



HAL
open science

In people's minds and on the ground: Values and power in climate change adaptation

Bruno Locatelli, Martin Laurenceau, Yaneth Roxana Calla Chumpisuca, Emilia Pramova, Améline Vallet, Yésica Quispe Conde, Ronal Cervantes Zavala, Houria Djoudi, Sandra Lavorel, Matthew J Colloff

► To cite this version:

Bruno Locatelli, Martin Laurenceau, Yaneth Roxana Calla Chumpisuca, Emilia Pramova, Améline Vallet, et al.. In people's minds and on the ground: Values and power in climate change adaptation. *Environmental Science & Policy*, 2022, 137, pp.75 - 86. 10.1016/j.envsci.2022.08.002 . hal-03818267

HAL Id: hal-03818267

<https://agroparistech.hal.science/hal-03818267>

Submitted on 17 Oct 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

In people's minds and on the ground: Values and power in climate change adaptation

Authors: Bruno Locatelli (1,2), Martin Laurenceau (2,3,4), Yaneth Roxana Calla Chumpisuca (5), Emilia Pramova (2), Améline Vallet (6, 7), Yésica Quispe Conde (8, 9), Ronal Cervantes Zavala (8, 9), Houria Djoudi (10), Sandra Lavorel (11), Matthew J. Colloff (12)

1: Forests and Societies, CIRAD, Univ Montpellier, France

2: CIFOR, Lima, Peru

3: AgroParisTech, Paris, France

4: Water Resource Management, Actors and Uses (G-EAU), Institute of Research for Development, Marseille, France

5: Universidad Nacional Micaela Bastidas de Apurímac, UNAMBA, Abancay, Peru

6: Ecologie Systématique Evolution, AgroParisTech, CNRS, Université Paris-Sud, Université Paris-Saclay, Orsay, France

7: CIREA, AgroParisTech, Cirad, CNRS, EHESS, Ecole des Ponts ParisTech, Université Paris-Saclay, Nogent-sur-Marne, France

8: Universidad Nacional Agraria de la Molina, Lima, Peru

9: SUNASS, Abancay, Peru

10: CIFOR, Bogor, Indonesia

11: Laboratoire d'Ecologie Alpine, CNRS, Université Grenoble Alpes, Université Savoie Mont Blanc, Grenoble, France

12: Fenner School of Environment and Society, Australian National University, Canberra, Australia

Accepted manuscript of the following paper:

Locatelli B., Laurenceau M., Chumpisuca Calla Y.R., Pramova E., Vallet A., Quispe Conde Y., Cervantes R., Djoudi H., Lavorel S., Colloff M., 2022. In people's minds and on the ground: Values and power in climate change adaptation. *Environmental Science and Policy* 137:75-86

<https://doi.org/10.1016/j.envsci.2022.08.002>

Abstract

As decisions on climate change adaptation involve stakeholders with different values, beliefs and attitudes (VBA), decision outcomes depend on how stakeholders interact and how power is distributed. In this paper, we explore the VBA of stakeholders involved in three water management projects focusing on dams, micro-reservoirs, or wetlands in a Peruvian watershed facing droughts. We apply a framework with the core ideas of the hydrosocial cycle, the decision context perspective, and the VBA hierarchy to show how stakeholders' perspectives and power influence practices on the ground. The analysis of VBA reveals three different perspectives on water management held by different stakeholder groups. First, a community-based perspective, frequent among local communities, favors micro-reservoirs managed by communities. Second, an infrastructure-based perspective, frequent among public sector stakeholders, shows a preference for dams managed by the private sector. Third, a nature-based perspective, with a preference for wetlands managed by the public sector, is found across stakeholder groups. In the three water management projects, different power distributions determine which VBA dominate and influence practices on the ground. Dams on the ground represent power from the public and private sectors, while micro-reservoirs represent local grassroots control. In the wetland project, the outcomes of the evolving hydrosocial cycle are still unclear and will depend on how multiple perspectives are considered. Examining and questioning the decision context in which adaptation occurs can help excluded stakeholders achieve more power and agency and tackle the fundamental question of 'adaptation of what and for whom'.

Highlights:

- We analyze values, beliefs, and attitudes (VBA) in climate change adaptation
- We study three water management projects in a Peruvian watershed
- Stakeholders in the projects have contrasted VBA
- Water management on the ground results from power distribution within projects
- Power relationships mediate the interactions between sets of VBA

1. Introduction

Climate change affects freshwater resources and poses big challenges for societies (Jiménez Cisneros et al., 2014). In the tropical Andes, where droughts or extreme rain events have always been a fact of life, climate change has been altering precipitation patterns (Pabón-Caicedo et al., 2020; Segura et al., 2020), with water security being further threatened by increasing human demand and glacier melting (Coudrain et al., 2005; Drenkhan et al., 2015). In addition, the conversion of mountain forests and wetlands into pasture and croplands has reduced the capacity of ecosystems to regulate water (Bonnesoeur et al., 2019; Locatelli et al., 2017) and increased the vulnerability of livelihoods and economies to water and climate risks (Mathez-Stiefel et al., 2017).

Diverse water management measures have been applied in the Andes for water security and adaptation to climate change. Beyond the usual technological and infrastructure measures (e.g. dams and canals), nature-based measures protect and restore wetlands, forests, grasslands and other ecosystems that store water or facilitate infiltration (Maldonado Fonkén, 2014; Podvin et al., 2014). Ancestral measures are also being revived, for example, “qochas” (micro-reservoirs built with a stone and earth dyke for storing water and enhancing water infiltration into soils), “andenes” (dry or irrigated terraces), and “amunas” (canals for increasing infiltration and groundwater recharge) (Erickson, 2018; Ochoa-Tocachi et al., 2019).

Water management is not only linked to the material flows of water but also to socio-political processes and feedback loops where water and society continuously influence each other (Budds et al., 2014; Linton and Budds, 2014). The hydrosocial cycle concept reflects this cyclical process, where the need to manage water affects the organization of society, which in turn affects the flows of water, which then lead to new forms of social organization (Linton and Budds, 2014). Central to the hydrosocial cycle are questions of how water internalizes and reflects social relations and how power is produced and perpetuated through water (Adams et al., 2019; Budds and Sultana, 2013). In this sense, whether to build dams and micro-reservoirs or restore wetlands to manage water is not a technical decision but a value-laden, social and political one.

Water management and adaptation to climate change are embedded in societal decision processes, which affect how a particular problem is addressed. The adaptation decision context perspective (Gorddard et al., 2016) focuses on the interacting systems of values (e.g., ideals of what is desirable), rules (e.g., norms, cultural regimes, heuristics, collective behaviors, formal regulations), and knowledge (e.g., scientific and technical, experiential and meanings-based). According to this perspective, values, rules and knowledge (VRK) determine how stakeholders define the available options, assess their outcomes, and interact to make decisions (Colloff et al., 2017; Gorddard et al., 2016). As in the hydrosocial cycle, power is central to the decision context as it determines how rules are decided or applied and whose values or knowledge count (Adger and Barnett, 2009; Nightingale, 2017; O'Brien and Wolf, 2010).

Adaptation decisions are strongly influenced by values (Adger and Barnett, 2009; O'Brien and Wolf, 2010), which are individual and collective motivations or moral framings that define priorities and guide actions. Decisions may involve people with contrasting values (Hicks et al., 2015), for example with openness to change opposed to conservation, or self-enhancement opposed to self-transcendence (Schwartz, 1994). These opposed values are often associated with diverging beliefs and attitudes (IPBES, 2022). Indeed, values influence attitudes towards specific behaviors through a hierarchically structured network of cognitions (Fulton et al., 1996; Homer and Kahle, 1988; Jacobs and Buijs, 2011), where abstract values are at the foundation, followed by guiding values and context-specific beliefs, and then by attitudes and behaviors (Vaske and Donnelly, 1999; Whittaker et al., 2006).

Attitudes are favorable or unfavorable evaluations of objects, situations, or concepts, whereas beliefs associate these objects or situations with certain attributes (Ajzen and Fishbein, 2000). Beliefs arise from personal understandings or experiences and are closely connected to both knowledge and emotions (Boldrin and Mason, 2009; Maggioni et al., 2006). The different beliefs that people have usually vary in strength and degree of connectedness to emotions and other beliefs (Ennis, 1994). Values and beliefs are thus important factors shaping public attitudes and preferences towards adaptation to climate change (Glenk and Fischer, 2010).

Water management decisions are often made by stakeholders with different values, beliefs and attitudes (VBA) regarding the available options. How stakeholders interact in the decision-making process, who decides for whom, how power is distributed, and what knowledge is dominant all affect decisions on water management, and influence who will win or lose from decision outcomes (Budds and Hinojosa, 2012).

One objective of this paper is to explore the different sets of values, beliefs, and attitudes (VBA) of the stakeholders involved in three water management projects based on dams, micro-reservoirs, and wetland conservation or restoration in a small watershed in Peru. The other objective is to analyze which stakeholders have the power to make decisions in each project.

We take the core ideas of the hydrosocial cycle (Linton and Budds, 2014), the value perspective of the VRK decision context (Gorrdard et al., 2016), and the VBA hierarchy (Fulton et al., 1996) to build a simple framework for examining different sets of VBA (adaptation in minds) and how they relate to water management decisions (adaptation on the ground) (Fig. 1). In the framework, social power, embedded in governance structures, mediates the interactions and tensions between the different sets of VBA and practices of stakeholders on the ground. The framework illustrates the VBA with which the different stakeholders enter the decision-making process. We posit that the hydrosocial cycle is useful to shed light on the struggles between VBA in decisions on water management or adaptation.

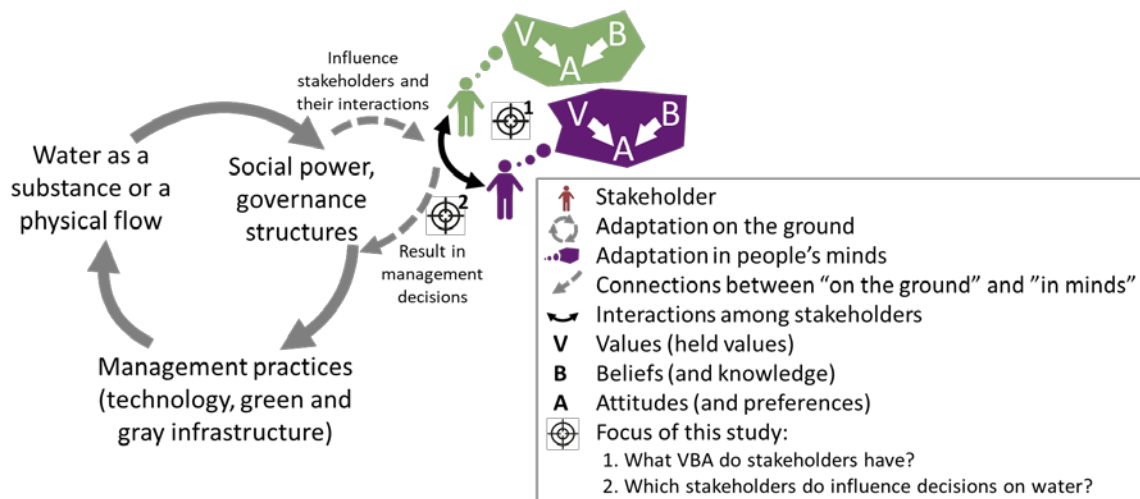


Figure 1. Proposed framework. The grey circular cycle is an adjustment of the hydrosocial cycle (Linton and Budds, 2014) and represents "adaptation on the ground". The dashed links and the values-beliefs-attitudes of two stakeholders are added to describe "adaptation in people's minds". Social power and governance structures mediate the interactions and tensions between the different sets of VBA of the stakeholders (black curved arrow), which result in management decisions.

2. Study site

The Mariño watershed is located in Peruvian Andes around Abancay, the capital city of the Apurímac region (Fig. 2). The watershed has an approximate area of 229 km², with a range of altitudes (from 1718 to 5235 meters above sea level) and diverse climates (from temperate semi-arid at lower altitudes to cold and humid in the mountains), all with strong contrasts between the rainy and the dry seasons (PACC and SENAMHI, 2012). According to the 2017 census, around 72,300 people lived in the two districts of the watershed, Abancay and Tamburco. Pasture represent 28% of the watershed area and agricultural lands 21% (with irrigated agriculture 17%) (CONDESAN, 2014). In the upper part, communities produce corn, potatoes, and livestock for own consumption and local markets, with cows and sheep grazing in the highlands. Individual farmers produce high value crops like avocado, sugarcane, and papaya in the lower part, as well as vegetables in the middle part for Abancay markets.

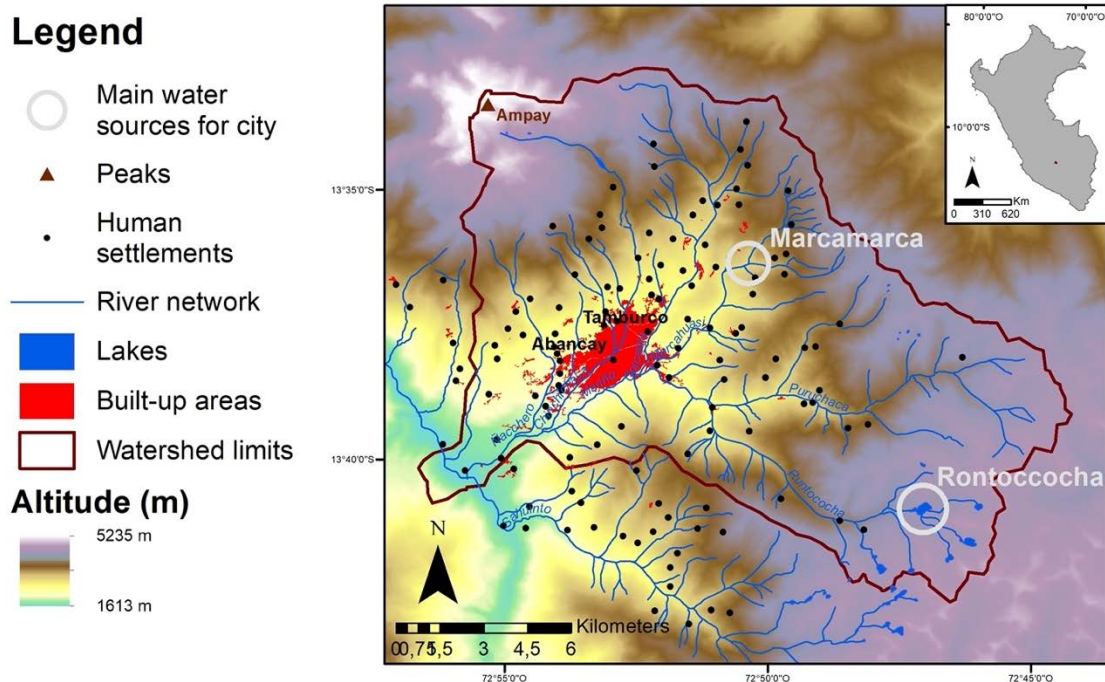


Figure 2. Map of the study site. Altitude ranges from 1613 m to 5180 m above sea level. The city of Abancay appears in red in the center of the map. The study site limits (brown line) correspond to the boundaries of the Mariño watershed. Source: adapted from Vallet et al. (2019)

The Mariño watershed faces various water challenges. Its Ampay glacier has lost more than half of its area between 1985 and 2017 (Serrano Chuima, 2018). Local people have reported changes with a later onset of the rainy season and a higher occurrence of torrential rain, storms, and hail (CBC, 2012). Total annual rainfall has significantly increased over the 1965-2008 period and may increase in the future (+21% over 2016-2044 compared to 1971-2000 on average across five climate models) (PACC and SENAMHI, 2012). Despite those trends, the region is exposed to droughts, which are part of the Andean climate variability and are often related to El Niño events. Watershed management projects in the area are based on the assumption that improved water regulation will address multiple water challenges whatever the future climate (PACC, 2013).

Water management and governance have a long history in the Andes since the pre-Inca civilizations (see Supplementary Material 1 for details on water governance in Peru and the study site). In the recent history, the economic liberalization of the 1990s attracted foreign investments in large dam projects and irrigated agribusiness, induced conflicts and changed power dynamics (Carey et al., 2012). New coalitions of communities, associations, and NGOs emerged to raise awareness of the risks posed by neoliberal water governance and climate change (Hogue and Rau, 2008; Lynch, 2018; Seward, 2014).

Water is a public good, property of the state in Peru. A National Water Authority (ANA) and its local agency (ALA) grant and monitor licenses to users, including rural communities (through their domestic use committees and irrigation committees) and municipal water companies. Rural communities are responsible for water management in their territories, under their own regulations and collective control. The municipal water company in Abancay (EMUSAP), a mixed private-public company (i.e., under private law but with the municipality as only shareholder), manages water supply to the city and invests in infrastructure and ecosystem conservation. The regional government can facilitate integrated water management but is sometimes criticized for an infrastructure bias in investments (CBC, 2012). Other water management stakeholders include several conservation and rural development NGOs. All these stakeholders have developed and implemented water management projects in the watershed using different measures, including dams, micro-reservoirs, and wetland conservation or restoration.

3. Methods

This study was part of a research project on ecosystem services in the Mariño watershed, which had previously built relationships with key individuals and institutions involved in natural resource management (Vallet et al., 2019). Fieldwork took place from May to August 2017. Interviews and surveys were conducted in Spanish or Quechua depending on the participants. After introducing our research and informing that all collected data would be anonymized, we asked participants to confirm their consent. Our research protocol was approved by CIFOR Research Ethics Review Committee (reference FTR044).

Understanding adaptation on the ground

We conducted semi-structured interviews with 40 key stakeholders (15 from the public sector, 14 from local communities, 9 from civil society, and 2 from private companies; 8 women and 32 men). The interviewees were selected for their knowledge, their involvement in local water management, and the diversity of institutions they represented. We built a list of institutions from lists of participants in previous meetings on water and completed the list with a snowball approach. The interviews dealt with water challenges and local water management initiatives (activities, outcomes, actors) (see interview guide in Supplementary Material 3).

We also engaged in field observations of water management activities during two months to understand water management and governance. We chose to work in the Rontoccocha area, where three water management projects had been implemented. These three projects were particularly interesting to study because each had applied a different measure (dams, micro-reservoirs, or wetland conservation). In addition to field visits with representatives of key organizations, we participated in community works on the ground, three workshops organized by NGOs with rural communities, and several workshops and events in the city. The semi-directed interviews, the field observations and the feedback from stakeholders (during meetings at the end of the research) were all used to describe adaptation on the ground.

For each project, we described which stakeholders had power to act or to decide. We considered the "power to" (i.e. the capacity to act on water management) and other forms of power that result from interactions among stakeholders (Partzsch, 2017): for example, some actors have a form of "power with" (i.e. the capacity to collaborate with others to act), whereas others have a "power over" (i.e. the capacity to force other actors to act). To understand who had power in the three projects, we asked questions and made observations about which stakeholders had "power by design" (e.g., if a formal agreement established which stakeholders participated in decision-making), "pragmatic power" (e.g., if the day-to-day implementation created opportunities for some stakeholders to informally influence decisions), or "framing power" (e.g., if a stakeholder framed problems and solutions for a project) (Morrison et al., 2019). An example of the later source of power is the framing power of an external expert who brings technical knowledge that is uncontested by other stakeholders (Stensrud, 2019). Although we separately analysed power asymmetries in the watershed with social network analysis (Vallet et al., 2020), here we simply identify the most powerful groups of stakeholders in each project, even though it mask the complexities of the micro-politics of project implementation.

Understanding values, beliefs and attitudes

Using a snowball sampling, we surveyed 62 people to understand differences in VBA regarding water management in a structured and statistically interpretable form (see survey form in Supplementary Material 4). The sample was composed of 16 women and 46 men, from 20 to 66 years old (median age 34). The respondents were from local communities in the upstream watershed (n=18), public

sector ($n=17$), civil society ($n=22$, 11 from associations and 11 from development or environmental NGOs), research/education ($n=5$, 3 from research and 2 from education).

Respondents represented all the institutions and groups of water management stakeholders (e.g., regional government, city authorities, national and local water authorities, national park service, ministry of agriculture, health authority, drinking water company, national sanitation authority, upstream rural communities, including community members, community authorities, community boards for water and sanitation, representatives of women associations and supervisors of water management). In the statistical analyses, we included only the three groups with 15 or more respondents: local communities, public sector, and civil society.

During the survey, people were asked to rate their agreement regarding 22 statements using a 7-level Likert scale (Table 1 and Supplementary Material 4). Ten statements related to five main values, inspired by previous works on cultural worldviews, for example on individualistic vs communitarian worldviews and egalitarian vs hierarchical worldviews (Kahan et al., 2007; Peters and Slovic, 1996) or environmentalism (Dunlap et al., 2000). These statements are often used to analyze relationships between environmental attitudes and cultural perspectives or worldviews (Price et al., 2014; Schultz et al., 2005). Six statements referred to the beliefs in the three water management measures (dams, micro-reservoirs, wetlands). Six statements referred to the attitudes towards the three water management measures and the three water managers (communities, public sector, private sector).

For beliefs and values, the responses to pairs of statements were reduced to a single variable through Principal Component Analysis. Within pairs, statements were positively and significantly correlated ($r=0.29-0.45$, $p<0.001$ to $p=0.02$) and the first component explained 64–73% of the variance of the two statements. In later analyses, we only used the variables resulting from the pairs of statements. Therefore, the survey responses resulted in a set of 14 variables (5 for values, 3 for beliefs, 6 for attitudes).

We analyzed the bivariate correlations among the 14 variables, and between them and respondent identities (age, group and gender). We summarized the correlations as a network of variables. Using an algorithm for detecting dense subgraphs called *cluster_fast_greedy* in the R-package *igraph* (Csardi, 2018), we identified groups of VBA variables with strong positive correlations among them.

We also applied multivariate analysis with a hierarchical clustering applied to the 14 variables. The elbow method identified the best numbers of clusters between three to five and the number of three clusters led to the most meaningful interpretation. The clusters of VBA were called “hydrosocial perspectives”, i.e. sets of beliefs and values of respondents, associated with attitudes toward water management and managers. All statistical analyses were done with R (R Core Team, 2019).

Table 1. List of statements that respondents rated on a 7-level Likert scale (strongly disagree, disagree, moderately disagree, neither disagree or agree, moderately agree, agree, strongly agree)

Group of variables	Variable	Statements
Attitudes toward management measures	In favor of wetlands	Wetland protection should be prioritized for water management.
	In favor of micro-reservoirs	Micro-reservoir construction should be prioritized for water management.
	In favor of dams	Dam construction should be prioritized for water management.
Attitudes toward managers	In favor of communities	Community organizations should manage water.
	In favor of public sector	Government should manage water.
	In favor of private sector	Private companies should manage water.
Beliefs	Belief in wetlands	Wetlands supply water to springs and rivers during dry periods. Wetland provide multiple benefits to all users.
	Belief in micro-reservoirs	Micro-reservoirs store water and also recharge downstream springs. Micro-reservoirs have a positive impact on the environment (water, birds).
	Belief in dams	Dams are efficient options to reduce water scarcity issues. Dam construction has a positive impact on water and the environment.
Values	Environment	The balance of nature is very delicate and easily disturbed. Mountains and lakes are living beings we should respect.
	Equality	We need to dramatically reduce inequalities between the rich and the poor. Our society would be better with a more equal distribution of wealth.
	Tradition	Water has to be managed with due respect to Yakumama (note: Yakumama is the goddess of water and rivers, similar to the Earth goddess Pachamama).. Making offerings to Yakumama is essential before an intervention on water.
	Welfare	People should be able to rely on the government for help when they need it. It's government's responsibility to make sure everyone's basic needs are met.
	Privatization	Private profit is the main motive for hard work. Water privatization is necessary in order to improve water use efficiency.

4. Results: Adaptation on the ground

Three water management projects have been implemented recently around the Rontoccocha lake, a major source of superficial water for the city (Fig. 3). The three projects aim at improving water availability and regularity for local communities, downstream farmers, and the city in a context of increasing demand and climate variability. The projects apply different water management practices based on dams, micro-reservoirs, and wetlands. They involve different stakeholders with different power in decision making (Table 2 and Fig.4, panel a). The projects are described in the next sections using our interviews and field observations (see Supplementary Material 2 for more background information).

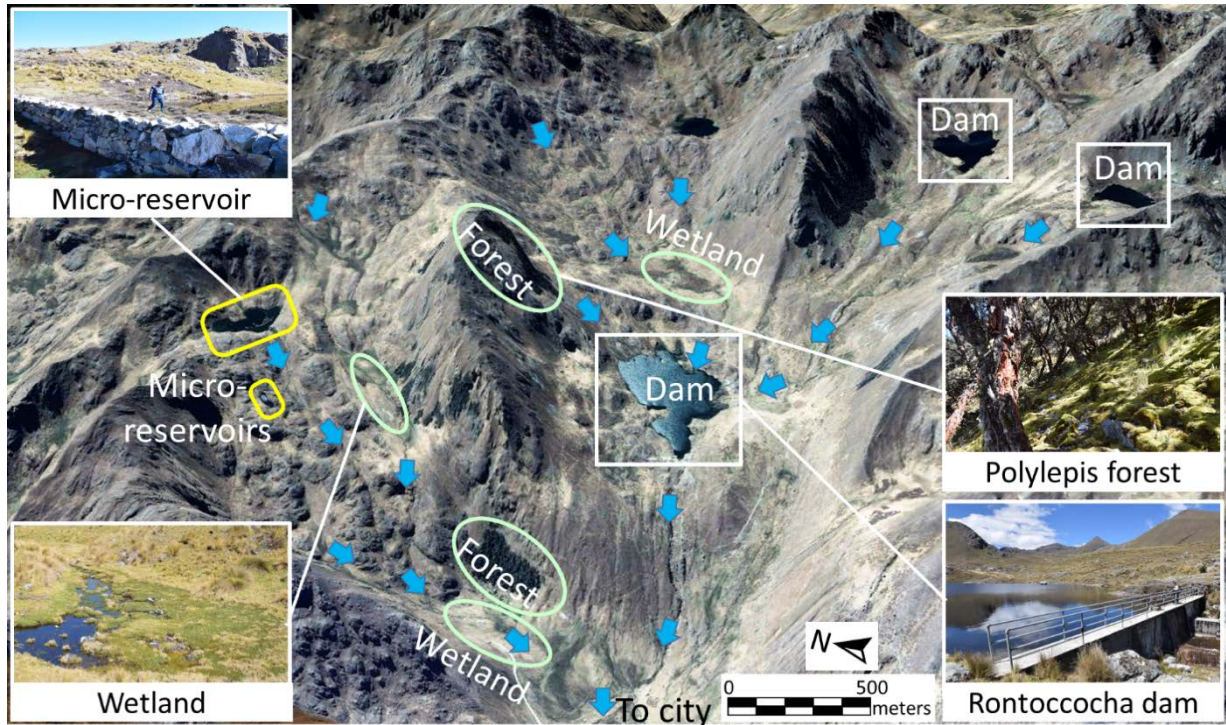


Figure 3. Dams (white squares), micro-reservoirs (yellow rounded rectangles), important ecosystems for water management (green ovals), and superficial water flows (blue arrows) near the Rontoccocha lake in the southeast of the Mariño watershed, Peru. Coordinates of the centre of the view are 13°40'28" S, 72°47'18" W. Mean altitude is 4200 masl (3D view from Google Earth, pictures: first author)

Table 2: Main characteristics of the three water management projects

Measure under focus	Project name	Project measures	Targeted water users	Core stakeholders	Governance and power in decision making
Dam	Mariño Project	Infrastructure (dams, irrigation systems)	Commercial agriculture and urban uses	Regional government, international donors	Decision-making by public entities. Limited involvement of local communities
Micro-reservoir	Restoring Hydrological Functioning	Micro-reservoirs in association with nature-based measures	Uses by local communities	NGO, local communities	Civil society initiative. Decision-making by NGO and local communities
Wetland	Mechanism of Compensation for Ecosystem Services or MRSE	Nature-based measures (wetland and grassland protection, reforestation)	Urban uses, possibly others	Drinking water company, NGO, local communities (and governmental agency as facilitator and supervisor)	Private-public-social partnership. Power is more on the payer side (the drinking water company) but decision-making modalities are still unclear

Dams have been built by the project for the “Integral Management of the Abancay Watershed”, later called the Mariño Project. It started in 2014 under the leadership of the Mayor and, later, the Regional Government and foreign donors. In June 2019, the Regional Government inaugurated two new dams. The project has a strong focus on infrastructure (dams and irrigation canals) for commercial agriculture at mid- and low-elevation but also for human consumption in the city. Dams are constructed on highland community lands, but communities have no control over water allocation from the dams, do not participate in decision-making and are not compensated for their land. Water allocation decisions are made by the governmental water authorities. Commercial agricultural interests and urban water needs are important factors influencing decisions. This has important implications for distributional and procedural equity.

Micro-reservoirs have been built in the project “Restoring the Hydrological Functioning of High Andean Ecosystems”, which was initiated in 2014 by a local NGO in association with a local community (Atumpata) and was then supported by international development agencies. After 2016, other communities, initially skeptical, joined the project. The project aims to restore the hydrological functioning of high Andean ecosystems and focuses on the construction of micro-reservoirs, often in wetlands and pastures. Micro-reservoir construction is done exclusively by community members, who build them in locations that benefit their own water needs, rather than the needs of the city downstream. With micro-reservoirs, communities can also secure control over community land and water resources, as it becomes more difficult for external actors to build dams in areas where there are micro-reservoirs.

Wetland conservation and restoration have been pushed by a payment for ecosystem services (PES), called mechanism of compensation for ecosystem services (or MRSE for its acronym in Spanish). Discussions started in 2010 about how to compensate highland communities for their role of water conservation. In the first PES contract between the municipal water company and two communities, communities commit to avoid grazing or cropping in hydrologically important areas, contribute their workforce to field activities (e.g., wetland fencing), receive in-kind support (material, technical

assistance, capacity-building) and are supposed to benefit from better water provision in the future. The expected beneficiaries of the improved hydrological services are the urban water users in Abancay (who fund the project through their water bills) and the two communities. One of the two communities was for a long time reluctant to endorse the project, as people feared it would lead to the privatization of water resources. Highland communities in the area are generally skeptical of interventions by external actors because they may destabilize community functioning and community decision-making practices on land and water. People were also concerned that ecosystem protection projects might lead to exclusion from critical grazing areas. The best grazing areas for the two communities are actually located in the wetlands, as they provide fodder during the dry season when other grasslands dry out. The project modalities, including benefit-sharing or compensation to the families affected by grazing restrictions, were under discussion at the time of this research. The roles of different stakeholders in decision-making were still unclear yet but appeared to be more balanced than in the other projects.

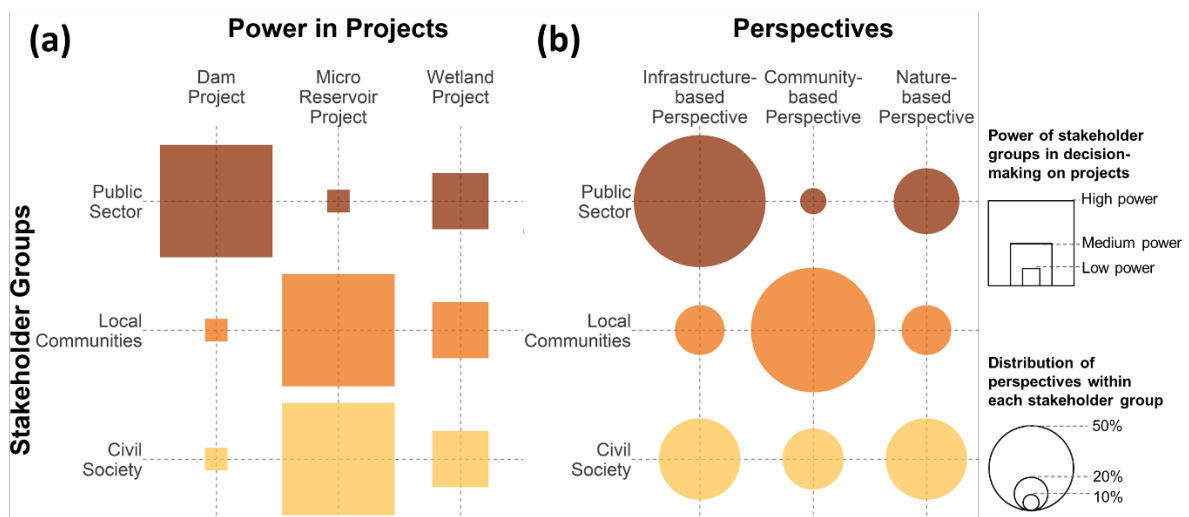


Figure 4. Power of different stakeholder groups in decision-making in the three project (panel a, which summarizes qualitative information collected during the interviews) and perspectives of different stakeholder groups regarding water management (panel b, which shows the results of the cluster analysis based on survey responses)

5. Results: Adaptation in people's minds

Associations between values, beliefs and attitudes

The attitudes toward different water management measures were not significantly correlated among themselves (Fig. 5, part a). On the contrary, attitudes toward managers showed clear oppositions: positive attitudes toward communities were associated with negative attitudes toward the public and private sector (Fig. 5b). There were three significant correlations, all positive, between attitudes toward measures and toward managers: attitudes in favor of local communities were associated with attitudes in favor of wetlands and micro-reservoirs, whereas attitudes in favor of the private sector were associated with attitudes in favor of dams (Fig. 5e).

Beliefs in dams and in wetlands were clearly opposed. Beliefs in micro-reservoirs were associated with beliefs in wetlands and were not opposed to beliefs in dams (Fig. 5c). Values related to the environment, tradition, and welfare were positively correlated among them, whereas equality and privatization were negatively correlated (Fig. 5d).

Attitudes were related to beliefs (Fig. 5f). There were obvious positive correlations between the three beliefs and the attitudes toward the three corresponding measures (e.g., beliefs in dams and positive attitudes toward dams). One correlation confirmed that micro-reservoirs went hand in hand with wetlands in people's mind: the belief that micro-reservoirs worked was associated with a positive attitude toward wetlands. Another correlation confirmed that wetlands and dams were opposed in people's mind: the belief in wetlands was associated with negative attitudes toward dams. The belief in micro-reservoirs was associated with a positive attitude toward communities and against the private sector.

Attitudes were related to values (Fig. 5g). Several expected correlations were observed (e.g., environmental values with attitudes in favor of wetlands, privatization values with attitudes in favor of private sector, values toward traditions with attitudes in favor of community). Unexpected correlations were more informative. For example, people with environmental values had a negative attitude toward the public sector, whereas privatization values were associated with a positive attitude toward the public sector.

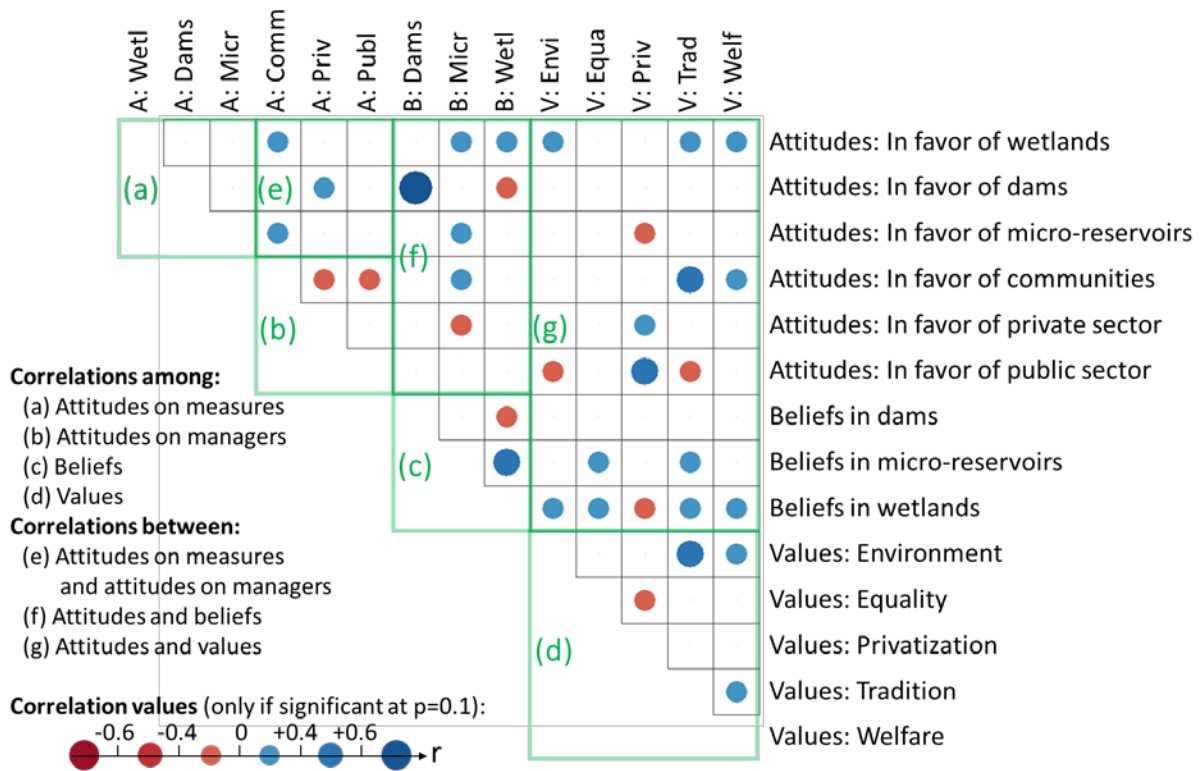


Figure 5. Correlations between the variables describing attitudes, beliefs and values (the same list is at the right and the top). Significant correlations (at $p=0.1$) are represented with circles of different sizes and colors (red for negative correlations and blue for positive).

The network of correlated variables clearly showed two contrasting sets of VBA variables (Fig. 6). Within the two sets, all significant correlations were positive, whereas significant correlations between variables of distinct sets were all negative. In one set, positive attitudes toward dams with the private and public sectors were associated with beliefs in dams and values in favor of privatization. In the other set, positive attitudes toward wetlands and micro-reservoirs with local communities were associated with beliefs in wetlands and micro-reservoirs and values related to the environment, tradition, equality, and welfare.

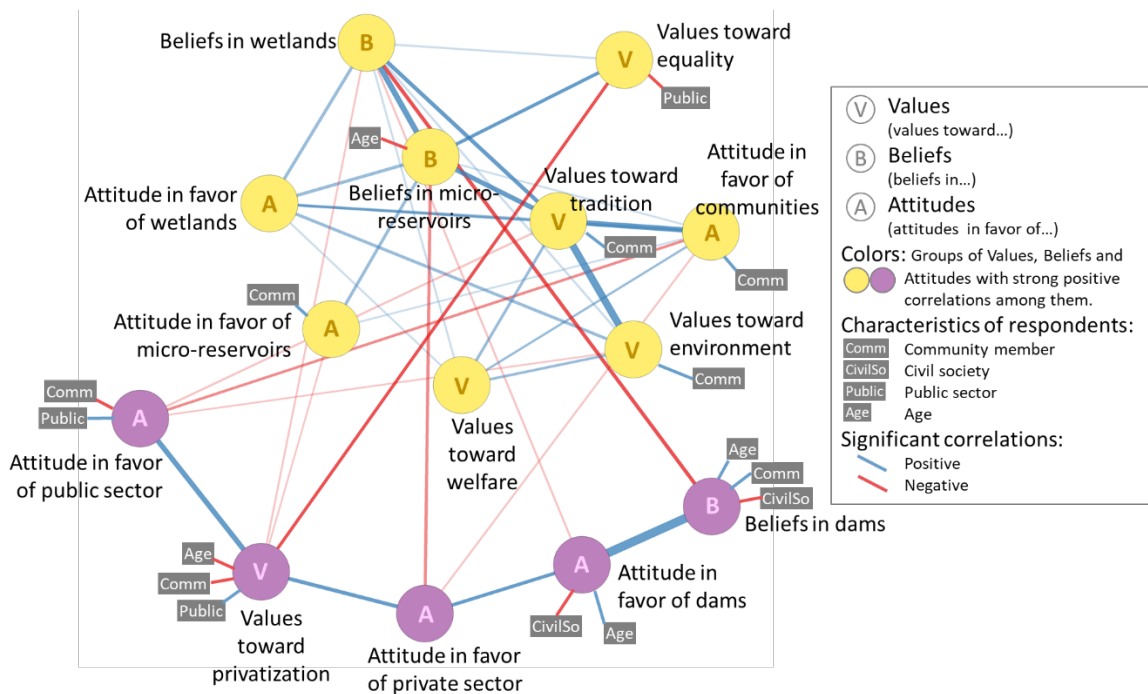


Figure 6. Network graph representing correlations between variables describing VBA (represented by circle nodes). Two nodes are closer to each other if the corresponding variables are more positively correlated. The links between nodes represent significant correlations (at $p=0.10$) (blue if positive, red if negative, thicker if the absolute correlation is higher). Node colors show the two groups of variables with positively correlated among them. Grey tags are added to the nodes to show significant correlations between variables and respondent characteristics (age and group)

Sets of VBA were related to individual characteristics of respondents, such as group or age (Fig. 6). Respondents from communities believed in dams and valued tradition and the environment but did not value privatization. They had a positive attitude toward micro-reservoirs with communities and a negative attitude toward the public sector. This mistrust of communities toward the public sector was reciprocal: public sector respondents had a negative attitude toward community involvement in water management (and positive toward the public sector). Public sector respondents also valued privatization and did not value equality. Respondents from civil society were characterized by their negative attitude toward dams and the lack of belief in this measure. There were some significant effects of age but not gender. Older people had a more positive attitude and more belief in dams, whereas younger people believed more in micro-reservoirs and valued privatization.

Hydrosocial perspectives

The cluster analysis identified three hydrosocial perspectives (Table 2), which were held by respondent from different stakeholder groups (Fig. 4, right). One perspective was about community-based management: it favored micro-reservoirs managed by local communities with and opposed the involvement of private and public sectors. In addition to believing in micro-reservoirs, the respondents with this perspective also believed that dams were good options for managing water. This perspective was associated with values in favor of the environment, equality, tradition, or welfare, and against privatization.

Another perspective was about infrastructure-based management. It included positive attitudes toward dams managed by the private sector and negative attitudes toward micro-reservoirs and wetlands with communities. The respondents with this perspective did not believe in micro-reservoirs or wetlands and valued privatization but not the environment, equality, tradition, and social security.

Finally, a nature-based perspective was in favor of wetlands with the public sector. The respondents with this perspective believed that wetlands were good for water. Respondents from local communities largely held a community-based perspective and respondents from the public sector largely held an infrastructure-based perspective, whereas respondents from the civil society were distributed almost evenly among the three perspectives (Fig. 4, panel b).

Table 3. Description of the three clusters built from the responses on VBA statements.

Cluster name and size	Attitudes toward management measures	Attitudes toward managers	Beliefs	Values
Community-based (n=19)	In favor of micro-reservoirs	In favor of communities. Against private and public sectors	Belief in micro-reservoirs and dams	Environment, equality, tradition, welfare. Against privatization
Infrastructure-based (n=23)	In favor of dams. Against micro-reservoirs and wetlands	In favor of the private sector. Against communities	No belief in micro-reservoirs or wetlands	Privatization. Against environment, equality, tradition, welfare.
Nature-based (n=20)	In favor of wetlands	In favor of the public sector	Belief in wetlands	

6. Discussion

We investigated the hydrosocial cycles of three water projects in a watershed in Peru and the VBA of stakeholders. We found that the three projects involved different practices and stakeholders with different decision-making power. We also identified contrasting sets of VBA between the three main groups of stakeholders involved in the projects.

With our survey and field observations, we have captured a snapshot of the hydrosocial cycle and related decision processes for water management and adaptation. With our focus on values within a broader VRK perspective on decision contexts, we recognize that we have not explored in detail the rules influencing how stakeholders interact in decision-making, nor the generic knowledge that stakeholders hold, both relevant for understanding decision contexts (Gorddard et al., 2016). Despite these limitations, our results provide useful insights into the perspectives of the stakeholders, the hydrosocial cycles on the ground, and the interactions and tensions within and between 'mind' and 'ground'. We discuss these points below.

A clear dichotomy in hydrosocial perspectives

Two sets of VBA appear in opposition. In the divide of values, private benefits or individual efforts are opposed to values related to equality, welfare and the environment, which resonates with the opposition between higher-order values (e.g., individualistic values vs. care for other people and the environment) (Schwartz, 1994). The opposed attitudes are more about the whom than the what and favor either communities or public and private sectors. For example, people from communities are not against dams per se but they have a negative attitude against those involved in dams (i.e., public-private partnerships).

A clash of two water perspectives is apparent, which can be related to the divergence between Andean worldviews and other worldviews that emphasize the dominance of humans over nature and the use of Western science and technology to control the environment (Andolina, 2012; Stensrud, 2016; Wilson and Inkster, 2018). Water management has long been entangled with processes of identity formation in Andean societies, where highland communities understand water through interconnecting physical, human and spiritual factors (Boelens, 2014) (Paerregaard, 2018). Scientific and technological notions of water control have been imposed on Andean societies since the colonial period through, for example, water infrastructure development, legitimizing exclusionary patterns of water distribution, and imposing values such as those related to efficiency and nature "servicing" man (Hogue and Rau, 2008; Trawick, 2003). Similar concerns about divergent values have been voiced with the ecosystem services concept and PES, which partially explains why PES schemes are frequently contested at the local level (Kull et al., 2015; Van Hecken et al., 2015; Van Hecken et al., 2018).

Dams on the ground: Power from the top

In the Mariño watershed, like in many other highlands, dams on the ground represent the power of the government, the water utility companies, and commercial agriculture (Lynch, 2018). Across the Global South, dams are symbols of modernization and nation-building (Bakker, 2012; D'Souza, 2008; Khagram, 2004). The technocratic, top-down, economic growth-focused development vision, supported by international development agencies such as the World Bank, mainstreamed the building of big dams and legitimized related new forms of governance, often at the expense of communal systems (Bakker, 2012; Khagram, 2004). This may explain why communities oppose such projects on the ground, even though they might agree that, technically, dams are a good solution. Dams, which represent the technology of efficiency in water management, can deprive communities not only of water but also of access to land and other resources, and erode collective management practices. They are constructed within, and perpetuate, specific configurations of power, economics,

ideology and knowledge (Carey et al., 2012; D'Souza, 2008). Dams thus embed and exert power which is relationally produced (Loftus, 2009).

The opposition to large infrastructure projects lies mainly in the fact that the communities do not benefit from such infrastructure, as in the case of the Rontoccocha dam, which can be explained by the decision-making process. The hydrosocial cycle observed in the dam project is connected to the 2009 Peruvian Water Law. The law defines water as a national patrimony and a public good to be managed for the benefit of everyone, giving absolute power to the state in distributing water according to what it considers as the best and most efficient use (Lynch, 2018; Roa-García et al., 2015). Even though the law mandates respect for peasant and indigenous rights and dictates integrated water management by all stakeholders, it prioritizes efficiency over equity. This enables the prioritization of commercial agriculture and urban water users over local communities (Lynch, 2018; Roa-García, 2014).

Micro-reservoirs: Grass root control on the ground

Communities are at the core of the hydrosocial cycle associated with micro-reservoirs, although it was a local NGO that catalyzed collective action and revived the tradition of micro-reservoir building. This is common in the Andes where “pro-Andean NGOs” play a prominent role in reviving traditions, promoting culture, and conserving local agrobiodiversity (Shepherd et al., 2010). Water management with micro-reservoirs is done in accordance to held community values, (e.g., respect for tradition, equality and environment) and the communitarian organizational system and labor exchange, which are at the core of community functioning and generate a sense of collective endeavor (Harvey, 2018).

In the hydrosocial cycle associated with micro-reservoirs, local knowledge is fully mobilized. Such knowledge is often considered as crucial for adaptation to climate change (Petzold et al., 2020; Postigo, 2020). In this hydrosocial cycle, local knowledge is not confronted with scientific or technological knowledge, a confrontation that is often at the detriment of local knowledge. In Peru, a study showed how local people did not dare to contradict the engineers, resulting in failed encounters and exacerbated differences between farmers and engineers (Stensrud, 2019). In a case of water management in Chili, the asymmetrical relationships between local communities and external agents were reinforced by the lack of capacity of local communities to understand technical reports on water (Usón et al., 2017). Similarly,

Community members believe that micro-reservoirs are not only effective for water and other benefits, but are also an essential strategy for self-determination and affirming claims on land stewardship. Highland communities hold environmental values but at the same time they do not state strong preferences for wetlands as a water management strategy, probably because of the risk of land grabbing associated with these measures (Adams et al., 2019; Borrás et al., 2012; Fairhead et al., 2012). Because of this risk, micro-reservoirs are a way for communities to mark out territories and confirm their power on them (Hudson, 1998). Communities often manifest their control or influence over a geographical space with physical boundary marks, visible investments, and new infrastructure (Bianco Benavides, 2014).

Wetlands and payment for ecosystem services: An hydrosocial cycle in construction

The hydrosocial cycle around the wetland project is less polarized than the two other projects, because powerful stakeholders are more diverse. Being in construction, it also differs from the other projects where power relationships and decision making are more settled. However, equity concerns are still to be addressed, for example, the ones related to compensation for grazing access loss or to how prioritized water management practices will actually benefit communities.

Equity considerations that go beyond the mere distributional equity of compensation for forgone land uses are important for a more just design of ecosystem conservation and PES schemes

(Kolinjivadi et al., 2015). Power relations and the complex tradeoffs between conservation and social equity usually remain obscure in the name of optimizing efficiency and ecosystem service flows in PES (Ishihara et al., 2017; Kull et al., 2015; Van Hecken et al., 2015; Van Hecken et al., 2018). The design of PES schemes is usually guided by the interests of powerful actors (Kolinjivadi et al., 2019), for example downstream commercial agriculture and urban centers rather than highland communities (Bleeker and Vos, 2019; Carey et al., 2012; Vallet et al., 2020).

PES can lead to land exclusion or deprivation of access to natural resources. There have been warnings that PES implementers may be attracted by a simple PES logic and forget local complexities such as power asymmetries and struggles for natural resource control (Rodríguez de Francisco and Boelens, 2014). PES and other green market mechanisms (such as offsets or mitigation banking) could lead to “green grabbing”, i.e. the appropriation of land and resources for environmental ends (Fairhead et al., 2012). Indeed, fearing the restriction to land access for the benefit of powerful downstream actors, one highland community in the Mariño watershed initially opposed the PES project, although this community was already active through collective work in wetland restoration and protection, a proposed PES activity.

Following the ideas of fundamental entitlements or freedoms as capabilities (Sen, 2009), Kolinjivadi and coauthors advocate for expanding the notion of justice and equity in conservation and PES by considering the impacts of these schemes on people’s freedom or capability to act, do, and be as they desire, or to achieve what they value (Kolinjivadi et al., 2015). If PES schemes only link increases in well-being with monetary compensations, cost recovery or conditional improvements in ES flows, important equity issues such as those related to empowerment and dignity will remain ignored.

As watershed PES schemes are increasingly developed in Peru, supported or scrutinized by a diversity of actors (including from civil society, academia, or national governmental organizations), there is hope that some local PES initiatives will succeed in navigating power relationships and defining objectives and modalities that are acceptable for most stakeholders. Elsewhere in the world, there have been experiences with PES accommodating multiples VBA and providing opportunities for local communities to define and achieve their own goals (Upton, 2020).

Power determines the dominant values, beliefs and attitudes

The distribution of decision power determines what VBA dominate the decision context and influences practices on the ground. The stakeholders of all projects have diverse perspectives on water management and the measures being applied on the ground depend on power distribution within the projects, particularly in the dam and micro-reservoir projects. The infrastructure-based perspective (favoring dams) is the most frequent among public sector stakeholders, who have decision-making power in the dam project, whereas the community-based perspective (favoring micro-reservoirs) is the most frequent among local community stakeholders, who are powerful in the micro-reservoir project.

Exploring the hydrosocial cycle provides an understanding of how power shapes the dominant values and perspectives in a decision process. The power of dominant groups is reflected in the dominant value systems, and their associated knowledge, with techno-scientific knowledge prevailing in some hydrosocial cycles in making sense of, and deciding about, environmental change but with indigenous or local knowledge prevailing in others (Rathwell et al., 2015; Tengö et al., 2014).

Each project can be seen as a battlefield where sets of VBA struggle for domination. A “battlefield of legitimacy” was described in Japan during the introduction of a PES scheme, with dominant and marginalised actors fighting to impose their views (Ishihara et al., 2017). At the end, it is not just about which values and management practices are included or excluded, but also about who wins or loses from those decisions and how ‘regimes of accumulation’ (of resources, power, and influence) emerge from decision-making contexts (Urteaga-Crovetto, 2016).

The perspectives dominating the decision context in a project depend on the power of stakeholders in the project but also on interactions between worldviews or knowledge systems at a level higher than the project. In projects for water management or adaptation to climate change in the Andes, the colonial history and the interventions of neoliberal international organizations reinforce hierarchical representations of knowledge, in which the technical knowledge of external experts is rarely challenged (Andolina, 2012; Mills-Novoa et al., 2020; Stensrud, 2019). A historical analysis of the hydrosocial cycle and of VBA can reveal such influences and their consequences for the decision context.

Implications for adaptation planning

This study provides important lessons for adaptation planning. Examining the hydrosocial cycle sheds light on the power relationships and the struggles between VBA in adaptation decisions in water management or in general (Carey et al., 2012). In adaptation, there would always be multiple conceptualizations of what is desired, based on what people consider important to preserve or achieve, including their identity and culture (O'Brien and Wolf, 2010). Adaptation interventions designed from outside, developed in different cultural and environmental contexts or guided by Western values, might not be sustainable or accepted in the long term, as evidenced by proposed adaptation solutions in Pacific small island states (Nunn et al., 2016). But even though adaptation research and practice has learned from the critiques of international development, institutions and strategies still fail to integrate the plural values and priorities of society, and answers are needed as to why this is happening (Gillard et al., 2016).

Because it reveals divergences between VBAs that are unknown to many stakeholders, an analysis like ours is a first step toward participative decision-making that enables deliberation and re-framing of conflicting values, interests and agendas (Colloff et al., 2018). Examining and questioning the decision context in which adaptation occurs can help excluded stakeholders achieve more power and agency and tackle the fundamental question of 'adaptation of what and for whom?' (Cote and Nightingale, 2012). With this initial discussion, we hope to prompt further research on how more pluralistic perspectives can be applied in practice for adaptation planning without unwittingly creating opportunities for new or further exclusion.

Deliberating and making decisions on adaptation based on plural values create space for novel approaches. But, because of power imbalances and the risk that dominant actors impose their perspectives, rights-based approaches have an important role to play, for example through formal protection of less powerful actors (including their right to free prior and informed consent regarding interventions in their lands). However, many examples show that formal rights may not be sufficient if they are not properly respected (Lovera-Bilderbeek and Lahiri, 2021). Processes such as the establishment of watershed PES in Peru should include clear safeguards (i.e., protective measures in form of standards for good practice for example regarding inclusiveness) and involve external actors (e.g., from the civil society) to scrutinize local decision-making processes or intervene as whistle-blowers or mediators.

The leaders of adaptation initiatives must have the skills to promote inclusiveness (Lliso et al., 2021), understand motivations and power relations (Adams et al., 2019), create a space where different values come face to face (Borrini-Feyerabend et al., 2013), facilitate discussions on values, and form a "crystallization process" to define shared values (Sethamo et al., 2020). Experiments such as T-labs ("Transformation laboratories") can create spaces for making values explicit and confronting different worldviews (Charli-Joseph et al., 2018), which is essential for transformative change (IPBES, 2022). A multiple evidence base approach can be applied to generate new insights from indigenous, local and scientific knowledge systems, by letting each knowledge system speak for itself, within its own context, without any one system dominating as an external validator (Tengö et al., 2014). Openness to different knowledge systems and world views prompts stakeholders to collectively

imagine futures that are radically different from the status quo and to prepare for navigating change in a more inclusive, just and legitimate way.

Acknowledgements

This paper is a contribution from the Transformative Adaptation Research Alliance (TARA, <https://research.csiro.au/tara/>), an international network of researchers and practitioners dedicated to the development and implementation of novel approaches to transformative adaptation to global change. The funding partners that have supported this research include the International Climate Initiative (IKI, project 15_III_075) of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), the Norwegian Agency for Development Cooperation (agreement QZA-016/0110), the French funding agency for research (project TRASSE ANR-CONACYT-17-CE32-0012), the European Union's H2020 research and innovation program (SINCERE Project), the French Ministry for the Ecological and Inclusive Transition, and the CGIAR Research Program on Forests, Trees and Agroforestry (CRP FTA) with financial support from the CGIAR Fund. The authors are grateful to Helvetas, the Andean Forest Program, CEDES, and IDMA for their support in organizing the field work. The authors thank all interviewees for their time and rich information, and anonymous reviewers for their useful comments.

References

- Adams, E.A., Kuusaana, E.D., Ahmed, A., Campion, B.B., 2019. Land dispossessions and water appropriations: Political ecology of land and water grabs in Ghana. *Land Use Policy* 87, 104068.
- Adger, W.N., Barnett, J., 2009. Four reasons for concern about adaptation to climate change. *Environment and Planning A: Economy and Space* 41, 2800–2805.
- Ajzen, I., Fishbein, M., 2000. Attitudes and the attitude-behavior relation: Reasoned and automatic processes. *European review of social psychology* 11, 1-33.
- Andolina, R., 2012. The values of water: development cultures and indigenous cultures in highland Ecuador. *Latin American Research Review* 47, 3-26.
- Bakker, K., 2012. Water: Political, biopolitical, material. *Social Studies of Science* 42, 616-623.
- Bianco Benavides, G., 2014. The Territorialization of a small community-The case of Huaytire, Peru. The University of Bergen.
- 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, 224-242.
- Boelens, R., 2014. Cultural politics and the hydrosocial cycle: Water, power and identity in the Andean highlands. *Geoforum* 57, 234-247.
- Boldrin, A., Mason, L., 2009. Distinguishing between knowledge and beliefs: Students' epistemic criteria for differentiating. *Instructional Science* 37, 107.
- Bonnesoeur, V., Locatelli, B., Guariguata, M.R., Ochoa-Tocachi, B.F., Vanacker, V., Mao, Z., Stokes, A., Mathez-Stiefel, S.-L., 2019. Impacts of forests and forestation on hydrological services in the Andes: a systematic review. *Forest Ecology and Management* 433, 569–584.
- Borras, S.M., Jr., Franco, J.C., Gomez, S., Kay, C., Spoor, M., 2012. Land grabbing in Latin America and the Caribbean. *Journal of Peasant Studies* 39, 845-872.
- Borrini-Feyerabend, G., Farvar, M.T., Renard, Y., Pimbert, M.P., Kothari, A., 2013. *Sharing power: A global guide to collaborative management of natural resources*. Routledge.
- Budds, J., Hinojosa, L., 2012. Restructuring and Rescaling Water Governance in Mining Contexts: The Co-Production of Waterscapes in Peru. *Water Alternatives* 5.
- Budds, J., Linton, J., McDonnell, R., 2014. The hydrosocial cycle. *Geoforum* 57, 167-169.
- Budds, J., Sultana, F., 2013. Exploring political ecologies of water and development. *Environment and Planning D: Society and Space* 31, 275-279.

- Carey, M., French, A., O'Brien, E., 2012. Unintended effects of technology on climate change adaptation: an historical analysis of water conflicts below Andean Glaciers. *Journal of Historical Geography* 38, 181-191.
- CBC, 2012. Gestión del agua y los conflictos en su interrelación con el cambio climático en la región Apurímac, PACC - Serie de investigación regional 6. Centro Bartolomé de las Casas (CBC), Programa de Adaptación al Cambio Climático (PACC), Cusco, Peru.
- Charli-Joseph, L., Siqueiros, J.M., Eakin, H., Manuel-Navarrete, D., Shelton, R., 2018. Promoting agency for social-ecological transformation: a transformation-lab in the Xochimilco social-ecological system.
- Colloff, M., Gorddard, R., Dunlop, M., 2018. The values-rules-knowledge framework in adaptation decision-making: a primer. Canberra: CSIRO Land and Water.
- Colloff, M.J., Martín-López, B., Lavorel, S., Locatelli, B., Gorddard, R., Longaretti, P.-Y., Walters, G., Van Kerkhoff, L., Wyborn, C., Coreau, A., 2017. An integrative research framework for enabling transformative adaptation. *Environ. Sci. Policy* 68, 87-96.
- CONDESAN, 2014. Informe del diagnostico hidrológico rápido en la microcuenca del río Mariño. CONDESAN (Consortio para el desarrollo de la ecorregión andina), Lima, Peru.
- Cote, M., Nightingale, A.J., 2012. Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Prog. Hum. Geogr.* 36, 475-489.
- Coudrain, A., Francou, B., Kundzewicz, Z.W., 2005. Glacier shrinkage in the Andes and consequences for water resources. *Hydrological Sciences Journal* 50, 925-932.
- Csardi, G., 2018. igraph: Routines for simple graphs and network analysis, version 1.2.2. <https://cran.r-project.org/package=igraph>.
- D'Souza, R., 2008. Drowned and Dammed: Colonial Capitalism and Flood Control in Eastern India. *Conservation and Society* 6, 206.
- Drenkhan, F., Carey, M., Huggel, C., Seidel, J., Oré, M.T., 2015. The changing water cycle: climatic and socioeconomic drivers of water-related changes in the Andes of Peru. *Wiley Interdisciplinary Reviews: Water* 2, 715-733.
- Dunlap, R.E., Van Liere, K.D., Mertig, A.G., Jones, R.E., 2000. New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal of social issues* 56, 425-442.
- Ennis, C.D., 1994. Knowledge and beliefs underlying curricular expertise. *Quest* 46, 164-175.
- Erickson, C.L., 2018. The domesticated landscapes of the Andes, In: Seligmann, L.J., Fine-Dare, K.S. (Eds.), *The Andean World*. Routledge New York, pp. 29-43.
- Fairhead, J., Leach, M., Scoones, I., 2012. Green Grabbing: a new appropriation of nature? *The Journal of Peasant Studies* 39, 237-261.
- Fulton, D.C., Manfredo, M.J., Lipscomb, J., 1996. Wildlife value orientations: A conceptual and measurement approach. *Human dimensions of wildlife* 1, 24-47.
- Gillard, R., Gouldson, A., Paavola, J., Van Alstine, J., 2016. Transformational responses to climate change: beyond a systems perspective of social change in mitigation and adaptation. *Wiley Interdisciplinary Reviews: Climate Change* 7, 251-265.
- Glenk, K., Fischer, A., 2010. Insurance, prevention or just wait and see? Public preferences for water management strategies in the context of climate change. *Ecological Economics* 69, 2279-2291.
- Gorddard, R., Colloff, M.J., Wise, R.M., Ware, D., Dunlop, M., 2016. Values, rules and knowledge: Adaptation as change in the decision context. *Environ. Sci. Policy* 57, 60-69.
- Harvey, P., 2018. Interrupted futures: co-operative labour and the changing forms of collective precarity in rural Andean Peru. *Journal of the Royal Anthropological Institute* 24, 120-133.
- Hicks, C.C., Cinner, J.E., Stoeckl, N., McClanahan, T.R., 2015. Linking ecosystem services and human-values theory. *Conservation Biology* 29, 1471-1480.
- Hogue, E.J., Rau, P., 2008. Troubled water: ethnodevelopment, natural resource commodification, and neoliberalism in Andean Peru. *Urban Anthropology and Studies of Cultural Systems and World Economic Development*, 283-327.
- Homer, P.M., Kahle, L.R., 1988. A structural equation test of the value-attitude-behavior hierarchy. *Journal of Personality and Social Psychology* 54, 638.
- Hudson, A., 1998. Beyond the borders: Globalisation, sovereignty and extra-territoriality. *Geopolitics* 3, 89-105.

- IPBES, 2022. Summary for policymakers of the methodological assessment regarding the diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (assessment of the diverse values and valuation of nature). Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES Plenary at its ninth session (IPBES 9), Bonn. <https://doi.org/10.5281/zenodo.6832427>.
- Ishihara, H., Pascual, U., Hodge, I., 2017. Dancing With Storks: The Role of Power Relations in Payments for Ecosystem Services. *Ecological Economics* 139, 45-54.
- Jacobs, M.H., Buijs, A.E., 2011. Understanding stakeholders' attitudes toward water management interventions: Role of place meanings. *Water Resources Research* 47.
- Jiménez Cisneros, B.E., Oki, T., Arnell, N.W., Benito, G., Cogley, J.G., Döll, P., Jiang, T., Mwakalila, S.S., 2014. Freshwater resources, In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 229-269.
- Kahan, D.M., Braman, D., Gastil, J., Slovic, P., Mertz, C., 2007. Culture and identity-protective cognition: Explaining the white-male effect in risk perception. *Journal of Empirical Legal Studies* 4, 465-505.
- Khagram, S., 2004. *Dams and development: Transnational struggles for water and power*. Cornell University Press.
- Kolinjivadi, V., Gamboa, G., Adamowski, J., Kosoy, N., 2015. Capabilities as justice: Analysing the acceptability of payments for ecosystem services (PES) through 'social multi-criteria evaluation'. *Ecological Economics* 118, 99-113.
- Kolinjivadi, V., Mendez, A.Z., Dupras, J., 2019. Putting nature 'to work' through Payments for Ecosystem Services (PES): Tensions between autonomy, voluntary action and the political economy of agri-environmental practice. *Land use policy* 81, 324-336.
- Kull, C.A., de Sartre, X.A., Castro-Larrañaga, M., 2015. The political ecology of ecosystem services. *Geoforum* 61, 122-134.
- Linton, J., Budds, J., 2014. The hydrosocial cycle: Defining and mobilizing a relational-dialectical approach to water. *Geoforum* 57, 170-180.
- Liso, B., Pascual, U., Engel, S., 2021. On the role of social equity in payments for ecosystem services in Latin America: A practitioner perspective. *Ecological Economics* 182, 106928.
- Locatelli, B., Lavorel, S., Sloan, S., Tappeiner, U., Geneletti, D., 2017. Characteristic trajectories of ecosystem services in mountains. *Frontiers in Ecology and the Environment* 15, 150-159.
- Loftus, A., 2009. Rethinking political ecologies of water. *Third World Quarterly* 30, 953-968.
- Lovera-Bilderbeek, S., Lahiri, S., 2021. Addressing power imbalances in biosequestration governance. *Global Policy* 12, 57-66.
- Lynch, B.D., 2018. *Water and power in the Peruvian Andes, The Andean World*. Routledge, pp. 44-59.
- Maggioni, L., Riconscente, M.M., Alexander, P.A., 2006. Perceptions of knowledge and beliefs among undergraduate students in Italy and in the United States. *Learning and Instruction* 16, 467-491.
- Maldonado Fonkén, M., 2014. An introduction to the bofedales of the Peruvian High Andes. *Mires and Peat* 15, 1-13.
- Mathez-Stiefel, S.-L., Peralvo, M., Báez, S., Rist, S., Buytaert, W., Cuesta, F., Fadrique, B., Feeley, K.J., Groth, A.A.P., Homeier, J., Llambí, L.D., Locatelli, B., Sandoval, M.F.L., Malizia, A., Young, K.R., 2017. Research Priorities for the Conservation and Sustainable Governance of Andean Forest Landscapes. *Mountain Research and Development* 37, 323-339.
- Mills-Novoa, M., Boelens, R., Hoogesteger, J., Vos, J., 2020. Governmentalities, hydrosocial territories & recognition politics: The making of objects and subjects for climate change adaptation in Ecuador. *Geoforum* 115, 90-101.
- Morrison, T.H., Adger, W.N., Brown, K., Lemos, M.C., Huitema, D., Phelps, J., Evans, L., Cohen, P., Song, A.M., Turner, R., Quinn, T., Hughes, T.P., 2019. The black box of power in polycentric environmental governance. *Global Environmental Change* 57, 101934.
- Nightingale, A.J., 2017. Power and politics in climate change adaptation efforts: Struggles over authority and recognition in the context of political instability. *Geoforum* 84, 11-20.
- Nunn, P.D., Mulgrew, K., Scott-Parker, B., Hine, D.W., Marks, A.D., Mahar, D., Maebuta, J., 2016. Spirituality and attitudes towards Nature in the Pacific Islands: insights for enabling climate-change adaptation. *Climatic Change* 136, 477-493.

- O'Brien, K.L., Wolf, J., 2010. A values-based approach to vulnerability and adaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change* 1, 232-242.
- Ochoa-Tocachi, B.F., Bardales, J.D., Antiporta, J., Pérez, K., Acosta, L., Mao, F., Zulkafli, Z., Gil-Ríos, J., Angulo, O., Grainger, S., 2019. Potential contributions of pre-Inca infiltration infrastructure to Andean water security. *Nature Sustainability* 2, 584-593.
- Pabón-Caicedo, J.D., Arias, P.A., Carril, A.F., Espinoza, J.C., Goubanova, K., Lavado, W., Masiokas, M., Solman, S.A., Villalba, R., 2020. Observed and projected hydroclimate changes in the Andes. *Frontiers in Earth Science* 8, 61.
- PACC, 2013. Para adaptarnos mejor al cambio climático en los Andes peruanos, Memoria de la Primera Fase. Programa de Adaptación al Cambio Climático (PACC), Lima, Peru.
- PACC, SENAMHI, 2012. Caracterización climática y escenarios de cambio climático al 2030 y 2050, y oferta hídrica superficial actual y futura de las regiones Cusco y Apurímac, Serie impresa de investigación regional N° 1. Programa de Adaptación al Cambio Climático (PACC), Servicio Nacional de Meteorología e Hidrología (SENAMHI), Lima, Peru.
- Paerregaard, K., 2018. Power in/of/as water: Revisiting the hydrologic cycle in the Peruvian Andes. *Wiley Interdisciplinary Reviews: Water* 5, e1270.
- Partzsch, L., 2017. 'Power with' and 'power to' in environmental politics and the transition to sustainability. *Environmental Politics* 26, 193-211.
- Peters, E., Slovic, P., 1996. The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power 1. *Journal of applied social psychology* 26, 1427-1453.
- Petzold, J., Andrews, N., Ford, J.D., Hedemann, C., Postigo, J.C., 2020. Indigenous knowledge on climate change adaptation: a global evidence map of academic literature. *Environmental Research Letters* 15, 113007.
- Podvin, K., Cordero, D., Gómez, A., 2014. Climate Change Adaptation in the Peruvian Andes: implementing no-regret measures in the Nor Yauyos-Cochas Landscape Reserve, In: Murti, R., Buyck, C. (Eds.), *Safe Havens: Protected Areas for Disaster Risk Reduction and Climate Change Adaptation*. IUCN, Gland, Switzerland, pp. 94-103.
- Postigo, J.C., 2020. The role of social institutions in indigenous Andean Pastoralists' adaptation to climate-related water hazards. *Climate and Development*, 1-12.
- Price, J.C., Walker, I.A., Boschetti, F., 2014. Measuring cultural values and beliefs about environment to identify their role in climate change responses. *Journal of Environmental Psychology* 37, 8-20.
- R Core Team, 2019. R: A language and environment for statistical computing, version 3.6.2 (2019-12-12) R Foundation for Statistical Computing, Vienna, Austria, <https://www.r-project.org/>.
- Rathwell, K., Armitage, D., Berkes, F., 2015. Bridging knowledge systems to enhance governance of environmental commons: a typology of settings. *International Journal of the Commons* 9.
- Roa-García, M.C., 2014. Equity, efficiency and sustainability in water allocation in the Andes: Trade-offs in a full world. *Water Alternatives* 7, 298-319.
- Roa-García, M.C., Urteaga-Crovetto, P., Bustamante-Zenteno, R., 2015. Water laws in the Andes: A promising precedent for challenging neoliberalism. *Geoforum* 64, 270-280.
- Rodríguez de Francisco, J.C., Boelens, R., 2014. Why power matters in Payments for Environmental Services (PES), Briefing Paper, No. 9/2014. Deutsches Institut für Entwicklungspolitik (DIE), Bonn.
- Schultz, P.W., Gouveia, V.V., Cameron, L.D., Tankha, G., Schmuck, P., Franěk, M., 2005. Values and their Relationship to Environmental Concern and Conservation Behavior. *Journal of Cross-Cultural Psychology* 36, 457-475.
- Schwartz, S.H., 1994. Are there universal aspects in the structure and contents of human values? *Journal of social issues* 50, 19-45.
- Segura, H., Espinoza, J.C., Junquas, C., Lebel, T., Vuille, M., Garreaud, R., 2020. Recent changes in the precipitation-driving processes over the southern tropical Andes/western Amazon. *Climate Dynamics*, 1-19.
- Sen, A.K., 2009. *The idea of justice*. Harvard University Press.
- Serrano Chuima, M.R., 2018. Impacto del cambio climático en el retroceso glaciar de la subcuenca del río Sahuanay, provincia de Abancay, Civil Engineer Thesis. Cesar Vallejo university, Lima, Peru.
- Sethamo, O.A., Masika, R.J., Harder, M.K., 2020. Understanding the role of crystallizing local shared values in fostering effective community engagement in adaptation planning in Botswana. *Climate and Development* 12, 448-456.

- Seward, J.E., 2014. An Intersectional Approach to Environmental Political Theory: A Case Study on Modern Andean Bolivian Indigenous Forms of Resistance and Communal Democracy in Relation to Water Rights, Politics and International Relations. Scripps College, Claremont University, Claremont, CA.
- Shepherd, C.J., Anderson, W., Hicks, D., McWilliam, A., van Eijck, M., Verran, H., Shepherd, C., 2010. Mobilizing local knowledge and asserting culture: The cultural politics of in situ conservation of agricultural biodiversity. *Current Anthropology* 51, 629-654.
- Stensrud, A.B., 2016. Climate Change, Water Practices and Relational Worlds in the Andes. *Ethnos* 81, 75-98.
- Stensrud, A.B., 2019. "You cannot contradict the engineer": Disencounters of modern technology, climate change, and power in the Peruvian Andes. *Critique of Anthropology* 39, 420-438.
- Tengö, M., Brondizio, E.S., Elmqvist, T., Malmer, P., Spierenburg, M., 2014. Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. *Ambio* 43, 579-591.
- Trawick, P.B., 2003. *The Struggle for Water in Peru: comedy and tragedy in the Andean commons*. Stanford University Press.
- Upton, C., 2020. Conserving Natures? Co-producing Payments for Ecosystem Services in Mongolian Rangelands. *Development and Change* 51, 224-252.
- Urteaga-Crovetto, P., 2016. Between water abundance and scarcity: discourses, biofuels, and power in Piura, Peru. *Antipode* 48, 1059-1079.
- Usón, T.J., Henríquez, C., Dame, J., 2017. Disputed water: Competing knowledge and power asymmetries in the Yali Alto basin, Chile. *Geoforum* 85, 247-258.
- Vallet, A., Locatelli, B., Barnaud, C., Makowski, D., Quispe Conde, Y., Levrel, H., 2020. Power asymmetries in social networks of ecosystem services governance. *Environ. Sci. Policy* 114, 329-340.
- Vallet, A., Locatelli, B., Levrel, H., Dendoncker, N., Barnaud, C., Quispe Conde, Y., 2019. Linking equity, power and stakeholders' roles in relation to ecosystem services. *Ecology and Society* 24, doi:10.5751/ES-10904-240214.
- Van Hecken, G., Bastiaensen, J., Windey, C., 2015. Towards a power-sensitive and socially-informed analysis of payments for ecosystem services (PES): addressing the gaps in the current debate. *Ecological Economics* 120, 117-125.
- Van Hecken, G., Kolinjivadi, V., Windey, C., McElwee, P., Shapiro-Garza, E., Huybrechs, F., Bastiaensen, J., 2018. Silencing agency in payments for ecosystem services (PES) by essentializing a neoliberal 'monster' into being: a response to Fletcher & Büscher's 'PES conceit'. *Ecological Economics* 144, 314-318.
- Vaske, J.J., Donnelly, M.P., 1999. A value-attitude-behavior model predicting wildland preservation voting intentions. *Society & Natural Resources* 12, 523-537.
- Whittaker, D., Vaske, J.J., Manfredi, M.J., 2006. Specificity and the cognitive hierarchy: Value orientations and the acceptability of urban wildlife management actions. *Society and Natural Resources* 19, 515-530.
- 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, 516-538.