TERRITORY, POLITICS, GOVERNANCE
https://doi.org/10.1080/21622671.2021.2023365

An emerging knowledge system for future water governance: sowing water for Lima

Fenna I. Hoefsloot [a], Javier Martínez [b] and Karin Pfeffer [c]

ABSTRACT

As urban infrastructures are built to last for decades, each infrastructure contains the anticipation for an uncertain future: a city-to-come, often built on capitalist and modernist dreams. In Lima, Peru, the model for water infrastructure development has long been a technocratic one, driven by values such as efficiency and modernization. However, facing a dual challenge of climate change and continuing urban growth, Lima's water utility agency, SEDAPAL, is increasingly integrating elements of Andean water governance systems – commonly referred to as the sowing and harvesting of water – in its future strategies to maintain urban water security. Our approach builds on knowledge system analysis to examine the different approaches to water governance as distinctive manifestations of understanding the socio-ecological changes in Lima's hydrosocial territory and how they are negotiated and integrated into Lima's infrastructure futures. Drawing on qualitative fieldwork in Lima and the Rímac watershed, our findings highlight the tension concerning what is incorporated in hybrid knowledge systems and what is sidelined. We conclude that, in the process of futuring, the integrations of knowledge systems should acknowledge plurality in epistemologies and positions and consider the historical contingencies that shape the exchanges between knowledge systems.

KEYWORDS

water governance; knowledge system analysis; indigenous knowledge; region; infrastructure; Peru

HISTORY Received 9 April 2021; in revised form 9 November 2021

INTRODUCTION

Situated in the arid coast of Peru and the valley of the Rímac River, Lima's development has been characterized by its environment and the struggle to maintain water security (Bell, 2015). This persists today as the dual trends of urbanization and climate change pose a challenge for planning Lima's water infrastructure and enhance the level of uncertainty in future scenarios. Since climate change is not only a future problem but one the world is experiencing today, the uncertainty does

CONTACT

[a] **(Corresponding author)** f.i.hoefsloot@utwente.nl
Faculty of Geo-Information Science and Earth Observation, Department of Urban and Regional Planning and Geo-Information Management, University of Twente, Enschede, the Netherlands.
[b] Faculty of Geo-Information Science and Earth Observation, Department of Urban and Regional Planning and Geo-Information Management, University of Twente, Enschede, the Netherlands.
[c] Faculty of Geoinformation Science and Earth Observation, Department of Urban and Regional Planning and Geo-Information Management, University of Twente, Enschede, the Netherlands.

not necessarily lie in the question *if* these trends will continue, but rather *how* climate change will affect the Andean ecosystems on which Lima depends for its water. Similarly, urbanization patterns have been uncertain in their pace and direction as the city has expanded in areas not anticipated for living, now sprawling over hills that were previously considered inhabitable.

Lima is thus experiencing a transition into a world whose material conditions we cannot properly anticipate, nor are we able to envision what their consequences will be for societies and ecosystems. In an attempt to address this uncertainty in future challenges, the water utility agency for the metropolitan area of Lima-Callao (SEDAPAL) as well as the national superintendence of water services (SUNASS) have adopted a multitude of strategies in the past, ranging from smart infrastructural development to the construction of the 'transbase', a tunnel that transfers water from the Amazon side of the Andes to the river catchment areas that service Lima (Hommes & Boelens, 2017). However, more recently, SEDAPAL has increasingly been integrating a pre-Hispanic water governance practice prevalent in large parts of the Peruvian Andes, commonly referred to as the sowing and harvesting of water (*siembra y cosecha de agua*), in its future strategies to maintain urban water security.

Specifically in the sector of water governance, which has long been characterized for its technocratic approach and the domination of engineering as the main knowledge-producing discipline (Hurlimann et al., 2017), the incorporation of nature-based solutions and indigenous technologies in water governance and infrastructural planning deserves our attention. Against a backdrop of a persisting colonial legacy of unequal socio-economic development, political exclusion and epistemic violence, the question arises to what extent the incorporation of the Andean model for water governance acknowledges epistemic diversity, the plurality in positions and perspectives, and works towards the empowerment of all actors in the process of futuring.

This paper draws on knowledge systems analysis (Muñoz-Erickson et al., 2017; Wijsman & Feagan, 2019) to examine the different models of water governance as distinctive manifestations of understanding the socio-ecological changes in Lima's hydrosocial territory (Boelens et al., 2016) and how they are negotiated and integrated into Lima's infrastructure futures. We contribute to the theory on infrastructural development in uncertain urban futures by empirically analysing how different knowledge systems are hybridized and incorporated in practice.

THEORETICAL FRAMEWORK

Speculation to what urban future is to come is an inherent part of planning the city and informs urban governments' strategies for dealing with uncertainty (Leszczynski, 2016). Leszczynski (2016) describes this as the process of 'futuring', for example, the ways that urban planning and governance engage with future visions in a material and discursive manner. The transformation of the noun 'future' into the gerund 'futuring' emphasizes the processual character of articulating urban futures, in which different viewpoints are negotiated, contested and mobilized (Hajer & Pelzer, 2018). Specifically, infrastructures built to last for decades hold in them the plans for the city-to-come. They form the temporal materialization of these anticipated futures. Which shape infrastructures take is informed by the context where they emerge and the knowledge system that favours their materialization. Hajer and Pelzer (2018) accentuate how a representation of reality is articulated through negotiation and the mobilization of knowledge. Space, relationships and entities are established and agreed upon by a certain group and form the basis for decision-making and future planning. Hence, it is important to question whose knowledge, values and needs inform future-oriented approaches (Wyborn et al., 2016). Knowledge system analysis helps one to understand the process and context through which a dominant viewpoint emerges within specific socio-ecological systems (Wijsman & Feagan, 2019).

Drawing on Foucauldian scholarship on the inseparability of power and knowledge, Muñoz-Erickson et al. (2017, p. 1) define a knowledge system as 'the social practices through which knowledge, ideas, and beliefs are produced, circulated, and put into action'. This definition of knowledge systems and their analysis emphasizes their relationality and raises the need to critically question the role of power and material in shaping knowledge systems (Muñoz-Erickson et al., 2017). The knowledge system analysis framework (Muñoz-Erickson et al., 2017) builds on literature on knowledge co-production (Jasanoff, 2004) and focuses on three focus areas: the elements of the knowledge system (knowledge claims, values and standards, epistemologies, and structures), the function of the knowledge system which includes the application and circulation of knowledge, and the political and organizational complexity of knowledge systems.

Knowledge systems are thus analysed as products of a specific institutional and political context (Muñoz-Erickson, 2014). However, what we consider knowledge and how we produce knowledge are fundamentally tied to whom we consider knowledgeable and the sites of knowledge production (Wijsman & Feagan, 2019). In other words, the analysis of the different knowledge systems that inform governance should be sensitive towards the reproduction of colonial relationships and the continuation of epistemic violence towards structurally marginalized communities (Jimenez & Roberts, 2019). In an aim to establish a feminist and decolonial analysis of knowledge systems, Wijsman and Feagan (2019) state that (1) knowledge systems should be understood as localized and spatially specific; (2) we should acknowledge the plurality of values and perspectives amongst, and within, knowledge systems; and (3) that the analysis of knowledge systems needs to address the distribution of power along colonial and patriarchal lines that undermine the legitimacy of knowledge systems emerging out of non-dominant societies. As the geographical position and the knowledge systems are intertwined, the region is not only a polygon on a map but an epistemic point of view. The ways we perceive problems and their solutions are materially and epistemically grounded in the region (Glass et al., 2019). Vice versa, rooted in debates on hydrosocial territories and socio-hydrology, both Robert (2019) and Molle (2009) stress the social and political nature of the region within water governance approaches. We use the concept 'hydrosocial territories' – without a hyphen between 'hydro' and 'social' – to emphasize how water, society and territory are intrinsically linked and co-evolve through human and biophysical practices (Boelens et al., 2016). Notions such as the 'river basin' or 'catchment area' pertain to a natural order, yet, in practice, their boundaries are determined not only by geographical space but also by political negotiation and cultural practices (Molle, 2009).

This is important as each knowledge system represents a specific 'regime of sight' and carries its specific mechanisms to validate information and legitimize decision-making (Jasanoff, 2017). Jasanoff (2017) distinguishes three general regimes of sight: (1) the view of nowhere representing the imagined objectivity of modernist science; (2) the view from everywhere representing the view of the expert which draws on reason; and (3) the view of somewhere representing personal and authentic experience. Each viewpoint has merit, and in each viewpoint certain issues are seen while others are overlooked. More importantly, each viewpoint reveals a new pathway or vision for future development (Muñoz-Erickson, 2014). Thus, it is important that the experiences, initiatives and knowledge that sprout from the different regions, being the city of Lima or the Andes, are considered within their regional context (Alencastre Calderón, 2013).

Hence, in this paper we analyse how different knowledge systems, with their specific regimes of sights, emerge as valuable and actionable in the context of future water insecurity in the Rímac watershed. We draw on Zimmerer and Bell (2015) as a starting point to distinguish between Andean knowledge systems (AKS) and modern-scientific knowledge systems (MSKS) and analyse the distinct modes of thinking about resource governance in the region of Lima. Based on Zimmerer and Bell (2015), we define the AKS as the indigenous knowledge system that is emergent from and rooted in the Andean landscape, cultures and epistemology. Within this

definition, indigenous knowledge refers to knowledge that is historically and culturally rooted in a specific community and serves as a means 'to express what people know and create new knowledge from the intersection of their capacities and development challenges' (Fabiyi & Oloukoi, 2013, p. 3). The AKS is closely tied to the relational ontology that has defined the worldview of Andean, and particularly Quechua communities. Contrasting with the modernist worldview, the Andean cosmovision is not based on the strict delineation between nature and culture but instead sees it as a responsibility of society to be in harmony with the natural realm (Ramírez González, 2020; Ulloa et al., 2021).

The MSKS is defined as the knowledge system that derives the principles of rigorous academic research as propagated in originally European (academic) traditions and which have become dominant in academia worldwide and claim universal relevance (Agrawal, 1995). We have added the hyphen in 'modern-scientific' to underscore that it specifically refers to the modernist and positivist traditions in scientific research as opposed to other forms of scientific scholarship. Through colonialization, the MSKS has gained dominance in most of today's countries, effectively erasing knowledge systems indigenous to colonialized countries in its process (Escobar, 1998). Also, in juridically decolonial states, the legacy of colonialization continues in denoting other forms of knowledge production and eradicating epistemic diversity (de Sousa Santos, 2016; Grosfoguel, 2011). Multiple authors have written about how indigenous systems of water governance (Hidalgo et al., 2017; Ulloa et al., 2021; Vera Delgado & Zwarteveen, 2008) or nature conservation (Escobar, 1998) have been stigmatized as 'backward' and ignored within water governance policies in Latin America. In effect, Lima's water sector has been characterized by an economic and modernist discourse, and SEDAPAL's dominant water governance model can best be labelled as integrated water resource management (IWRM) (Miranda Sara et al., 2017). Worldwide, IWRM has been welcomed as a blueprint approach for coordinating various water uses (hydropower, domestic and industrial supply, irrigation) and increasing control over water as a natural resource (Molle, 2009). In Lima, this form of 'modernizing' water governance has additionally been characterized by the processes of infrastructural expansion and the neo-liberal policy reforms that stimulate public–private partnerships in water management (Ioris, 2016).

Nevertheless, much due to the resilience and resistance of indigenous peoples (Ulloa et al., 2021; Wilson & Inkster, 2018; Zimmerer & Bell, 2015), AKS have prevailed over time and are playing an increasingly important role in the regional governance of the hydrosocial territory. Zimmerer and Bell (2015) analyse historically how, in the context of landscape governance, different knowledge systems in the Andean countries of Latin America and how these have mutually influenced each other ever since colonization. Similarly, Ulloa et al. (2021) describe how community groups in the Andes strategically appropriate techno-scientific methods and knowledge to rearticulate their local knowledge and be acknowledged as experts in the field of environmental governance. For example, by incorporating local knowledge on weather forecasts and agricultural trends with climate modeling, new strategies for climate crisis adaptation can be devised (Valdivia et al., 2010). These encounters have informed hybrid governance models that combine worldviews, epistemologies, values and structures of MSKS and AKS. The hybridization is often the result of prolonged struggle and negotiation over each of these elements (Ulloa et al., 2021).

It is from this framework (Figure 1) that we analyse the transition towards a 'new water culture' as the encounter between two knowledge systems and a negotiation regarding knowledge claims, values and standards, epistemologies, structures, and regions. We will first and briefly present our research approach in the third section. The fourth section uses insights from the framework development of Muñoz-Erickson et al. (2017) to analyse the MSKS and the AKS in relation to the water governance approaches. Finally, in the fifth section we discuss the emergence of a hybrid water governance approach for addressing the future challenges in the Rímac watershed.

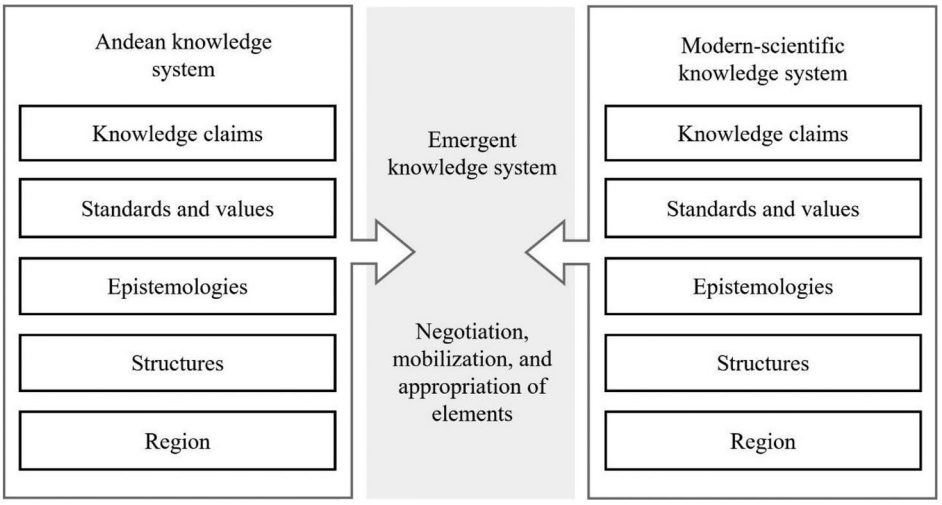

Figure 1. Conceptual framework for the encounter between the Andean knowledge systems (AKS) and modern-scientific knowledge systems (MSKS) in water governance.
Source: Authors based on Muñoz-Erickson et al. (2017) and Wijsman and Feagan (2019).

CONTEXT, METHODS AND POSITIONALITY

Empirically, this paper is based on data collected during a six-month fieldwork period in Lima in 2019–20. This included field visits, observations and seven interviews with water governance and management experts of SEDAPAL, local government and civil society within Lima. Additionally, two focus groups were conducted: one with employees of SEDAPAL and another with experts from research institutions, government and civil society. Each interview was between 30 and 90 minutes and conducted in Spanish or English, depending on the interviewee's proficiency in either language. The focus group meetings were, on average, 2 hours and conducted in Spanish. The focus group meetings were transcribed and coded in ATLAS.ti™ according to the principles of thematic analysis.

During two field visits to San Pedro de Casta we interviewed community leaders and visited the sites where pre-Hispanic infrastructure called '*amunas*' are being renovated. *Amuna*s are best described as small channels that slow the flow of rainwater so the soil can absorb it (Figure 2). Water sown in the upper parts naturally emerges from the subsoil during the dry season in the springs located near the communities, effectively extending the wet season (Ochoa-Tocachi et al., 2019). Their foundation has, in many cases, been there for centuries, but not maintained continuously. The *amuna*s are particular to the central Andes of Peru (Martos-Rosillo et al., 2020). However, similar water governance and management approaches based on the sowing and harvesting of water can be observed in other Latin American countries such as Chile, Ecuador and Bolivia. Using the '*waru*' – a pre-Hispanic water management technique used by Aymara people to mitigate fluctuating precipitation patterns in southern Peru and Bolivia – as an example, Earls (2009) explains how water management systems emergent from the Peruvian Andes each conform to the logic of a particular landscape and watershed.

By looking into the case of the *amuna*s, we illustrate how indigenous knowledge systems emergent from Andean cultures and landscapes are present in and inform water governance approaches in the Rímac River basin. Specifically, the recuperation of the *amuna*s in San Pedro de Casta has explicitly gained much attention over recent years due to its proximity to Lima, making it an interesting case to analyse in relation to the water governance models

Figure 2. A restored *amuna*.
Photo: Aquafondo (aquafondo.org.pe).

emerging from the city. San Pedro de Casta is a village of 928 inhabitants (INEI, 2018) in the Santa Eulalia River's upper catchment, the primary water source for the Rímac River (Figure 3). Its community depends mainly on small-holder farming and cattle-rearing for daily subsistence and income.

Finally, the first author attended a series of high-level, multi-stakeholder meetings to develop a new master plan for the metropolitan area of Lima-Callao, and the ExpoAgua 2019 (in person) and 2020 (online), the annual conference on water infrastructure and technology in Peru. The field visits and attended meetings were documented in notes by the first author. Master plans and advisory reports of SEDAPAL and SUNASS have been used as additional material in analysing the integration of the two models in SEDAPAL's current strategies.

We analysed the documents and interview data based on four elements of knowledge systems (Muñoz-Erickson et al., 2017): the knowledge claims, values and standards, epistemologies, and structures. Knowledge claims are defined as the non-verifiable statements that represent a specific worldview; values and standards are the normative principles that steer decision-making processes; epistemologies are the ways of knowing and reasoning about the world; and structures are the social and institutional networks which create and facilitate a certain knowledge system (Muñoz-Erickson et al., 2017). In line with Wijsman and Feagan's (2019) decolonial and feminist intervention in knowledge system analysis, we added the element 'region' in our analysis to emphasize the localized and situated character of the knowledge systems we are discussing. The region, in this case, represents the geographical boundaries of the infrastructural system discussed and what and who is considered part of the hydrosocial territory. These five elements resulted in five code-groups for the analysis in ATLAS.ti. The coding was conducted by the first author. It is important to note that by breaking down the knowledge systems into these elements and separately analysing them, we are going against the holistic approaches that underpin the AKS and

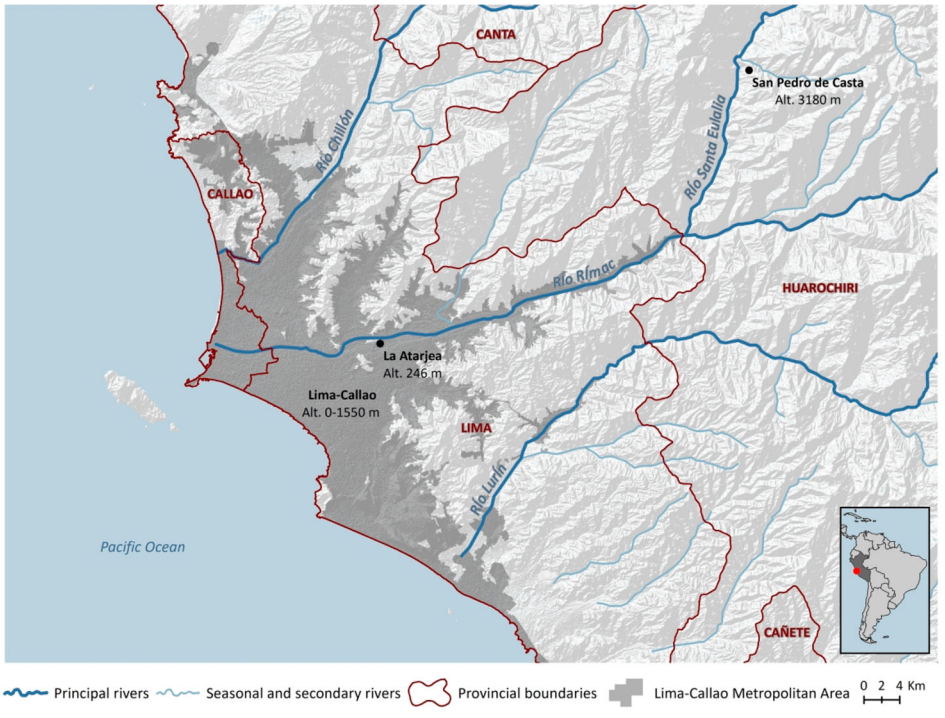

Figure 3. Map of the research region.
Source: Authors.

follow the methodology in which we are trained that aligns more with modern-scientific approaches to knowledge generation.

Moreover, considering that we are researchers from and/or affiliated with a university in the Global North, we want to take the opportunity to reflect on the tension that arises due to this position. We feel it important to address this fact since we will be discussing knowledge systems that have long been oppressed by the very traditions in which we are trained. We acknowledge that our positionality severely limits our understanding of the Andean knowledge and the cosmovision on which it is built. Therefore, in describing the AKS and Andean model for water governance, we have specifically built our research not only on the fieldwork we undertook but also on academic and non-academic sources from Peru and Andean communities in particular.

We have structured the findings section of this paper primarily according to the elements of the knowledge systems analysis framework describing the knowledge claims, the values and standards, the epistemologies, and the region. The structures of the knowledge systems, and their main actors, are described throughout all sections of the findings. However, first, we will describe the ExpoAgua of 2019 as a literal and symbolic space of encounter between the two knowledge systems and their visions for the future water governance in the Rímac watershed.

THE ENCOUNTER BETWEEN MODERN-SCIENTIFIC AND INDIGENOUS KNOWLEDGE

In 2019, the ExpoAgua, Peru's leading annual technical fair for the water sector, was themed '*Hacia una Nueva Cultura del Agua*', or 'Towards a New Water Culture'. During the three-day gathering, national and international companies, governments, and knowledge institutions had

the opportunity to present their interpretation of a new water culture. The visions for the future of the water sector ranged from fully digitalized infrastructures in which virtual reality will allow to travel through water pipes and semi-automated water distribution systems to socio-ecological imaginings in which the city and its surrounding landscapes are fully harmonized.

In general, the organizations presenting these different anticipations of the futures can be categorized along predictable lines. Engineers from multinational firms presented their newest innovations and technological futures while civil society organizations and researchers urged for a more ecological- and human-centred systems.

Strikingly, SEDAPAL crossed these lines and participated in both narratives. On day 1, SEDAPAL presented a narrative characterized by smart technological innovation. On day 2, their presentation revolved around maintaining ecosystem services and promoting responsible consumption. Perhaps most important, during the closing speech of the 2019 event, the president of SEDAPAL expressed the ambition to invest in the maintenance of water sources, granting particular attention to the *Sembramos Agua* (We Sow Water) projects that draw from pre-Hispanic Andean water governance approaches. This ambition was solidified in December 2020 with the signing of a cooperation agreement between SEDAPAL and the regional government of Lima to start the development of activities following the principles of sowing and harvesting water that should benefit communities in the upper river basins of the Chillón, Rímac and Lurín, as well as the Lima-Callao metropolitan area (Gobierno Regional de Lima, 2020). The Sembramos Agua projects are aimed to take place in 40 areas in the provinces of Huarochiri and Canta (Figure 3) and focus on reforestation, the recuperation of *amuna*s and the construction of reservoirs. SEDAPAL will finance the projects by investing 1% of the monthly water bill collection in Lima and Callao into a dedicated fund (Bleeker & Vos, 2019; SUNASS, 2017). At the end of 2020, it was estimated that this investment fund held up to 100 million soles (US$24.5 million), earmarked for nature-based solutions and the protection of ecosystem services (Gobierno Regional de Lima, 2020).

This crossing of lines and the participation in both narratives is exemplary for the increased interest in Andean water governance systems and aligns with the current tendency of SEDAPAL to give more relevance to environmental issues within water management and reduce the inequalities between urban and rural water consumers (Robert, 2019). However, the implementation of projects and actual investment has been postponed several times due to a lack of institutional will within SEDAPAL and delays in creating legal and technical structures that allow for the execution of the plans (Bleeker & Vos, 2019). Community leaders from San Pedro de Casta we spoke with at the time the ExpoAgua 2019 took place indicated they had been 'knocking on SEDAPAL's door'[1] to get institutional and financial support for their work to little avail, even though their activities recuperating the *amuna*s fit within the ambitions of the Sembramos Agua projects.

Nevertheless, the acknowledgment of these Andean infrastructures and their integration in the future projections of Lima's water infrastructure marks a divergence in what has been the hegemonic discourse in Peru's water governance for the past decades. As a result, as least as presented during the ExpoAgua conferences, a new hybrid model for water governance emerges that draws on MSKS and AKS to articulate their vision for the future. In the following sections, we unpack per element of a knowledge system where these two visions for water governance meet and where there is still room for further engagement.

KNOWLEDGE CLAIMS: WHAT IS WATER AND WHAT IS THE RIVER?

To unpack the emergence of a hybrid water governance model, we first need to ask what water is and what the river is according to the different knowledge systems we analyse. These

questions are crucial as the conceptualizations of water and the river inform our ideas about how they should be governed (Wilson & Inkster, 2018). More profoundly, focusing on how water and the river are defined brings attention to these elements' social, cultural and political connotations.

Indicative of the worldview of the MSKS are words such as 'water supply and demand', 'natural resources' and the 'Rímac system'. By defining water as a resource, the governance approach that follows from this conceptualization is, in its basis, an economic model driven by the dynamics of offer and demand. This is reflected in the schematic models created of the watersheds which represent the Rímac and Santa Eulalia rivers as a series of demand and supply nodes, connected via transmission links representing either natural streams (rivers, creeks, springs) or engineered canals (Bell, in press). In such a schematic and linear representation, the river is defined by its function to transport water to urban consumers. As one SEDAPAL engineer described, 'the Rímac is no longer a river but a canal that serves the domestic and industrial consumption of Lima-Callao'.[2] This representation of the watershed is simplified – without cultural and spiritual connotations – yet effective. It allows us to model future scenarios and speculate about the interventions that might mitigate the challenges to water security.

Within MSKS, not only the watershed is simplified. Water itself is abstracted to its chemical and physical properties (Calderón, 2000), and water scarcity and loss are considered to occur in the context of poor management and outdated technologies. The proposed solutions to mitigate water scarcity are therefore open, highly technocratic, and driven by commercial ambitions and efficiency. Specifically, during the Fujimori and García administrations in the 1990s and 2000s, water was narrowly approached through the frame of scarcity, a problem that was rationalized to require more infrastructural development and market involvement (Ioris, 2016). In Lima, modernizing water has also been the process of commodifying water.

Since in the AKS water is defined as omnipresent, a totality that is simultaneously part of all others,[3] there are no meticulous delineations between nature, technology and society such as defined within modern-scientific thinking in the AKS. This holistic approach to water that characterizes the AKS is reflected in the models for water governance that have emerged in the Andes (Alencastre Calderón, 2013). In the words of one of the community leaders interviewed in San Pedro de Casta: 'water is life and not easily abstracted into one dimension'.[4] They continued to explain how water, as the gift of the *Apu* (the mountain, the supreme deity) for the survival of all living beings, is both physical and spiritual. This worldview is reflected in traditions such as water festivals during which the community pays tribute to the deities that bring the rain season and maintenance efforts organized annually in anticipation of the rainy season (Ministerio de Vivienda Construcción y Saneamiento, 2007).

While the worldviews in the AKS and the MSKS result in different water governance models, we notice points of encounter between 'water is life' and 'modern water' in thinking about future water security. Foremost, in the recent focus on nature-based solutions and the integration of spiritual connotations to water in the communication of SEDAPAL. Whereas SEDAPAL's 2014–2040 master plan did not yet mention the *amuna*s or other nature-based solutions, they have gained a prominent place in their promotional and educational material, as shown during the ExpoAgua conferences. For example, in 2018, SEDAPAL developed and published a serious game[5] for educating children about water security challenges and our responsibility to maintain harmony between people, nature and the ecosystem at large. It tells the story of César, the spirit of the river catchment (in the body of a water drop wearing a hat reminiscent of the *chullo*, a style traditionally linked to communities living in the Andean highlands), who wakes up after 1000 years to help recuperate the catchment area. Players can help the spirit of the watershed keep the river healthy and adapt to climate change by choosing between different types of interventions such as removing factories, planting trees or recovering ancestral practices such as the *amuna*s in the upper, middle and lower catchment areas.

Vice versa, we notice a similar movement in how the Sembramos Agua projects have adopted elements of the 'modern water' worldview in arguing for the value of the *amuna*s. The current national and international recognition of their potential to help mitigate the effects of climate change has motivated the community of San Pedro de Casta to collaborate with local non-governmental organizations (NGOs) to restore the *amuna*s to their functioning state. As part of the process of the sowing and harvesting of water, the *amuna*s are a tool in the active and circular engagement with the mountain, the soil, the rain and the water bodies, to maintain water security. Specifically, community leaders framed the *amuna*s as a technique to secure water resources not only for the village and agriculture but also for Lima. In doing so, the focus is more on the restorative potential of the *amuna*s rather than the spiritual and ritualistic dimensions of 'water is life'. One civil society expert explained: 'when you hear the villagers talk about water resources, rather than using the Quechua world for water, *yaku*, they are taking away, diminishing what they have to communicate to be accepted'.[6] As we will unpack further in the following sections, this framing of the *amuna*s as servicing Lima's water security helps in the village's strategic positioning in relation to the city and in seeking collaborations with researchers and NGOs.

VALUES AND STANDARDS

The notion of responsibility is fundamental to understanding how these two knowledge systems interact as it is a central value in both the AKS and MSKS and crucial in thinking about future water governance. Particularly, the recent focus on the Sembramos Agua projects fits within a general shift towards the increased valuation of ecosystems for water security and the redefinition of responsible water governance within IWRM as dominant water governance discourse in Lima (Miranda Sara et al., 2017).

Similar to other indigenous nations (Wilson & Inkster, 2018), the values for water governance in the AKS derive from the idea of mutual responsibility for mutual survival. Commenting on the water distribution between irrigation, human consumption or cattle, one of San Pedro de Casta's residents explained it is impossible to create a hierarchy in needs as all entities depended on water and each other. Therefore, there is a responsibility to care for all humans and more-than-human entities, including natural, geophysical and spiritual bodies. However, in conversation some disagreement emerged over the distribution of water. Where some community leaders stated all entities have an equal right to water, others argued responsible water governance should first serve humans and human needs. Nonetheless, a standard for 'good' water governance emerges from this sense of reciprocal responsibility (Ramírez González, 2020) which is reflected in the fact that the construction, maintenance and administration of water infrastructures, such as the *amuna*s and the water distribution system, are organized communally.

Robert (2019) explains how the IWRM approach in Lima departs from a distinct logic that sees water as a public service. As a result, responsible water governance is generally defined in terms of guaranteeing the quality and the environmental and financial sustainability of water service provision for domestic and industrial consumers (Robert, 2019). Most notably, these values are demonstrated in the effective canalization of the River Rímac through the construction of the three water-transfer projects within the main watershed (Hommes & Boelens, 2017) and the implementation of digital technologies for the real-time monitoring of water flows within the city (Hoefsloot et al., 2020). These projects are often financed by the national government and bilateral donors and executed by international consortia (Hommes & Boelens, 2017). Correspondingly, Lima's water governance is often evaluated based on international benchmarks and values of neighbouring countries. This is illustrated in how the coverage is low considering what 'can be expected of an upper-middle-income country'[7] or in the recurring statement that the percentage of non-revenue water is one of the lowest in Latin America. Effectively, within the

MSKS, the standard for what is considered 'good' water governance is largely based on the quality of water governance in the larger region.

With the increased recognition of future risks to water security due to climate change and urbanization, environmental sustainability – approached as the maintenance of water resources for the future – has become a more central value. SEDAPAL's 2014–2040 master plan includes several climate change adaptation and mitigation policies, such as the payment for ecosystem services in the upper river basin, aimed to help conserve and administer water resources. However, always from an economic justification. As the World Bank writes in its advice for the future sustainability of Lima's water services: 'Water plays a critical role in the growth of the Peruvian economy' (World Bank, 2018, p. 10).

Combining a focus on efficiency, quantity, quality and reliability with sustainability, these policies represent the 'new water culture' presented during the ExpoAgua. Nevertheless, within this emergent sustainable approach to water governance, the sense of responsibility towards the more-than-human world is quite thin as it is based on a human-centred approach rather than grounded in a logic that presupposes the relationality of all beings, including more-than-human entities. Thus, in practice, the encounter between the two knowledge systems means that the mitigation of natural degradation is presented as a cost-effective means to improve water services in the city today and, in the long run, serve urban well-being and economic prosperity (Bleeker & Vos, 2019).

EPISTEMOLOGIES AND KNOWLEDGE CIRCULATION

The third dimension in knowledge system analysis concerns the way of knowing and knowledge flows. In 2018, Peru enacted the Law on Climate Change with the purpose of establishing principles for the coordination, articulation and execution of public policy for the mitigation and adaption to climate change. Within this law (*Ley Marco Sobre el Cambio Climático*), the first-mentioned focus for integrated climate change management is the recuperation, valorization and use of traditional knowledge from indigenous peoples in designing climate change mitigation and adaptation measures. Recognizing the expertise of indigenous peoples marks a departure from previous paradigms that have suppressed knowledge produced outside of modernist science.

Historically, water problems in Lima have been defined as infrastructural and managerial problems rather than natural, which favoured engineering knowledge, emerging from MSKS, in thinking about possible solutions (Bell, 2015). Today, this still speaks to an enduring orientation towards exact measurements and computational modeling based on numeric data to supervise and plan the water infrastructure (Hoefsloot et al., 2020). In several interviews, SEDAPAL has been critiqued on its conceptual 'tunnel vision'[8] regarding what is considered valuable knowledge and the resulting overreliance on engineering interventions to solve water governance issues. A civil society leader interviewed echoed this view and explained how hydrological 'expertise' is a characteristic reserved for engineers, if possible, with degrees from private or foreign universities. Other expertise or ways to generate knowledge are disregarded as irrelevant. Several interviewees emphasized the need for more interdisciplinary perspectives on water governance, including insights from other scientific fields such as urban studies or physics. Others argued that SEDAPAL should include other ways of knowing, to be more open towards tacit and indigenous knowledge.

The Andean water governance approach primarily draws on the experiential, tacit and context-embedded knowledge of communities such as San Pedro de Casta. Information is thus empirical, knowledge is generated through lived experience, often held by the elders and community leaders, and infrastructures are nature based and produced through manual work. Traditionally, this knowledge is gained and shared through experience and oral history rather

than numeric data or written text and generally not recognized within the MSKS. In a focus group with experts from SEDAPAL, one participant commented on the role of the *amuna*s in increasing water security. While the 'rescuing traditional knowledge for the use of the *amuna*s'[9] was valued, the expert was not convinced of their role in providing a solution to Lima's water challenges. They continued that it was not considered possible to 'sell' them as a solution for Lima's water problems due to uncertainty over the quantification of what percentage of water volume available could be attributed to the *amuna*s.

The importance of numeric data and modern-scientific knowledge in strategically positioning the *amuna*s in relation to the city is not lost on the community of San Pedro de Casta. Community representatives have actively searched for collaborations with researchers from Peruvian and international universities to explore and document the effects of their work according to the guidelines of the MSKS. For example, over the past years, master's students from a university in Lima have visited San Pedro de Casta annually as part of an elective course on water management. In Huamantanga, a village in the neighbouring Chillón River catchment area, Ochoa-Tocachi et al. (2019) collaborated with the community and local authorities to measure the effectiveness of the *amuna*s in stalling the water run-off. In spite of the fact that the AKS profoundly challenges positivist epistemologies, using modern-scientific research practices to 'proof', the outcome of the Sembramos Agua projects in maintaining water sources for the whole catchment area not only valorizes their work within the IWRM model but also within their respective communities. As Ulloa et al. (2021) note, communities have learned to speak the language of the 'experts' and, in the case of San Pedro de Casta, are in the process of translating their knowledge to be incorporated into MSKS.

National and international NGO's play an important role as 'translators' between these two systems by funding academic research and pilot projects in which they gather modern-scientific knowledge from numeric data about the functioning and effects of the *amuna*s as nature-based solutions. As a particular form of codified knowledge, data are important in financial decision-making and helps guarantee the continuation of international and national funding. In the words of a director of an NGO: 'data is important to move investment money'.[10] They argued that with the payment for ecosystem services scheme, the financial and administrative structure had been created to invest in green infrastructure. Quantifying the impact of a potential investment through pilot studies is key in actually mobilizing these funds. Today, several academic articles have been published about the recuperation of the *amuna*s (Ochoa-Tocachi et al., 2019; Peña Laureano et al., 2016), adding 'legitimacy' to their experience and work within the mainstream discourse and effectively validating elements of the Andean water governance model as an approach for maintaining water security for the city.

Although this translation is effective, it also steers the AKS to assimilate to the epistemologies of the MSKS, rather than appreciating the Andean ways for knowing and knowledge-sharing for their own worth. This is problematic as it assumes a hierarchy between ways of knowing, contrary to the values of knowledge co-production (Muñoz-Erickson, 2014). Several residents in San Pedro de Casta referred to the Sembramos Agua projects as important for the re-acquirement of knowledge partially forgotten. The *amuna*s and the water governance system are closely tied to their historical legacy and ways of knowing that have long been oppressed through colonialism. Hence, recuperating the *amuna*s and the knowledge systems they are built from are closely linked to acts of decolonizing epistemologies.

REGIONAL PERSPECTIVES

Throughout the previous sections, one of the recurring themes has been the relationship between the city of Lima and the village of San Pedro de Casta in the encounter of the two knowledge

systems. This section will further explore these dynamics and unpack how the 'region' and the knowledge systems co-produce each other. Central to this dynamic is the geographical, political and cultural delineation of the boundaries of the region for water governance (Molle, 2009). Practice proves that these boundaries are malleable depending on the issue discussed. They can be flexible when discussing Lima's need to access water from outside of its provincial limit. For example, in developing a new metropolitan master plan, the planning institute explored the possibility of including the rivers north and south of the metropolitan area within their proposal to maintain future water security. Or as illustrated in the formation of the council for water resource management, which overarches the catchment areas of the Chillón, Rímac and Lurín rivers. This council was installed to harmonize the scale of water governance with the natural boundaries of the landscape rather than administrative boundaries and, in the process, reconfigure the relationships between urban and rural actors in water governance (Robert, 2019).

Nevertheless, Robert (2019) explains how the river council has been confined by administrative boundaries and governmental hierarchies. As SEDAPAL and SUNASS fall under the auspices of the national government, the main decision-making power is centralized on the state level. Water users are invited to participate in the decision-making of the river council. Still, the coordination between the different water authorities is weak, and the municipalities of Lima and Callao have little influence over the water within their territories (Bleeker & Vos, 2019; Hordijk et al., 2014).

Yet, the lines drawn on the map become fixed when discussing the need to provide good quality and quantity drinking water to communities that have settled or live outside the metropolitan area. As explained by an employee of the municipality of Lima-Callao: 'In the ideal world, the administration and management model would be on the scale of the watershed,'[11] but for communities outside of the administrative boundaries of SEDAPAL, it does not have the institutional mandate nor the responsibility to provide water to those areas. These lie with the communal water authorities, the Junta Administrativa de Servicios de Saneamiento (JASS), which are supported by the Ministerio de Vivienda, Construcción y Saneamiento (Ministry of Housing, Construction and Sanitation).

While the IWRM model predominantly aims to operate top-down at the scale of the three basins that flow through the province of Lima (Alencastre Calderón, 2013; Robert, 2019), the Andean models for water governance predate the national and local water authorities' artificial administrative boundaries. They are primarily defined by geographical and natural features in the terrain, such as the mountain's isoline, the river basin, the flora and fauna (Earls, 2009). More importantly, as illustrated through the annual water festival, the Andean approach in San Pedro de Casta also considers non-material elements (spiritual, past and future) to be part of the system. Reflecting upon these differences in viewpoints regarding water governance between San Pedro de Casta and Lima, one interviewee stated: 'they look from the city up, and we look from the mountain down'.[12] Looking from the mountain down, it is emphasized that in addition to being a critical resource for human life, water is fundamental for other dimensions of rural life such as cattle rearing (water is needed to maintain green pastures) and the protection against environmental risks such as landslides (water is needed for reforestation). Additionally, looking from the mountain down, you can see the city as a metropolis sprawling over three large river valleys with water and green ecosystems that need to be valued and safeguarded. From the viewpoint of the city up, Lima is imagined in a desert. A particular framing that is reinforced in both popular and academic writing by the continuous repetition of the statistic that Lima, behind Cairo, is the second-largest city situated in a desert. Looking through this lens, it is easy to follow the analysis that there is an absolute water shortage and that water needs to be retrieved from additional sources such as the other side of the Andes or the Pacific ocean.

(A)SYMMETRIC HYBRIDIZATION OF KNOWLEDGE SYSTEMS

The increased risks of water scarcity due to climate change and urbanization have raised the need for innovative approaches for future water governance. In this paper, we have analysed how knowledge is negotiated and mobilized in preparation for challenges to come within the Rímac watershed and beyond. These dynamics are particular to the process of futuring: where different visions for the future come together and materialize in plans and infrastructure (Hajer & Pelzer, 2018; Leszczynski, 2016). Informed by indigenous movements, struggles and resistance in Peru, Latin America and worldwide, there is an increased valuation for indigenous knowledge systems and governance approaches. It is in the encounter of the knowledge systems that a hybrid and forward-looking approach to water governance emerges as presented during the ExpoAgua.

Previous literature has often analysed the acknowledgment of indigenous knowledge systems and models for water governance related to conflicts over the access to and maintenance of clean water in the context of capital intensive infrastructural projects such as dams or large scale irrigation projects that directly impact the water security of indigenous communities (Hidalgo et al., 2017; Swyngedouw & Boelens, 2018; Ulloa et al., 2021; Wilson & Inkster, 2018). The case of the Sembramos Agua projects we have analysed, however, is not linked to a direct conflict between two parties but seen as a potential strategy to mitigate climate change risks to both the city and the Andean communities. Breaking down the knowledge systems from which the different water governance models emerge into their elements, it is evident how they fundamentally differ. Yet, both models, although different in their knowledge claims, values, epistemologies, structures, and regions, have both undergone a certain degree of hybridization by adopting elements of each other's knowledge systems to adapt their ways of knowing and water governance practices (Table 1).

Nonetheless, while both sides seek collaborations to address the current and future challenges for water security, the power disparities between the AKS and the MSKS result in asymmetries in at least two respects. First, insights emergent from the AKS are only considered seriously after being translated to the MSKS. Second, the Andean water governance model is mainly acknowledged for its value in relation to the city, not in and of itself. We will discuss the former first and afterward return to the latter.

The power of the MSKS depends not only on the structures that reinforce its position but also on the methodologies it uses that are presented as objective and standardized ways of knowing: a view from nowhere (Jasanoff, 2017). Complex socio-environmental systems are schematically represented in supply–demand models in which the landscape and the watershed are producers of water as a resource and the city as its main consumer (Bleeker & Vos, 2019). In other words, the MSKS is selective in what it considers as part of the system and towards the knowledge it integrates. As illustrated in our analysis of the knowledge claims and epistemologies of the two knowledge systems, this imagined objective and decontextualized approach is fundamentally different from the relational and embedded approach to water governance that is emergent from the AKS. Despite the expansive view of the hybrid water governance approach in bringing together these two systems, the main encounters have been focused on translating the knowledge from the AKS to the MSKS. The dominance of the structure and epistemologies of the MSKS is so powerful that rather than opening up towards other ways of knowing, it steers the AKS to assimilate. By mobilizing methods of, and experts from, MSKS to validate the Andean water governance model, it becomes possible to integrate the infrastructures and insights for water governance without further engagement with its fundamental knowledge claims, epistemologies, structures and region in which it is situated. This assumes the possibility of context-free models for water governance, yet, at the same time,

Table 1. Elements of the Andean knowledge systems (AKS) and modern-scientific knowledge systems (MSKS).

		AKS	MSKS	Hybrid knowledge system
Elements	Knowledge claims	'Water is life' – Andean cosmovision	'Modern water'	Water is a natural resource
	Values and standards	Communal responsibility for communal well-being	Quality, quantity, efficiency and reliability	Sustainability: maintaining resource levels for well-being
	Epistemologies	Context embedded and tacit ways of knowing	Engineering and experimental methodologies and conceptual approaches	Modern-scientific methods to research Andean infrastructures
	Structures	Andean communities	(Inter)national collaborations characterized by public–private partnerships in knowledge production	Community projects supported by international research and civil society organizations
	Region	The Andes. Includes human and more-than-human entities	Inter-river basin of the Chillón, Rímac and Lurín	Inter-river basin of the Chillón, Rímac and Lurín
Water governance models		Siembra y cosecha de agua (sowing and harvesting of water)	Integrated water resource management (IWRM)	Sustainable water governance: 'new water culture' captured in the Sembramos Agua projects

Source: Framework derived from Muñoz-Erickson et al. (2017) and Wijsman and Feagan (2019).

depends on the physical and intellectual labour of communities who have been marginalized since colonialization.

Because indigenous knowledge systems' worth is constantly questioned (Ulloa et al., 2021), dynamics such as those just described are the rule rather than the exception. As detailed by Ulloa et al. (2021), the power of the MSKS is recognized and mobilized by indigenous peoples to position themselves and their knowledge strategically within emerging hybrid knowledge systems. In a similar fashion, through collaborations with NGOs and universities in Peru and abroad, the community of San Pedro de Casta is engaging with modern-scientific approaches to make their evidence 'credible'.

The second asymmetry we identify is in the repurposing of the Andean water governance system for the city. Although some attention is given to the Andean water governance model's pre-colonial roots and the people who have constructed them, this is often misguided to the extent that the approach of sowing and harvesting water is refunctionalized to serve the interest of the Lima-Callao metropolitan area and are rarely understood in their own terms. This is illustrated in the discursive framing of the *amuna*s as infrastructures that maintain water security in the upper and lower catchment areas and the institutional and financial frameworks created to stimulate the recuperation of the *amuna*s within the Sembramos Agua projects. Specifically, the payment for ecosystem services scheme frames the *amuna*s as a cost-effective intervention to secure water resources for urban and industrial consumers (Bleeker & Vos, 2019) and serves as a tool to reconfigure the boundaries of the region for Lima's water capture (Robert, 2019).

The analysis shows us that although the repurposing of the *amuna*s for the city is driven mainly by non-governmental and governmental actors based in Lima, the community of San Pedro de Casta appropriates this narrative to drive home their point for nature-based, indigenous water governance and gain support for their efforts. By emphasizing the importance of the intended benefit for the overall watershed, including Lima, they can attract financial and institutional assistance.

However, as the Andean landscapes and infrastructures gain acknowledgment for their importance in maintaining water security for the city, we have to be wary of the risk of them being identified as only serving the metropolitan region. In the face of continued urbanization and climate change, the metropolitan government is exploring possibilities to increase access to watersheds outside its juridical territory. If the landscapes of San Pedro de Casta are seen as crucial for water production, it might warrant the metropolitan government's control over the watershed and limit the community's sovereignty over water sources. As Mehta et al. (2012) argue, water grabbing is often an incremental process made possible through the re-appropriation and financialization of natural resources and negotiations between actors of unequal power.

Hence, in both respects, we find that the asymmetry results from the dominance of one knowledge system and one centre of knowledge production. The emerging hybrid water governance model is an example of the opening up for plurality in future imaginaries and how two different knowledge systems can be in dialogue (de Sousa Santos, 2016). Nevertheless, the rules for the exchange of knowledge are set by the dominant knowledge system, and other water governance models are only considered if they contribute to its aims. As such, it is possible that the selective repurposing of the *amuna*s to create more productive hydrosocial territories will undercut the common aspirations of both the modern-scientific and the Andean approach to water governance of maintaining water security. Moreover, the repurposing of the *amuna*s for the city reproduces the colonial conceptualization of the river as a 'linear feature' servicing the urban consumers and with rural waters (Bell, in press, p. 4). Being more open to water's cultural and spiritual connotations could inspire us to see the problems with water distribution and use within the city in a different light. Specifically, moving closer to the Andean definition of good water governance, which builds on a relational worldview, might inspire a collective sense of responsibility regarding water use amongst Lima's residents and institutions.

This makes us reflect on how we can acknowledge the progress made in recognizing the value of plural knowledge systems while also questioning the losses along the way; how this encounter requires leaving behind spirituality, culture and tradition to be included in the emerging knowledge system. On the basis of these experiences, what, then, might be the conditions for symmetrical hybridization between modern-scientific and indigenous knowledge systems? de Sousa Santos (2016) argues it is possible to bring together different ways of knowing in a 'decolonial mestizaje', for example, a form of hybridity which acknowledges epistemological plurality and is committed to socio-economic and environmental justice. Hence, we suggest two principles for symmetrical encounters between knowledge systems for future planning. First, we propose that there has to be an acknowledgment that all knowledge systems are emergent from particular worldviews, values, epistemologies, structures and regions. By accepting this, we open up the possibility of plurality in all these elements. As the Andean and modern-scientific water governance models collide and contradict, situatedness is not theoretical; the solutions that are proposed emerge out of a legacy of knowledge and science, yet at the same time follow directly from the local challenges faced within the Rímac watershed. The cultural and regional context from which a knowledge system emerges, it being either the spiritual landscape of the Andes or the globalized and metropolitan urbanity of Lima, is crucial for understanding anticipations for future challenges and, as a result, present different solutions to mitigate water insecurity. Second, in line with Bell (in press), we argue that we must keep history in mind. This specifically refers to

the acknowledgment of the patterns of coloniality on which knowledge systems operate. If we do not acknowledge how structural inequalities echo in today's encounters between people and knowledge systems, we will most likely reproduce these inequalities.

CONCLUSIONS

What the climate crisis and urbanization challenges make apparent is that we are witnessing a critical moment in time, one in which we know that basic conditions of our planetary system and societal organization are changing, yet we cannot predict how it will unfold. Evidently, these changes have far-reaching ecological and societal consequences pressing us to think beyond the governance approaches that have been dominant thus far (Miranda Sara et al., 2016). Hajer and Pelzer (2018) describe how thinking about the future governance approaches is a process that occurs on multiple levels and in consecutive stages. In this paper, we draw on knowledge system analysis to examine the process of futuring at one stage, namely the emergence of a hybrid approach to water governance as a result of the encounter between modern-scientific and AKS as presented during the ExpoAgua conferences. Our analysis highlighted the tension concerning what is incorporated in hybrid knowledge systems and what is sidelined. Specifically, it shows how the hybridization of knowledge systems is an active process during which epistemologies are appropriated, values are exchanged and actors reposition themselves within the structure of the emergent knowledge system.

Returning to our question – to what extent the incorporation of the AKS into Lima's water governance practices acknowledged epistemic diversity, the plurality in positions and perspectives, and works towards the empowerment of all actors in the process of futuring – we conclude that it is possible to see how the hybridization of the two systems might represent a new chapter in water governance which is open to diverging perspectives for water governance to address current and future environmental challenges. Yet, at the same time, considering the situatedness of knowledge (de Sousa Santos, 2016; Wijsman & Feagan, 2019), it becomes apparent that as knowledge is extracted from its regional context and mobilized to serve other regions and people, this hybridization is asymmetric and does not work towards overcoming structural inequalities amongst actors and between knowledge systems. This is not to say that there is no other way. In the process of futuring, the integration of knowledge systems should embrace plurality in epistemologies and positions and consider the historical contingencies that shape the exchanges between knowledge systems. We encourage further research to empirically investigate the potentials and challenges for achieving real transformation by thinking through and with multiple knowledge systems in developing just futures.

ACKNOWLEDGEMENTS

A first draft of this paper was presented during the NOIR Water Infrastructure and Regional Governance workshop organized by the editors of this special issue, Michael Glass, Jen Nelles and Jean-Paul Addie. We thank them and all the participants at the workshop for helping shape this research at an early stage. Also, we thank the two anonymous reviewers for their thorough and constructive commentary. A special thanks to Liliana Miranda Sara, Mariel Mendoza Flores, Eufronio Obispo Rojas and Susana Gaete Sara for their indispensable support and help in conducting fieldwork. Most importantly, we thank and are indebted to the communities in San Pedro de Casta and Lima for generously sharing their knowledge, time and energy for this work.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

NOTES

1. Interview with a community leader, San Pedro de Casta, 28 September 2019.
2. Focus group with SEDAPAL engineers, 19 February 2020.
3. A. Alencastre Calderón, personal communication, 12 February 2020.
4. Interview with a community leader, San Pedro de Casta, 7 December 2019.
5. Sembrando Agua, developed by SEDAPAL EGASE (Sedapal's environmental management and ecosystem services team) and ANEVI CORP. Game design by Bryan Silva and Ottoman Silva from ANEVI CORP. Published in 2017 by SEDAPAL. For a full explanation of the game, see https://www.youtube.com/watch?v=rjV_FL7a9k0/.
6. Expert focus group, 21 January 2020.
7. Focus group with SEDAPAL engineers, 19 February 2020.
8. Expert interview, 5 October 2019.
9. Focus group with SEDAPAL engineers, 19 February 2020.
10. Expert interview, 3 December 2019.
11. Expert focus group, 21 January 2020..
12. Group conversation with community leaders, San Pedro de Casta, 28 September 2019.

ORCID

Fenna I. Hoefsloot http://orcid.org/0000-0002-3373-3580
Javier Martínez http://orcid.org/0000-0001-9634-3849
Karin Pfeffer http://orcid.org/0000-0002-6080-1323

REFERENCES

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change*, *26*(3), 413–439. https://doi.org/10.1111/j.1467-7660.1995.tb00560.x

Alencastre Calderón, A. (2013). Hacia un balance de la gestión del agua: ¿Explotación de un recurso natural o gestión sostenible de un bien común? In E. Toche M (Ed.), *Susurros desde Babel* (Vol. Perú Hoy, pp. 327–344). DESCO. https://www.iproga.org.pe/articulos/aguabiencomun.html.

Bell, M. G. (2015). Historical political ecology of water: Access to municipal drinking water in colonial Lima, Peru (1578–1700). *Professional Geographer*, *67*(4), 504–526. https://doi.org/10.1080/00330124.2015.1062700

Bell, M. G. (in press). Overlooked legacies: Climate vulnerability and risk as incrementally constructed in the municipal drinking water system of Lima, Peru (1578–2017). *Geoforum; Journal of Physical, Human, and Regional Geosciences* (February), https://doi.org/10.1016/j.geoforum.2021.02.016.

Bleeker, S., & Vos, J. (2019). Payment for ecosystem services in Lima's watersheds: Power and imaginaries in an urban–rural hydrosocial territory. *Water International*, *44*(2), 224–242. https://doi.org/10.1080/02508060.2019.1558809

Boelens, R., Hoogesteger, J., Swyngedouw, E., Vos, J., & Wester, P. (2016). Hydrosocial territories: A political ecology perspective. *Water International*, *41*(1), 1–14. https://doi.org/10.1080/02508060.2016.1134898

Calderón, C. (2000). Retos en la concepción del agua en el mundo. In J. van Kessel, & H. Larraín Barros (Eds.), *Manos sabias para criar la vida.anos sabias para criar la vida. Technologica Andina* (pp. 231–245). Simposio del 49° Congreso Internacional de Americanistas.

de Sousa Santos, B. (2016). Epistemologies of the South and the future. *From the European South*, *1*, 17–29. http://europeansouth.postcolonialitalia.it.

Earls, J. (2009). Organización social y tecnológica de la agricultura andina para la adaptación al cambio climático en cuencas hidrográficas. *Tecnología y Sociedad*, *16*(8), 13–32.

Escobar, A. (1998). Whose knowledge, whose nature? Biodiversity, conservation, and the political ecology of social movements introduction: Biodiversity as a cultural and political discourse. *Journal of Political Ecology*, *5*, 53–82. https://doi.org/10.2458/v5i1.21397

Fabiyi, O. O., & Oloukoi, J. (2013). Indigenous knowledge system and local adaptation strategies to flooding in coastal rural communities of Nigeria. *Journal of Indigenous Social Development*, *2*(1), 1–19. http://www.hawaii.edu/sswork/jisd%5Cnhttp://scholarspace.manoa.hawaii.edu/.

Glass, M. R., Addie, J. P. D., & Nelles, J. (2019). Regional infrastructures, infrastructural regionalism. *Regional Studies*, *53*(12), 1651–1656. https://doi.org/10.1080/00343404.2019.1667968

Gobierno Regional de Lima. (2020, December 28). Firman convenio con SEDAPAL para ejecutar proyectos de siembra y cosecha de agua en la región Lima. *Nota de Prensa*, https://www.gob.pe/institucion/regionlima/noticias/322291-firman-convenio-con-sedapal-para-ejecutar-proyectos-de-siembra-y-cosecha-de-agua-en-la-region-lima.

Grosfoguel, R. (2011). Decolonizing post-colonial studies and paradigms of political-economy: transmodernity, decolonial thinking, and global coloniality. *TRANSMODERNITY: Journal of Peripheral Cultural Production of the Luso-Hispanic World*, *1*(1), 1–38. https://escholarship.org/uc/item/21k6t3fq. https://doi.org/10.5070/T411000004

Hajer, M. A., & Pelzer, P. (2018). Energy research & social science 2050 – An energetic odyssey: Understanding 'Techniques of Futuring' in the transition towards renewable energy. *Energy Research & Social Science*, *44*(July 2017), 222–231. https://doi.org/10.1016/j.erss.2018.01.013

Hidalgo, J. P., Boelens, R., & Vos, J. (2017). De-colonizing water. Dispossession, water insecurity, and indigenous claims for resources, authority, and territory. *Water History*, *9*(1), 67–85. https://doi.org/10.1007/s12685-016-0186-6

Hoefsloot, F. I., Martínez, J., Richter, C., & Pfeffer, K. (2020). Expert-amateurs and smart citizens: How digitalization reconfigures Lima's water infrastructure. *Urban Planning*, *5*(4), 312–323. https://doi.org/10.17645/up.v5i4.3453

Hommes, L., & Boelens, R. (2017). Urbanizing rural waters: Rural–urban water transfers and the reconfiguration of hydrosocial territories in Lima. *Political Geography*, *57*, 71–80. https://doi.org/10.1016/j.polgeo.2016.12.002

Hordijk, M., Miranda Sara, L., & Sutherland, C. (2014). Resilience, transition or transformation? A comparative analysis of changing water governance systems in four southern cities. *Environment and Urbanization*, *26*(1), 130–146. https://doi.org/10.1177/0956247813519044

Hurlimann, A., Wilson, E., & Keele, S. (2017). Framing sustainable urban water management: A critical analysis of theory and practice. In S. Bell, A. Allen, P. Hofmann, & T.-H. Teh (Eds.), *Urban water trajectories* (pp. 53–68). Springer International Publishing.

INEI. (2018). *Censos Nacionales 2017: XII de Población, VII de Vivienda y III de Comunidades Indígenas*. Instituto Nacional de Estadistica e Informática. https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1541/tomo4.pdf

Ioris, A. A. R. (2016). Water scarcity and the exclusionary city: The struggle for water justice in Lima. *Peru. Water International*, *41*(1), 125–139. https://doi.org/10.1080/02508060.2016.1124515

Jasanoff, S. (2004). *States of knowledge: The co-production of science and the social order. States of knowledge: The co-production of science and the social order*. Routledge. https://doi.org/10.4324/9780203413845.

Jasanoff, S. (2017). Virtual, visible, and actionable: Data assemblages and the sightlines of justice. *Big Data & Society*, *4*(2), 205395171772447. https://doi.org/10.1177/2053951717724477

Jimenez, A., & Roberts, T. (2019). *Decolonising neo-liberal innovation Using the Andean philosophy of 'Buen Vivir ' to reimagine innovation hubs* (Vol. 1) Springer International Publishing. https://doi.org/10.1007/978-3-030-19115-3.

Leszczynski, A. (2016). Speculative futures: Cities, data, and governance beyond smart urbanism. *Environment and Planning A*, *48*(9), 1691–1708. https://doi.org/10.1177/0308518X16651445

Martos-Rosillo, S., Durán, A., Castro, M., Vélez, J. J., Herrera, G., Martín-Civantos, J. M., … Peña, F. (2020). Ancestral techniques of water sowing and harvesting in Ibero-America: Examples of hydrogeoethical systems. In M. Abrunhosa, A. Chambel, S. Peppoloni, & H.I. Chaminé (Eds.), *Advances in Geoethics and Groundwater Management: Theory and Practice for a Sustainable Development* (pp. 489–492). Springer. https://doi.org/10.1007/978-3-030-59320-9_104

Mehta, L., Veldwisch, G. J., & Franco, J. (2012). Introduction to the special issue: Water grabbing? Focus on the (Re)appropriation of finite water resources. *Water Alternatives*, *5*(2), 193–207.

Ministerio de Vivienda Construcción y Saneamiento. (2007). *Mitos y leyendas del agua en el Perú. (Ministerio de Vivienda Construcción y Saneamiento, Ed.)*.

Miranda Sara, L., Jameson, S., Pfeffer, K., & Baud, I. (2016). Risk perception: The social construction of spatial knowledge around climate change-related scenarios in Lima. *Habitat International*, *54*(2), 136–149. https://doi.org/10.1016/j.habitatint.2015.12.025

Miranda Sara, L., Pfeffer, K., & Baud, I. (2017). Unfolding urban geographies of water-related vulnerability and inequalities: Recognising risks in knowledge building in Lima, Peru. In S. Bell, A. Allen, P. Hofmann, & T.-H. Teh (Eds.), *Urban water trajectories* (pp. 81–98). Springer International Publishing. https://doi.org/10.1007/978-3-319-42686-0_6.

Molle, F. (2009). River-basin planning and management: The social life of a concept. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *40*(3), 484–494. https://doi.org/10.1016/j.geoforum.2009.03.004

Muñoz-Erickson, T. A. (2014). Multiple pathways to sustainability in the city: The case of San Juan, Puerto Rico. *Ecology and Society*, *19*(3), 1–9https://doi.org/10.5751/ES-06457-190302.

Muñoz-Erickson, T. A., Miller, C. A., & Miller, T. R. (2017). How cities think: Knowledge co-production for urban sustainability and resilience. *Forests*, *8*(203), 1–17. https://doi.org/10.3390/f8060203.

Ochoa-Tocachi, B. F., Bardales, J. D., Antiporta, J., Pérez, K., Acosta, L., Mao, F., Zulkafli, Z., Gil-Ríos, J., Angulo, O., Grainger, S., Gammie, G., De Bièvre, B., Buytaert, W. (2019). Potential contributions of pre-Inca infiltration infrastructure to Andean water security. *Nature Sustainability*, *2*(7), 584–593. https://doi.org/10.1038/s41893-019-0307-1

Peña Laureano, F., Condori, E., & Charca, M. (2016). Recarga artificial de Acuíferos en Alta Montaña. Las *Amuna*s de Santa Eulalia. In *XVIII Congreso Peruano de Geología* (pp. 1–4).

Ramírez González, M. E. (2020). Criando agua y humanos en el Ande: la experiencia de la comunidad Fortaleza Sacsayhuaman en Cusco-Perú. *Anthropologica*, *38*(45), 109–132. https://doi.org/10.18800/anthropologica.202002.005

Robert, J. (2019). (De)construcción de gobernanza del agua urbana en Lima. La experiencia del Consejo de Recursos Hídricos. *Medio Ambiente y Urbanizacion*, *90–91*, 83–110.

SUNASS. (2017). SUNASS y SEDAPAL promueven la creación del grupo impulsor MRSE que apoyará a SEDAPAL en el cuidade de sus fuentes de agua. Retrieved September 6, 2020, from http://www.sunass.gob.pe/doc/NotasPrensa/2017/Marzo/np061_2017.pdf.

Swyngedouw, E., & Boelens, R. (2018). ' … And not a single injustice remains': hydro-territorial colonization and techno-political transformations in Spain. In R. Boelens, T. Perreault, & J. Vos (Eds.), *Water justice* (pp. 115–133). Cambridge University Press. https://doi.org/10.1017/9781316831847.008.

Ulloa, A., Godfrid, J., Damonte, G., Quiroga, C., & López, A. P. (2021). Monitoreos hídricos comunitarios: conocimientos locales como defensa territorial y ambiental en Argentina, Perú y Colombia. *Íconos – Revista de Ciencias Sociales*, *XXV*(69), 77–97. https://doi.org/10.17141/iconos.69.2021.4489

Valdivia, C., Seth, A., Gilles, J. L., García, M., Jiménez, E., Cusicanqui, J., Navia, F., Yucra, E. (2010). Adapting to climate change in Andean ecosystems: Landscapes, capitals, and perceptions shaping rural livelihood

strategies and linking knowledge systems. *Annals of the Association of American Geographers*, *100*(4), 818–834. https://doi.org/10.1080/00045608.2010.500198

Vera Delgado, J., & Zwarteveen, M. (2008). Modernity, exclusion and resistance: Water and indigenous struggles in Peru. *Development*, *51*(1), 114–120. https://doi.org/10.1057/palgrave.development.1100467

Wijsman, K., & Feagan, M. (2019). Rethinking knowledge systems for urban resilience: Feminist and decolonial contributions to just transformations. *Environmental Science and Policy*, *98*, 70–76. https://doi.org/10.1016/j.envsci.2019.04.017

Wilson, N. J., & Inkster, J. (2018). Respecting water: Indigenous water governance, ontologies, and the politics of kinship on the ground. *Environment and Planning E: Nature and Space*, *1*(4), 516–538. https://doi.org/10.1177/2514848618789378

World Bank. (2018). *Modernization of Water Supply and Sanitation Services Project*. http://documents1.worldbank.org/curated/en/118971532835034687/pdf/Peru-Modernization-PAD-07092018.pdf.

Wyborn, C., van Kerkhoff, L., Dunlop, M., Dudley, N., & Guevara, O. (2016). Future oriented conservation: Knowledge governance, uncertainty and learning. *Biodiversity and Conservation*, *25*(7), 1401–1408. https://doi.org/10.1007/s10531-016-1130-x

Zimmerer, K. S., & Bell, M. G. (2015). Time for change: The legacy of a Euro-Andean model of landscape versus the need for landscape connectivity. *Landscape and Urban Planning*, *139*(December 2017), 104–116. https://doi.org/10.1016/j.landurbplan.2015.02.002