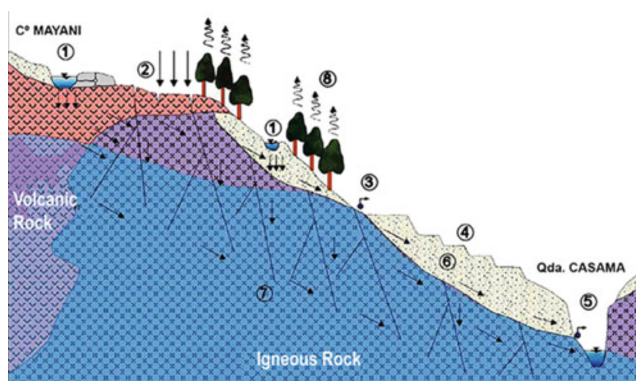

Fig. 1 Conceptual scheme of an *amuna*

3 To Retain Water

Ancestral farmers have learned to survive in harsh climate, cultivating many different products at as many different ecological niches as they can gain access to. This practice does not reduce the risk of loss in each plot but avoids the total loss of food and seeds and provides them with a cushion to survive until the next harvest. Wherever possible, they also attempt to modify their farming landscape, by preparing terraces, for example. Terracing can be defined as man-made alteration of sloping land topography, with the object of making better use of natural resources such as soil, water, and climate. Regarding climate, terracing enables the creation and improvement of microclimates, protecting the environment from advective transferal of energy, reducing temporal changes, conserving the components of greenhouse effects in the atmosphere, creating an environment of turbulence or air mixture that reduces the loss of preserved energy, and favour the development of crops. In addition, a terrace reduces soil erosion to a minimum; helps infiltrate the rain or irrigation water; and maintains the moisture longer in soil (Fig. 2).

The importance and usefulness of terraces may have decreased in modern times; but even in locations where irrigated terraces have been dismantled, irrigation is still in use, since natural precipitation is insufficient for agriculture.

In the South American Andes, farmers have used terraces, known as *andenes* (Fig. 2), for over a thousand years to farm potatoes, maize, and other native crops. Terraced farming was developed by the Wari culture and other peoples of the south-central Andes. It is estimated that its construction started approximately 3000 years BC, developing along with the expansion of corn cultivation. The terraces purpose was to stop erosion, expand the agricultural frontier, retain moisture, and form microclimates.

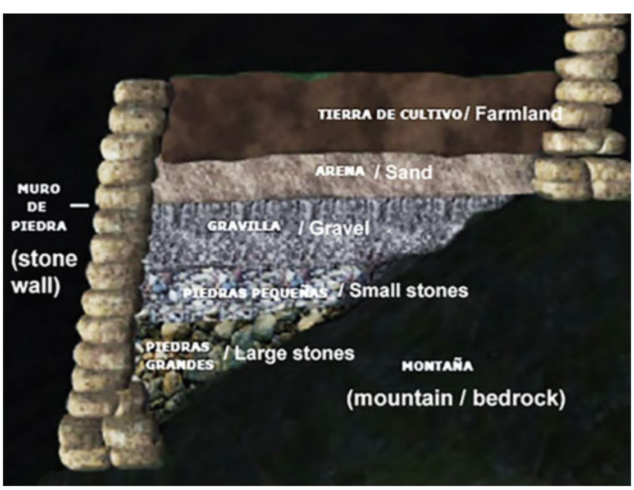

Fig. 2 Cross section of an *andene*

Fig. 3 Andenes of Tipón (Peru)

In Peru, there is an approximate area of one million hectares of terraces, of which approximately 10% is in permanent use, 20% in temporary or stationary use and 70% abandoned or destroyed (Masson 1986). One of the highest expressions is Tipon (Fig. 3) located 21 km from Cuzco consisted in 12 agricultural terraces with areas ranging from 1200 to 4500 m^2 (Wright 2006).

4 To Collect Water

Qanats have played a vital role in groundwater extraction since ancient times. These subterranean aqueducts run across the desert like the body's veins, bringing life and prosperity to the people who used to live off the water flowing down them. This technology is the focal point of the genesis of civilization in some parts of the world. The harsh environment drove people to invent the technology of the qanat and the know-how revolving around it. Due to their distinctive features, qanats discharge aquifer water continuously (Fig. 4), so that users (farmers, settlers, nomads, etc.) can perfectly adapt themselves to water fluctuations affected by droughts and wet years (Yazdi and Khaneiki 2010).

In the south coast of Peru, in the inhospitable desert of Nazca, there are more than 50 subterranean galleries, called *puquios* (Fig. 5) that connect the point of a surface with the groundwater and discharges into a small reservoir (*cocha*). Spaced along the gallery there are open holes commonly called eyes that connected to the surface of the earth with the gallery to provide a means of access to the galleries for cleaning (Schreiber and Rojas 2006). These structures have emerged in response to a long period of drought in the region around 560 AD (Thompson et al. 1985).

Fig. 4 Cross-section of a qanat

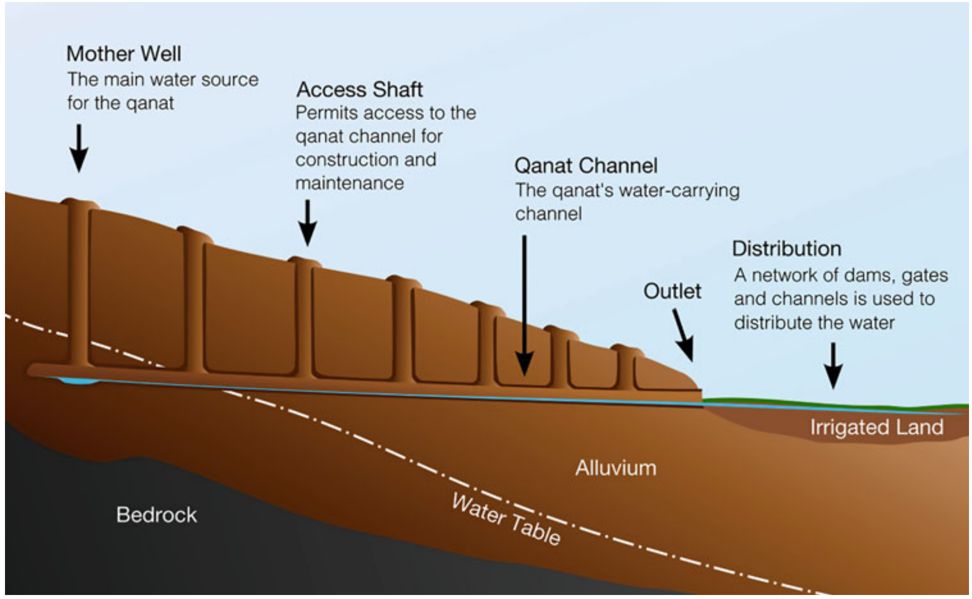

Fig. 5 Aerial view of a *puquio*

5 Concluding Remarks

The focus of ethics is not on water, seen in isolation, but on the water cycle and how the cycle connects the earth and the atmosphere. To live in an ethically responsible society, we need to modify water planning and management in order to achieve fairer access to drinking water, as well as providing effective social responses to public health concerns without jeopardizing ecosystems.

All these ancestral techniques are a clear example of symbiosis between human being and his environment. For indigenous peoples of Amerindian civilizations water is sacred. They celebrate rituals of requesting rains, they thank for the fruits, give offerings to the different deities that provoke the rains. These ceremonies are practiced at the top of the hills, at the source of springs, at the wells and in the riverbeds.

For indigenous societies, rivers, lakes, and meteorological phenomena that cause rain, snow or hail are part of a cosmogonic and spiritual universe, which is lived and reformulated on a daily basis. Water is not so much a “resource” as it is the core of the entire network of planetary life.

Indigenous societies do not give to water an economic valuation. Unlike those who see in the water an element that is applied for productive purposes, especially for industry and agribusiness or for urban and tourist development, indigenous people consider that water is the origin of life. Nowadays there is a growing need to recognize the cosmogonic and spiritual representations of indigenous societies around water and their possible contributions to a more balanced vision for their use and conservation. In this sense. Although the western and indigenous conceptions of water resources can cause conflicts, they can be a factor of complementarity and cooperation that feed strategies for a sustainable development. There are several lessons to be learned in contemporary times that highlighted on the causes of the environmental disaster and the loss of common goods essential for life, such as water. In particular, the hegemony and cult of “modern” technology as a unique solution for water management and its dissociation of cultural dimensions and ecological contexts. As well as the fragmentation of the socio-cultural matrix of water, which undermines the holistic and integral vision, and privileges the privatization of a common good in a scenario of globalization and free market, in order to submit the cultural dimension to the economic dimension: Water as a commodity and private good. The pre-Colombian communities developed ingenious adaptation measures to meet their needs. Today, the problem remains: the need to achieve a sustainable balance between availability and demand for water. In these times of the threats of climate change impacts on water resources of the planet, in which one example is the accelerated reduction of the volume of water contained in the glaciers of the Andes, it would be very useful to revisit these measures adaptation implemented by our ancestors and apply today in a new scientific and technological context.

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