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# Climate Risk Management

journal homepage: [www.elsevier.com/locate/crm](http://www.elsevier.com/locate/crm)

## Urban dwellers' adaptive capacity as a socio-psychological process: Insights from Lima, Peru

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### ARTICLE INFO

#### Keywords:

Climate change  
Adaptive capacity  
Urban  
Cognitive processes  
Social norms  
Lima

### ABSTRACT

This study examines the adaptive capacity of urban dwellers in the face of a changing climate dealing with water insecurity. It builds on the case of Lima residents' responses to the extreme events brought by the 2017 El Niño Costero, used here as a temporal analogue. Our novel, process-oriented approach to framing adaptive capacity integrates elements from both environmental behavior and new institutionalism literatures. Based on interviews with Lima residents, policymakers, and stakeholders as well as on a qualitative document analysis of national and city policies we identify and characterize the socio-psychological processes that are critical to understanding why individuals adopt (or not) different adaptive strategies. We show how governance and social institutions (from municipal regulations to gender roles) influenced residents' perceived vulnerability and how this, in turn, structured their coping actions during the El Niño Costero episode. We further demonstrate that ways in which individuals deploy coping mechanisms structure their future adapting paths through practices that privilege the status quo while deferring risks in time and space. In this context, the interrelation of residents' cognitive processes with evolving social norms lead to five strategies for dealing with climate change. The discussion reflects on the need to address institutionalized social inequalities that permeate Lima's daily urban life in order to enhance the adaptive capacity of the most vulnerable, and on the relationship between residents and authorities on the pathway to urban resilience.

### 1. Introduction

In already challenging urban contexts for water security<sup>1</sup>, climate change threatens to exacerbate extreme climatic events and unpredictable rainfall patterns that can lead to more frequent and intense droughts and floods (Rosenzweig et al. 2018; Rosenzweig et al. 2011). This could compromise water quantity and quality, directly affecting urban populations' livelihoods and infrastructure (e. g., housing, sewage systems, transport systems, energy systems) (Kashyap 2004). Climate threats to water security can have significant consequences on human health and well-being, safety, the environment, economic growth, and local development (Satterthwaite et al.

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<sup>1</sup> Water security denotes the accessible and sufficient good quality water for social, economic, and cultural uses, adequate water to sustain and enhance ecosystem functions (de Loë et al., 2007) coupled with an acceptable level of water-related risks to social and ecological systems (Grey & Sadoff, 2007). The concept of water security is subject of scholarly debates, for further reading please see: Bakker 2012, Varady et al., 2016; & Zeitoun et al., 2016.

<https://doi.org/10.1016/j.crm.2021.100352>

Received 3 August 2020; Received in revised form 20 July 2021; Accepted 2 August 2021

Available online 13 August 2021

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2007; UN-Habitat 2011; WHO and UNICEF 2012; Wilbanks et al. 2007). These concerns are especially salient in urban areas of low- and middle-income countries experiencing demographic growth. Climate change is likely to add pressure to an already mounting demand and competition for limited water resources. Cities such as Lima, Peru, where 10% of the population is still unserved by the public water network, could soon be under perpetual water stress, undermining water provision reliability (World Bank 2015).

In the last decade, researchers have increasingly studied the vulnerability of urban areas to climate change and assessed their adaptation plans (Meerow and Mitchell 2017; Rosenzweig et al. 2018). This scholarship has, however, remained focused on exposure to climate risks resulting from urbanization, giving only limited attention to urban societies' sensitivities and capacities to adapt to climate change (Flórez Bossio et al. 2019; Garschagen and Romero-Lankao 2015). When studies do address the adaptation of urban areas, scholars predominantly analyze policy and governance issues at the city scale, leaving largely unattended the question of urban populations' response to government-led adaptation plans, policies, and interventions. A deeper understanding of urban adaptation at the individual level is needed to understand these responses and ultimately improve the effectiveness of policies and influence citizens to adopt positive autonomous adaptive actions (Brink and Wamsler 2019; Helm et al. 2018).

Empirical studies of adaptation processes in non-urban settings show that social barriers, experienced at the individual level, play an important role in constraining the effectiveness of local government's adaptation policies (Baker et al. 2012; Jones 2010; Lehmann et al. 2015; Measham et al. 2011). The findings indicate that residents can—and sometimes do—respond negatively to policies devised by governments to respond to climate change hazards. But in contrast to studies on climate change in rural contexts and to the broader social-ecological systems literature (Beratan 2007; Eakin et al. 2016; Hamilton et al. 2018; Truelove et al. 2015), individual-scale analyses of institutional and behavioral barriers are still lacking from urban adaptation research (with few exceptions such as Brink and Wamsler 2019; Liang et al. 2017).

This paper begins to fill this gap through a city-wide case study of Lima residents' adaptive capacity to climate change. At the most general level, adaptive capacity refers to the ability of a system (social or ecological), region, community, household, or individual to perceive, cope with, prepare for, and adapt to the effects and consequences of climate change, including climate variability and extremes (Brooks and Adger 2005; Ford and Smit 2004; Grothmann and Patt 2005; Hinkel 2011; Plummer and Armitage 2010; Smit and Wandel 2006). This study further emphasizes the contextual nature of adaptive capacity, understood as varying across and within localities, among social groups and individuals, and over time (Leichenko 2011; Romero-Lankao et al. 2014; Shi et al. 2016). In so doing, it supports a process-oriented analysis focused on areas wherein individual-level socio-psychological dynamics intersect with broader socio-normative dynamics in the process of adaptation (Bunce and Ford 2015; Flórez Bossio et al. 2019).

In this study, we use this process-orientated approach to document and analyze the adaptive capacities of Lima's urban residents in the face of an extreme climatic event that happened between February and April 2017 during the El Niño Southern Oscillation (ENSO). This climate phenomenon occurs irregularly, at two- to seven-year intervals, producing widespread and severe changes in climatic conditions. During these episodes, drastic rainfall increases contribute to coastal flooding, mudslides, water pollution, and increased water-borne diseases (Brown 2014; Cobb et al. 2003). Although this phenomenon has repeatedly affected the north of Peru, in 2017 an unusual event known as *El Niño Costero* severely affected the country's north and central coast, including the Peruvian capital's water security. These climatic events were, in many ways, consistent with climate change scenarios formulated for Lima, where the most plausible scenario foresees permanent droughts with extreme events and intense rainfall (Calvo 2012; Miranda Sara et al., 2017). We use this period as a "temporal analogue," an approach that studies present experiences with climatic phenomena as a means to gain understanding of future vulnerability and responses (Ford et al., 2010).

In what follows, we bring insights from environmental behavior and new institutionalism to study individuals' adaptive capacity. Our analysis relies on over a hundred interviews with Lima residents documenting their experiences during the climate extremes of 2017, and their current strategies for dealing with climate change threats to their water security. This is complemented by an analysis of governance and social institutions that structure individuals' responses through interviews with policymakers and stakeholders, and a review of relevant policy documents.

## 2. Conceptual framework: the adaptive capacity of urban dwellers

Our conceptualization of urban dwellers' adaptive capacity to climate change draws on insights from environmental behavior and new institutionalism studies. At the crossroads of psychology and behavioral economics, environmental behavior research puts attention to the role that cognitive and affective processes play in shaping a wide range of environmental behaviors (De Groot and Steg 2008; Kaplan 2000). Empirical studies have focused on individuals' attitudes, motivations, and values that lead to conscious behavioral intentions (Sheeran 2002). Yet, the literature sheds light on the fact that individuals' reactions to external stimuli are not the mere result of rationalized thought processes. Instead, they involve multiple mental heuristics that individuals use when evaluating situations and making decisions about how to respond, which often lead to cognitive biases that affect individuals' behavior (Kahneman and Tversky 1979). In this view, environmental behavior literature provides for an in-depth understanding of cognitive and affective processes that facilitate or prevent individuals from seeking the most appropriate forms of adaptation (Grothmann and Patt 2005; Helm et al. 2018; Jones and Tanner 2015; Truelove et al. 2015; van der Linden 2015).

Regarding climate change, scholars have identified relevant heuristics and biases (called behavioral barriers) that can lead people to maladapt, whereby an adaptation action does not succeed in reducing vulnerability but instead increases it, for example, by downplaying the severity of a threat or giving only the illusion of control over it (Clayton et al. 2015; Gifford et al. 2011; Grothmann and Patt 2005; Magnan et al. 2016). Studies examining the role of behavioral barriers in adaptation processes tend to assume the existence of a direct link between cognitive processes and adaptation actions, frequently operationalized between risk perception and intended adaptations (Lo 2013). Such assumptions are problematic, especially in view of the growing number of empirical studies

highlighting a range of factors that mediate the relation between risk perception and adaptation. These mediating factors concern other psychological processes (e.g., self-efficacy and controllability beliefs) (Grothmann and Patt 2005; Jones and Tanner 2015; Kuruppu and Liverman 2011) as well as social norms (e.g., gender norms) upheld by local socio-cultural institutions (Adger 2003; Brooks and Adger 2005; Thorn et al. 2015; van der Linden 2015).

Such findings point to the importance of approaching adaptive behavior as inherently situated and contextual. This, in turn, calls for greater attention to the broader social, political, and economic processes happening at the urban scale, as these shape the local institutional contexts where individuals will adapt. New institutionalism provides a useful lens in this regard. This school of thought challenges methodological individualism by considering that human behavior is mediated by social institutions broadly defined as rules, norms, and beliefs (Ostrom 1990; Scott 2001). From this perspective, institutions consist of cultural-cognitive, normative, and regulative norms that, together with associated activities and resources, provide stability and meaning to social life (Ostrom 1990; Scott 2001; Scott 2010). Echoing insights from the environmental behavior scholarship, neo-institutional scholars argue that individuals do not make decisions (or act according to them) based solely on their highest utility expectations or on processes of collective argumentation. Instead, individuals take into account both the consequences and the appropriateness of intended actions, while being enabled and constrained by the formal and informal norms that organize all forms of repetitive and structured social interactions (Ostrom 2005). While there are different strands of new institutionalism, we build upon rational choice institutionalism, which examines how institutions shape the structure of situations in which individuals or groups then elaborate strategies when pursuing their preferences (Ostrom 2007; Scott 2010). This strand argues that institutions, given their determinant structuring role, are essentially providing individuals with information about the likely behavior of other people or organizations, and about the incentives and disincentives attached to different courses of action (Lowndes 2002; Ostrom 2007; Scott 2010).

These insights are echoed in climate change research concerned with the ways in which institutions facilitate or constrain actors from dealing with new circumstances and uncertainty related to a changing climate (Bisaro et al. 2018; Matthews and Sydneysmith 2010; Oberlack 2017). However, adaptation studies that account for the role of institutions tend to define them relatively narrowly as organizations rather than rules and norms (Grothmann et al. 2013). This is especially true for deeper-level institutions that shape cognition. And yet, as demonstrated in the discussion of the environmental behavior scholarship, social cognition—understood as the cognitive process of perceiving and acting upon information about how others act in given situations—brings a fuller understanding of how individuals deal with changes and uncertain contexts.

In this study, we bring together the insights from environmental behavior and new institutionalism schools. While new institutionalism enables the identification and characterization of institutions in the urban space, the environmental behavior literature sheds light on urban dwellers' cognitive and affective processes within that institutional context. These ideas are central to this study as we approach the diversity of behavioral strategies that emerged within Lima's socio-urban institutional context.

### 3. Methodological approach

The aim of our study is to investigate the capacity of Lima's urban residents to adapt to climate threats to water security using a temporal analogue approach. This approach relies on past and present experiences and responses to climatic variability and extremes as a way to understand current and future vulnerability processes (Ford et al. 2010; Glantz 1992; McLeman and Hunter 2010).

The temporal analogue used in this study is an ENSO event, called El Niño Costero, which occurred between February and April 2017. This ENSO event differed from the El Niño basin-wide phenomenon because it was spatially confined along the coasts of Peru and Ecuador (IGP 2017), as opposed to involving the El Niño-related expansion of warm waters coming from the western and central equatorial Pacific (Ramírez and Briones 2017). Hence, El Niño Costero is a different and rare kind of El Niño, the previous one dating back to 1925 (Takahashi and Martínez 2017). It represents a particularly valuable temporal analogue for the study of urban adaptive capacities in Lima because the climate extremes that the city endured in 2017 are similar to those projected by climate change scenarios for the city (see Section 4). Preceding El Niño Costero, Lima had endured a drought in December 2016 and maximum and minimum temperature anomalies (up to 5-degree increases) in early 2017. During that same year, El Niño Costero led to exponential rainfall increases in February and March (SENAMHI, 2017).

As explained above, individuals are the unit of analysis of this study. Following the conceptual approach discussed earlier, we combined various data sources to examine the institutional and socio-psychological determinants and processes shaping Lima residents' adaptive capacity. First, we performed a qualitative document analysis (QDA) of policy documents ( $n = 12$ ) concerned with climate change and water management. These documents were identified by reviewing the most recent compendium of Peruvian environmental law, the websites of the Ministry of the Environment and Lima Metropolitan Municipality, and searching for decrees published in the official Peruvian newspaper "El Peruano". We coded each policy document using MAXQDA 2018. We examined national- and city-level policies in order to identify and characterize the formal institutional arrangements (such as laws, regulations) that frame the process of adaptation in Lima. This provided a portrait of the different governance structures and formal institutions that influence urban residents' capacity to adapt.

Second, we rely on data from semi-structured interviews conducted with key stakeholders ( $n = 15$ ) and residents of Lima ( $n = 115$ ) from July 2017 to May 2018. Building on the results of QDA, interviews with stakeholders and policymakers further examined the formal structures and processes underpinning the management of climate risks to water security in Lima, which influences individuals' responses to climatic threats (see interview guideline in Appendix A). We initially mapped the governmental organizations involved in climate change adaptation and risk management in Lima, as well as the non-governmental organizations that had participated in climate change consultation processes. After identifying the first key informants, we used a snowball sampling technique to further recruit national ( $n = 5$ ), city ( $n = 2$ ), and district policymakers ( $n = 4$ ) and other stakeholders ( $n = 4$ ) working on climate change, risk

management, and urban planning. While these interviews were meant to gain knowledge of the governance structures shaping individual adaptation, they also shed light on the perspectives of policymakers themselves as individuals taking public adaptation decisions. Interviews with urban residents focused on their daily experiences with water in the city and during the 2017 climate extremes, and on their knowledge and perceptions about climate change (see [Appendix B](#) for interview guidelines). Through these interviews, we explored residents' capacity to deal with threats by discussing how they perceive their own water (in)security and incentives or constraints to adapting and by documenting their adaptive practices before, during, and after the ENSO-related extreme events. We used a purposeful sampling to include residents with diverse characteristics (e.g., age, location, occupation, socioeconomic status). To this end, we recruited participants among users of 25 key public spaces selected across the city (i.e., plazas, parks, commercial centres, markets, transport stations). To ensure the inclusion of a diversity of people in our sample, the main investigator (CFB) and two local research assistants conducted recruitment at these different spaces at different times of the day (mornings, afternoons, and evenings) and week (weekdays and weekends). We reached saturation<sup>2</sup> after interviewing 115 urban residents (see [Table 1](#)), between the ages 18 and 80, living in 37 districts distributed across the city's five main zones: North Lima (n = 5/8), South Lima (n = 8/11), Central Lima (n = 13/15), East Lima (n = 6/9), and Callao (5/7). All interviews were conducted in Spanish and transcribed. The main investigator coded the interview transcripts using MAXQDA 2018. Following the conceptual approach presented above, the stakeholder interviews were coded deductively focusing on the governmental policy approaches and legal structures in place. For coding residents' interviews, we used constructs such as self-efficacy, perceived risks, perceived vulnerability, as well as individuals' social cognition in relation to neighbors, city residents and authorities' responses. All interviews were also coded inductively to account for emergent themes. Then, the main investigator cross-referenced themes with residents' attributes (i.e., gender, age group, district) to identify relevant coded themes for these groupings.

#### 4. Study area: Metropolitan Lima

Lima's metropolitan area has two distinct regional administrative territories: Lima and Callao (hereafter "Lima"). Together, these two territories are divided into 50 districts, each with its own municipality, conventionally grouped into five zones: North Lima, South Lima, Central Lima, East Lima, and Callao. Overall, the area is home to approximately 10 million inhabitants (INEI 2015), growing at 1.5% per year (INEI 2016).

Historically, Lima has been a highly socially segregated city (Fernández de Córdova et al., 2016; Ioris 2016). In the 1990s, however, this started to shift, such that the city's many socio-economic profiles and population groupings are now less likely to be consolidated in distinct homogenous areas (Fernández de Córdova et al., 2016). The social composition of districts is heterogeneous, with scattered degrees of diversity in terms of migrant origin, socio-occupational categories, and per capita income (Fernández de Córdova 2012). However, what can be observed is that income and environment inequalities augment as one moves out of Central Lima towards the peripheries (Fernández de Córdova et al., 2016). The lack of land for urbanization has led people to construct their homes in floodplains and in other high-risk areas (Calderón Cockburn 2017), while public services have failed to keep up with the pace of expansion (Fernández-Maldonado 2008; Ioris 2016; Matos Mar 2012). To this day, 10% of the population is still unserved by the public water network.<sup>3</sup>

Lima is under permanent water stress. With only 9 mm of precipitation per year in the city, the water supply depends almost entirely on precipitation in the upper watersheds and on glacial meltwater from the Andes. Water shortages, wide rainfall variation due to ENSO, and competition for water between sectors and user groups severely affect the city's quantity and quality of water (GIZ 2014; World Bank 2015). Nonetheless, Lima's water consumption is high. On a daily basis, the Lima population uses approximately 66 gallons of water per capita, well above the average of 40 gallons for other large cities in South America (The Nature Conservancy n.d.). Levels of consumption, however, vary largely across districts and there are polarized perceptions on the availability and price of water between rich and poor districts (LIWA n.d.). According to an estimate of a World Bank study (2015), the Peruvian water utility—Sedapal—will be unable to ensure water reliability<sup>4</sup> by 2040 should the demand by then exceed 920 Mm<sup>3</sup>, regardless of future flows. With the current flow being 855 Mm<sup>3</sup>, the highest plausible demand in 2040 would be 1800 Mm<sup>3</sup>. However, should future flows decrease, as estimated by the IPCC, Sedapal may be unable to ensure water reliability even if future demand were to fall to today's level. It has been argued that long-term climate change impacts may leave the city under perpetual water stress (World Bank 2015).

Climate change is a major threat to the city's water security because it leads to the accelerated melting of the glaciers in the Andes as well as changes in rainfall patterns in the upper watersheds (Thompson et al. 2017; Vuille et al. 2008). In this region, future temperature and precipitation changes are uncertain; so, with rainfall possibly increasing or decreasing, droughts may also become more severe and more common (Pachauri et al. 2015). Local experts consider that the most plausible climate change scenario for Lima in 2040 is one leading to permanent droughts with extreme events and intense rainfall (Calvo 2012; Miranda Sara et al., 2017).

#### 5. Results

The conceptual approach presented above facilitated gathering information on the institutional and behavioral factors that influence adaptive capacity. In this section, we present the findings organized in four subsections about: 1) the socio-urban setting in

<sup>2</sup> We define saturation as the point when no new information was observed in the data during its collection.

<sup>3</sup> This figure was provided by an anonymous representative from Lima's water utility during an interview in July 2017.

<sup>4</sup> Water reliability was defined as meeting 90% of demand 90% of the time, measured monthly.

**Table 1**  
Demographics of Residents Interviewed.

Gender	
Male	46
Female	69
Age	
18–30	46
31–50	40
51–80	29

which individuals experienced El Niño Costero; 2) the coping mechanisms used by dwellers to deal with imminent climate extremes, and the way these mechanisms were bounded by social norms; 3) the interactions between these coping mechanisms and adapting to climate change; and 4) the socio-psychological processes leading to individuals' (non)adaptive strategies for dealing with climate change.

### 5.1. Socio-urban setting

Interviews with residents, stakeholders, and policymakers showed that individuals were significantly affected by the climate extremes of 2016–2017, mainly by El Niño Costero. The rainfall anomalies, an increase between 1500 and 2000% compared to previous years, led to flash floods and flooding that affected citywide water provision, with water treatment systems getting clogged and having to be shut down. Subsequently, the lack of water led to increased costs of alternative sources (e.g., bottled water, water trucks) and overall social stress about securing water for one's personal intake. Residents reported experiencing strong negative emotions (i.e., fear, anger, sadness, anxiety, annoyance) in responding to the lack of water. Flooding and mudslides had direct impacts only on the communities settled in river banks, namely by flooding homes, damaging public urban infrastructure, and contributing to water-borne diseases such as dengue.<sup>5</sup> Nevertheless, flooding and mudslides affected all Lima residents indirectly in the form of moderate food shortages (due to damaged roads) and, to a lesser degree, of electricity shortages (due to the clogged hydroelectric plants). Residents reported that upon realizing the scale of the physical and economic consequences of El Niño Costero they had negative feelings (i.e., hopelessness, helplessness, insecurity, apathy) when thinking about the future of Lima or their own wellbeing were a similar event to happen again.

The way residents experienced and responded to these climatic hazards was mediated by the city's water management, which perpetuated everyday inequalities, and moderated by the location of individuals' households and their residential water infrastructure. Dwellers' experiences of water (in)security were directly related to Lima's water management institutions. Interviews with residents indicated that the distribution of water is regularly uneven between and within districts. As stakeholders explained, Lima's water utility, SEDAPAL, provides and distributes water using economic efficiency principles that in practical terms mean that areas of the city that pay a higher water tariff receive water 24/7, whereas areas of the city that pay a lower tariff receive water only for limited hours per day or certain days of the week.<sup>6</sup> Nonetheless, the latter are still better off than the ten percent of Lima residents who are not connected to the system at all and who must obtain water from other sources. Further, stakeholders and policymakers questioned the unjustified sequence in which areas of the city recovered the water service during El Niño Costero, and thus criticized the management principles that seemed to be reinforcing the systemic inequalities of water provision.

Moreover, residents showed to have very little knowledge about the governance of their water. Interviewees repeatedly expressed their realization, during El Niño Costero, that residents in other parts of the city had daily water limitations or that they were surprised that residents in established or wealthier areas were also affected by the lack of water. This points to an overall limited knowledge about Lima's water management's rules and procedures, which is nurtured by weak public communication and discussion about Lima's current and future water situation considering climate change. Thus, the water governance institutions structured residents' perceptions of water and related risks, such that different population groups had different views based on their perception of access and distribution of water in the city, and their own vulnerability to climate risks.

Nevertheless, while access to a secure water source was shown to be critical, interviews with residents revealed that individuals' objective and perceived vulnerability was also moderated by the water infrastructure they had set up in their homes. Individuals who had a water tank in their households had access to water for a longer time (between 1 and 3 days longer) than households who did not. As a woman interviewed from the San Martín de Porres district mentioned: "Honestly, in my house, built of concrete, we weren't very affected because we have a water tank (...) So uh, let's say we didn't have a lot of difficulties. But I actually saw my neighbors [struggling], right? We gave them water; but we also saw a sea of people looking for water." Individuals equipped with water wells likewise had an alternative water source in times of water shortages. Respondents with water wells were mostly located in the eastern districts of the city, an area dominated by agricultural spaces within the metropolis and with ongoing establishment of new informal settlements. As stakeholders highlighted, it has taken the water utility up to 20 years to set up public water services for new dwellers, and even then water shortages are recurrent. Hence, many residents have taken the initiative to install water tanks or construct water

<sup>5</sup> According to PAHO (2017), there were 87 cases in the Lima region as a consequence of El Niño Costero.

<sup>6</sup> Sedapal has since changed its water tariff structure.

dwells on their own accord as a way to ensure water availability. However, residents under conditions of tenure insecurity, alongside low incomes, reported being unable to afford water tanks and to instead use large barrels for storing water on a regular basis. While this practice also allowed them to save water during El Niño Costero, it could not do much to abate the feeling of powerlessness among this group of the population during the extreme events.

The location of households—be it with regard to neighborhood or elevation (low- or high-terrain area)—is likewise a key moderating factor in how Lima's residents are affected by water shortages and mudslides (see Table 2). Water pressure is weaker in the upper hills when public water reservoirs haven't been installed and where many of the low-income families that recently migrated to Lima have settled. Moreover, citywide, respondents reported that households occupying the lower levels of buildings have stronger and steadier water provision than those in the higher levels. These differences were accentuated during the climatic events. Regarding mudslides, households' proximity to rivers or streams is likewise a critical factor, insofar as it exposes them to destruction and flooding. Even though current policies set rules and incentives to evacuate at-risk homes, interviews with residents suggested that individuals' decisions to remain in at-risk areas are explained primarily by their affective and economic investment in their properties. Interviews with stakeholders further supported this finding, as they pointed out past programs to relocate residents. Residents in households at risk reported feeling unsettled about the prospect of relocating to proposed alternative areas, as those locations tended to be more difficult to access or to lack public services, which would exacerbate their conditions of marginality. At the same time, these individuals showed confidence in the capability of the new built infrastructure to effectively channel mudslides over the long term.

## 5.2. Coping mechanisms in dealing with climate risks

Residents reported perceiving that Lima was completely running out of water during El Niño Costero, which generated a shared feeling of distress across the city. Given Lima's widespread previous experiences<sup>7</sup> with brief or lengthy water limitations, residents already had a know-how in reconfiguring their water-use practices when hit by El Niño Costero. These coping mechanisms, implemented at both the household and the individual level, were influenced by larger societal coping dynamics regulated by governance and social institutions. Individuals' responses, from coping to adapting, differ across age, gender, location, and socioeconomic status (see Table 2).

Residents took actions that affected all members of the household. These actions included preventive measures (e.g., storing water after having been informed by the authorities of imminent water shortages or protecting the house with cement bags) or behavioral changes (e.g., use of disposable dishes to avoid the use of water). Interviews with residents revealed that individuals relied mostly on ties with family and work relations (bonding and bridging ties) to implement these actions, and less on those with neighbors. Indeed, the population had hardly been socially organized prior to the climatic events and lacked the built trust for working together. As a resident from the Barranco district stated "Mostly [neighborhood] organizations are in informal settlements; but in [more advanced] towns like us, there aren't associations; everyone lives on their own and that's all." These weak social ties thus acted as a barrier for neighbors to take locally coordinated coping measures, and even contributed to the emergence of conflicts between neighbors seeking to secure water for their households. However, residents from areas that had been developed only recently, or that were still in the process of developing, reported having stronger ties with their neighbors, mainly because they continued working together to obtain land recognitions and public services.

Interviews with residents demonstrated that social ties further moderated people's previous experiences with extreme events in the city. At the individual level, interviews in the Chosica district showed that residents who had already experienced mudslides and flooding were prepared to take individual coping actions (e.g., move furniture to the second floor) but also relied on neighbors' contingency plans (e.g., mudslide alert system) in contrast to the population that hadn't had previous experiences with extreme climatic events. Yet, unexperienced residents in the Punta Hermosa district, who didn't have emergency plans, proved capable of rapidly organizing themselves to protect the most vulnerable (e.g., securing children in school buildings and providing living resources for over a month), which can be attributed to the strong social ties in this particular neighborhood. Interviews with stakeholders in Chosica and Punta Hermosa districts further supported these findings as they recalled the prominence of social ties in responding to the extreme events. Thus, while previous experiences positively influence residents in ensuring emergency plans, social cohesion is able to compensate for a lack of experience and facilitate coping mechanisms between neighbors.

We also found that residents' coping strategies at both the household and individual level were structured by gender roles prevalent in Lima. The woman's role in the household was key in the process of organizing alternative water practices, with families relying heavily on women as household protectors. However, women in traditional male-led households reported that their decision-making power was limited because men would take the final monetary or infrastructural decisions. At the individual level, women's reported coping actions were focused on changing their own behavior to reduce water consumption by decreasing their personal water intake, altering their diet, changing personal cleaning practices, recycling water, and using water available in locations outside of their homes (e.g., gym). In contrast, most men stated that rather than changing their behavior to reduce their water consumption, they sought alternative water sources elsewhere in ways that tended to require economic resources and physical strength (e.g., fetching water outside of the city). The actions of men complied with their roles as providers of their families. Interestingly, the gendered differences in coping actions between men and women were less pronounced among the youth (aged between 18 and 25), who did not report much difficulty in changing their water consumption habits and who saw themselves as being "adaptable" to water restrictions for a limited

<sup>7</sup> Most adults in Lima have experienced water scarcity in their day-to-day life, either by migrating to an area of Lima without water connections, by recurrent water shortages during the 1980s and 90s internal conflict, or by the common daily water restrictions in a number of districts.

**Table 2**  
Key differences across age, gender, location, and socioeconomic status.

	Age, Gender, Location, & Socioeconomic Differences
A. Socio-urban setting	<p>A. <i>Location</i>:</p> <ol style="list-style-type: none"> <li>1. Pronounced physical impacts on riverbank communities.</li> <li>2. Everyday uneven distribution of water between city neighborhoods influences perceived vulnerability and sensibility to climatic events.</li> <li>3. Differences in public and private water infrastructure condition sensibility to climatic events.</li> <li>4. Residences elevation moderates physical impacts.</li> </ol>
B. Coping mechanisms in dealing with climate risks	<p>A. <i>Location</i>:</p> <ol style="list-style-type: none"> <li>1. Stronger social ties in recent urban developments leading individuals to coordinate coping strategies with their communities.</li> <li>2. Individuals' previous experience enables fast coping actions, while social cohesion moderates lack of previous experience in areas with weaker social ties with extreme events.</li> </ol> <p>B. <i>Gender</i>:</p> <ol style="list-style-type: none"> <li>1. During crises, women tend to decrease their water intake and reduce water use, men seek alternative water sources.</li> <li>2. The above gender-based differences were less pronounced among the youth.</li> </ol>
C. Interactions between coping mechanisms and adapting to climate change	<p>A. <i>Gender</i>:</p> <ol style="list-style-type: none"> <li>1. Women predominantly continue coping actions in reducing water consumption after the water shortage was over, up until one year later.</li> </ol>
D. Socio-psychological processes leading to individuals' (non)adaptive strategies	<p>A. <i>Age</i>:</p> <ol style="list-style-type: none"> <li>1. Adults believed that they were less likely to experience a negative impact than the elderly or children.</li> <li>2. Senior adults and elderly more often linked their perceptions of low controllability over climatic events with their religious beliefs.</li> </ol> <p>B. <i>Socioeconomic status</i>:</p> <ol style="list-style-type: none"> <li>1. Individuals with higher socioeconomic status perceived themselves as less vulnerable and believe that their current resources could ease future climatic impacts.</li> </ol>

number of days. This adaptability occurred in spite of the youth having limited access to water, as educational institutions, who offer a source of water, were closed during times of water shortage.

### 5.3. Interactions between coping mechanisms and adapting to climate change

Interviews with residents, stakeholders, and policymakers suggested that coping with El Niño Costero led to an increased understanding of the value of water and the associated risks of water insecurity, and that the social coping dynamics have structured emergent social norms about water-use practices. However, coping actions and dynamics have also strongly privileged the status quo, narrowing the overall scope of individuals' capacity to adapt to climate change.

The majority of residents interviewed reported that due to El Niño Costero, they had a new or greater appreciation of water resources for their daily life and for Lima as a whole. As a resident from Comas acknowledged, "We realized that there is need for water; without water you can't do anything. At least without electricity we can light a candle, right? But without water you can't do anything, right?" In addition, residents frequently reflected on their overall dependence on nature for their wellbeing and the damage done by society to the environment. These new considerations shed light on the underlying disconnection between urban lifestyles and the daily reliance on ecosystem services in the city. Dwellers are detached from the process of collection and distribution of water, and in many cases individuals even displayed lack of knowledge about Lima's water sources. The climatic events have thus served to close this gap, making residents more aware of water's value and the possible risks to water security of Lima.

Interviews showed that individual coping actions in reducing water consumption were often incorporated (predominantly by

women, 79%) into their daily life after the water shortage was over, up until one year later.<sup>8</sup> The continuation of water-saving practices was enhanced by emergent social norms on preserving water. Several interviewees recognized that they themselves, or people they knew, had outspokenly criticized the misuse of water of others, not only within their own inner social circle but also with strangers in the city. Despite the emerging social norms around water, half of the interviewees who reported adjusting their water consumption behaviors only did so for several weeks to a month, reporting difficulties in changing their own habits, with the discomfort this meant for their daily life, or the perceived lack of need to continue saving water once water availability is back to normal. In addition, many individuals who considered themselves as having attained a certain level of efficiency in using water (in comparison with “others”) no longer saw the need to pursue further improvements over the medium or long term.

In the same way, residents who reported having enough water in their household water tanks during El Niño Costero<sup>9</sup> mentioned that they did not feel vulnerable regarding the prospect of water shortages occurring in the near future, and thus lacked incentives to incorporate long-term water-sustainable practices. Therefore, while the tanks were an effective means to cope, they also transferred costs in time and led residents to misconstrue their future ability to deal with dangerous climate change risks to their water security. In addition, interviews revealed that those individuals who had coped by decreasing their personal water intake were also more cognizant of the fact that the absence of drinking water, or not using water for an extended period of time, would lead to hygiene and health issues. Interviews also revealed that coping actions transferred costs in space as residents had searched for water in the city surroundings, but that they could not maintain this practice on a daily basis due to time and cost constraints over the long term.

#### 5.4. Socio-psychological processes leading to individuals’ (non)adaptive strategies

One year after El Niño Costero, Lima residents had developed distinct strategies for dealing with climate change, which are structured by five socio-psychological processes. These processes entail the conjunction of social norms and rules with individual-level cognitive and affective mechanisms for dealing with climate change. Hence, in a city heading towards a population of 10 million people, we observe that these processes vary according to personal characteristics and backgrounds (see [Tables 2 & 3](#)).

First, interviews revealed that most residents are aware of climate change, yet mostly understand it as a global process with impacts at the global and national levels (i.e., threats to polar bears or melting glaciers). Most interviewees thought that climate change may affect ENSO, often recalling the intensity of El Niño Costero of the year before. Interestingly, however, interviews showed that residents hardly made the association that climate change will have a direct impact on their own city, Lima. This disassociation may be explained by the interviewees’ lack of knowledge about Lima’s water sources as well as by a cognitive dissonance they were experiencing by having knowledge of climate change risks while nonetheless believing that nature is inherently unpredictable and hence “natural events” are unmanageable. As one interviewee said, “For example, the frequent rain or thunders that happened in Lima, we aren’t used to it. So we can’t be prepared in the face of nature, because it’s unknown what nature has laid out for us. And I believe that neither scientists nor Senamhi<sup>10</sup> can [deal] with nature. (...) Climate change can worsen El Niño for us; we’re polluting the environment (...)” Residents’ inconsistent beliefs about climate change and nature lead them to channel their attention and efforts to taking environment-friendly actions and conservation initiatives tackling the global threat to nature, which is at the same time incentivized by the climate change governance in Lima. QDA and interviews with policymakers indicated that current policies and projects in Lima feature mitigation strategies more so than adaptation ones, which, while contributing to reducing GHG emissions, will not directly reduce residents’ vulnerability. At the same time, interviews with policymakers revealed their personal beliefs and expectations about residents’ behavior. Policymakers repeatedly mentioned that residents ought to ‘behave well’ in socio-environmental terms, supporting the global fight against climate change. In turn, they deemed themselves responsible to raise individuals’ awareness about current global environmental challenges, but little was mentioned about communicating local risks.

Second, interviews with residents indicate that since El Niño Costero, many residents have an increased recognition that the city is vulnerable to climatic extreme events. Residents interviewed perceive that Lima is not prepared for climatic changes, be they changes in temperature or rainfall, including the impacts thereof on water availability and public and private infrastructure. In addition, they are not convinced that the three levels of government in the urban space are dealing with climate risks or even planning on doing so, which is mediated by widespread mistrust in authorities, enhanced by current corruption cases. Yet, despite residents’ recognition of the city’s vulnerability, they do not feel directly vulnerable to climatic events. Interviewees believed that they were less likely to experience a negative impact than others. Individuals’ perceived personal impacts were generally framed in comparison to more disadvantaged people (e.g., people who lost their house), vulnerable groups (e.g., children, elderly), or higher-risk areas (e.g., cities in the north of Peru). At the same time, individuals minimize their possible exposure to such events (e.g., mudslide will not affect my house by the riverbank) and trust that their current resources could ease impacts (e.g., if I have a job, I will have the financial resources). These framings demonstrate residents’ widespread optimism bias regarding the sensitivity and exposure to climate change. Therefore, residents’ increased risk perception of Lima’s vulnerability has not translated into an increased sense of personal vulnerability or an increased preparedness or adaptive actions for dealing with the impacts at the individual level; instead, it entails a *laissez-faire* strategy in terms of adapting to climate change.

Third, while the above cognitive mechanisms for dealing with climate change were recurrent, some respondents (authorities, stakeholders, and residents) did show concern about the threats that climate change poses to Lima and the need to act. In these cases,

<sup>8</sup> Interviews were taken one year later after El Niño Costero.

<sup>9</sup> This is a subset of the group of residents who had water infrastructure in their homes.

<sup>10</sup> Senamhi is the National Meteorology and Hydrology Service of Peru.



**Table 3**  
Examples of socio-psychological processes leading to (non)adaptive strategies.

Cognitive & affective processes		Institutions			Individuals' strategies for dealing with climate change
Type	Descriptors	Cultural-cognitive level	Normative level	Regulatory level	
Cognitive dissonance	<ol style="list-style-type: none"> <li>1. Anthropogenic climate change is happening</li> <li>2. Climate change may affect ENSO</li> <li>3. Climate change is melting glaciers</li> <li>4. Nature is unpredictable</li> <li>5. Lima is not threatened by climate change</li> </ol>	<ol style="list-style-type: none"> <li>1. Limitations on acquiring knowledge about nature</li> </ol>	<ol style="list-style-type: none"> <li>1. Social expectations on contributing to socio-ecological wellbeing</li> </ol>	<ol style="list-style-type: none"> <li>1. National climate change mitigation policies.</li> <li>2. Municipal incentives for sustainable household practices</li> </ol>	Environment-friendly strategy: recycle
Optimism bias	<ol style="list-style-type: none"> <li>1. Lima is vulnerable to climate change</li> <li>2. But I'm less likely to be exposed to disasters</li> <li>3. I'm not vulnerable to climate change</li> </ol>	<ol style="list-style-type: none"> <li>1. Peruvians having ancestral knowledge in dealing with El Niño</li> <li>2. Economic resources allow individuals to thrive through difficult times</li> </ol>	<ol style="list-style-type: none"> <li>1. It is fair and just that people who are more disadvantaged get support</li> <li>2. Lack of governmental practices</li> <li>3. Distrust of authorities</li> </ol>	<ol style="list-style-type: none"> <li>1. National and city regulations forbid settling in risk-prone areas</li> </ol>	Laissez-faire strategy: continue living close to river banks
Faith-in-technology bias	<ol style="list-style-type: none"> <li>1. Lima is vulnerable to climate change</li> <li>2. I'm concerned about climatic threats to my personal wellbeing</li> <li>3. Technological innovations can decrease my vulnerability</li> </ol>	<ol style="list-style-type: none"> <li>1. Technology is very advanced to protect urban residents</li> <li>2. Urban development requires investment in water infrastructure</li> <li>3. Individual construal of self as independent</li> </ol>	<ol style="list-style-type: none"> <li>1. Increasing the water supply for Lima is good</li> <li>2. Men in households should secure and provide resources</li> </ol>	<ol style="list-style-type: none"> <li>1. Incentives for sustainable buildings, such as water-smart technologies</li> </ol>	Technological strategy: invest in household water infrastructure
Low perceived controllability	<ol style="list-style-type: none"> <li>1. Nature cannot be managed, nor can climate change</li> <li>2. My response actions will not be sufficient to increase my own resilience</li> </ol>	<ol style="list-style-type: none"> <li>1. Belonging to religious group and associated faith in god's will</li> <li>2. Limitations on acquiring knowledge about nature</li> </ol>	<ol style="list-style-type: none"> <li>1. Citizen's role in society is to behave well</li> <li>2. God's role is to protect humans and manage nature</li> </ol>		Moral strategy: pray more
Authoritative bias	<ol style="list-style-type: none"> <li>1. Authorities have the skills and technical knowledge to adapt to climate change</li> <li>2. Authorities are less likely to make mistakes</li> </ol>	<ol style="list-style-type: none"> <li>1. Individual construal of self as interdependent</li> </ol>	<ol style="list-style-type: none"> <li>1. Authorities have a parental role in taking care of citizens</li> <li>2. The citizen's role is to abide by guidelines set by authorities during crises</li> <li>3. Absent governmental practices</li> </ol>	<ol style="list-style-type: none"> <li>1. Hierarchical governance arrangements.</li> <li>2. Lack of regulatory norms or incentives to adapt at the individual level</li> </ol>	Coping strategy: In the face of lack of support during crises, reduce personal water intake

respondents vocalized strong interest in technological strategies that facilitate sustaining the water supply for Lima and that help protect communities from the environmental hazards. At the city level, in the water sector, authorities are keen on investing to expand the water sources that provide water to Lima, through water transfers from further water basins (e.g., Cañete River) and salinization plants in areas without reliable water supply (i.e., currently under construction in the Santa Maria del Mar district). Policymakers have worked on measures to increase the water offer, though demand-side measures to reduce water consumption have yet to be considered. At the individual level, residents had or were in the process of installing water tanks in their homes, to increase resistance to droughts, as well as water-efficient fixtures (e.g., toilets, faucets). Similarly, in dealing with mudslides and flash floods, local authorities facilitated the installation of debris flow barriers (*mallas*) in the steep valleys above population centers of the Chosica-Lurigancho district. The installation of the *mallas* followed the failed attempt to relocate residents located in a zone declared as being of immitigable risk (Mechler, 2017). Interviewees in this district supported the installation of more *mallas* as they were successful in protecting the area during the 2017 flashfloods. During the interviews, residents reported feeling content and safe thanks to the *mallas*. This sense of security may lead to further settlement in this area, which would put the population at risk in the long term.

Fourth, yet a further set of residents interviewed showed a low external locus of control regarding climate change and related events (i.e., ENSO). The low controllability in the climate threats is transferred to a low efficacy in reducing their own vulnerability and/or adapting to new conditions (i.e., their self-adaptive capacity). Overall, this sentiment exacerbates a feeling of despair among individuals in dealing with “natural events.” Several of the interviewees, mostly senior adults and elderly, also linked their perceptions of low controllability of climatic events to their religious beliefs, such that only god could reduce the risk or impacts. For example, one resident from Chosica said, “But what can be done with nature? No one can take responsibility for that. We must request God to prevent anything worse from happening to us. We need to behave well with him so that he won’t hassle us.” Based on these beliefs, adaptation strategies are best delegated to a higher force who is trusted to take care of people and prevent climatic threats from happening. In that sense, respondents say that there is a need to pray more often, to appease god, or to call on Limeños to improve their daily behavior so that god will stop punishing them with climatic hazards. Similarly, some residents in the Cieneguilla district, in keeping with ancestral beliefs and traditions, put offerings in the river banks with the hope that this will calm the forces of nature in the coming seasons.

Fifth, residents were asked to ponder on the governmental and individual responsibilities in adapting to climate change. Beliefs about governmental responsibility, in conjunctions with the perceived impacts, mediate current adaptive strategies. While some residents think that the authorities should bear greater responsibility in the adaptation process, others think it is a shared responsibility. In the former case, residents associate the authorities’ responsibility with the notion of a paternal state that takes care of citizens. In the latter case, residents advocate that society should take action, collectively, considering the limits of governmental support. In both cases, residents expect their authorities to provide them with the relevant information before making adaptive decisions. When these expectations were not met, they reported feeling the need to act on their own, to compensate, which usually resulted in coping strategies. Such strategies appeared to hinge more strongly on residents’ economic capacity (e.g., to acquire materials necessary for coping) rather than on adapting their behaviors (e.g., changing daily water habits), which would be more beneficial in the long term for the city as a whole.

## 6. Discussion

The extreme climatic events that affected Lima in 2016–2017 have led to an increased recognition that Lima is vulnerable to climate change. The overwhelming perception that Lima is not prepared for climatic changes, with variation in either temperature and/or rainfall, or the impacts thereof on water availability and public and private infrastructure has opened the political agenda for climate change adaptation, and has encouraged residents to consider their water security prospects in light of the threat. With our case study, we have examined urban dwellers’ adaptive capacity in Lima using an unusual ENSO event as a temporal analogue. Our methodological approach allowed us to examine individual responses to abrupt climatic events affecting water security, and to understand dwellers’ adaptive strategies in light of further climate change uncertainties for their city. This approach was useful to unveil the different socio-urban conditions between neighborhoods in a large metropolitan area, and thus highlights the importance of understanding adaptive capacity in relation to city-wide and neighborhood-specific dynamics. Further, our study responds to the lack of clarity on whether people who take coping actions to decrease their vulnerability to current climate variability are also developing their capacity to adapt to climate change (Schaer 2015). For this, we advanced a conceptual approach to understanding adaptive capacity as a process that looked at both the behavioral and the institutional factors shaping adaptive capacity in the urban milieu. Following this approach, the qualitative methods used allowed us to investigate in-depth the adaptation process in Lima. This conceptual approach can be used to analyze other urban areas across low- and middle-income countries, considering that the socio-psychological processes that emerge in the analysis constitute deeper-level factors that are contextually and culturally relevant.

Current attempts to understand the process of urban adaptation have mostly focused on adaptation governance, looking at planning and policy implementation, often overlooking dwellers’ interests, experiences, and beliefs. It is frequently assumed that residents form a homogenous group (Brink and Wamsler 2019) that will positively respond to adaptation plans. In Lima, we observed that authorities share the belief that residents need to “behave better” and that they trust that focusing their policy efforts on raising awareness about environmental problems will incentivize people to act more sustainably. Two main problems arise from not considering individual-level characteristics and associated dynamics in urban adaptation. First, studies show that increased awareness about climate change alone will not increase adaptive behavior, given the mental and affective mechanisms that mediate adaptation (Clayton et al. 2015; Gifford et al. 2011); and in many cases the targeted behavioral change goes counter to cultural and personal beliefs and values (Hulme 2009; Jooste et al. 2018; O’Brien and Wolf 2010). In our study, we have shown the importance of socio-psychological processes as part of the process of adaptation. Even though most Lima residents have knowledge about climate change and have

experienced first-hand impacts of the climatic events in 2017, individual perceptions and cognitions, together with the social institutions found in Lima, delineate existing adaptive strategies. We find that cognitive dissonance, optimism bias, technological paradigms, locus of control, and authoritative beliefs shape Lima residents' adaptive strategies. These psychological processes are influenced by: gender roles, social ties, religious norms, urban lifestyles and a related disconnection from nature, paternalism, absent government practices, and hierarchical and collaborative ideals of governance. These social institutions structure individuals' interactions with their families, neighbors, coworkers, and strangers, which manifests in individuals expecting certain coping responses and adaptive strategies from these actors in the urban milieu, and in adjusting their own behavior to the expectations (i.e., social cognition). One year after El Niño Costero, we observed that residents support and/or take on strategies for dealing (or not) with climate change in line with coping, sustainability, morality, technology, and laissez-faire approaches. Based on the distinct socio-psychological processes leading to these strategies, adaptation governance needs to consider individuals as the complex human beings they are by designing policies and measures that appropriately incentivize adaptive behavior.

The second problem, stemming from a lack of attention to individual-level factors, is the assumption that residents are a homogenous group when designing adaptation policies, which disguises systemic inequalities. We have challenged this misconception by looking into the diversity of experiences and beliefs that shape how each individual understands and deals with climate change threats throughout Lima. Our findings portray residents' diversity in terms of the settings in which they find themselves (e.g., availability of water infrastructure) and of the social interactions that moderate their coping actions (e.g., intrahousehold dynamics), both of which influence the adapting scope (e.g., water valuation). A main consideration that follows our results is that current inequality in water access and distribution, as well as the unequal support of local governments in responding to climatic threats, directly undermine residents' capacity of coping with climate change impacts on their water security. Currently, the experience of daily water use differs greatly within the city, and will gradually get worse with the increasing climate change impacts. With El Niño Costero, residents had to overcome the impacts on their water security, as it affected most residents' finances and daily routines while also giving rise to numerous physical and mental health issues. While acute physical health issues were limited to those directly affected, mental health issues prevailed across Lima, albeit more so by those who already felt too disempowered to change their living conditions, given their marginality. However, mental health impacts have received little attention in climate change literature (Cunsolo and Ellis 2018; Fritze et al. 2008; Gifford and Gifford 2016) and more research is needed to understand how the degree of distress related to systemic inequalities alters coping actions and overall adaptive behavior in urban areas. This is important as urban adaptation plans often fail to incorporate poverty and other social systemic exclusions established in cities, which can contribute to greater inequalities (Dodman et al. 2019). Thus, considering the contextual factors that shape individuals' adaptive capacity in the city would help policymakers to better respond to specific group needs in urban areas.

Finally, we conclude that studying the relationship between residents and authorities is fundamental. Authorities establish policies that structure the adaptation scope of residents. And residents' actions affect not only their personal safety but also overall public adaptation (Brink and Wamsler 2018; Wamsler and Brink 2014). As we've seen in Lima, authorities' enthusiasm for technological measures to solve Lima's current water stress situation seems to obstruct considerations about incentivizing demand-side measures to reduce residential water consumption for the long term. This is not to say that the adaptation responsibilities should burden residents, but that a comprehensive outlook should be cultivated on the possibilities of reducing the impacts of climate change and on fostering adaptive behavior of individuals, one that builds urban social resilience on a broader scale. Lima residents have now experienced and coped with a period of water insecurity in their daily lives, have gained new knowledge about climate extremes, and are expecting—to varying degrees—their authorities to step up to the challenge in an environment of mistrust. The current processes of individualization and disintegration of social organizations found in Lima is likely to undermine adaptive capacity (Cinner et al. 2018), and mere exposure to climate change cannot be expected to suffice to foster adaptive behavior (Ray et al. 2017; Zografos et al. 2016). Under this scenario, our study has shown the existence of several strategies used by residents to deal with climate change, some of which are adaptive and others not. Thus, it would be very valuable to analyze the socio-economic and governance determinants of adaptive capacity of residents across Lima neighborhoods.

## 7. Conclusion

This research has integrated new institutionalism and environmental behavior to study urban dwellers' agency in adapting to climate change within the normative structures of their socio-urban milieus. This approach is used to examine the Lima dwellers' responses to the extreme events brought by the 2017 El Niño Costero, which is used as a temporal analogue. We identified the socio-psychological processes leading to coping, sustainability, morality, technology, and laissez-faire strategies for dealing with climate change. These five strategies were found to be the result of the interrelation of residents' cognitive processes (i.e., cognitive dissonance, optimism bias, technological paradigms, locus of control, authoritative bias) with evolving social norms (i.e., gender roles, social ties, religious norms, urban lifestyles and a related disconnection from nature, paternalism, absent government practices). The findings contribute to understanding why, even in situations with widespread climate change awareness and previous experience with extreme events, individuals do not adopt adaptive practices, a key concern of the climate change community. This paper lays the groundwork for future studies exploring and comparing culturally based socio-psychological adaptation. Examining individual-level factors is further needed to inform the development of adaptation policies such that these consider the diversity of urbanites' conditions and effectively incentivize personal and societal resilience.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgments

We sincerely appreciate the support of key informants and residents from Lima. Further, we acknowledge the feedback from Oliver Coomes (McGill University). This work was funded by the International Development Research Centre (IDRC) [108544-030, 2017], Fonds de Recherche du Québec - Société et Culture (FRQSC) [B2Z-258163, 2018], and the Social Sciences and Humanities Research Council of Canada.

## Appendix A. Semi-structured interviews – Stakeholders

### Interview Guideline

1. Has your organization been working on climate change adaptation? What is the role of the organization in Peru? And Lima?
2. From your perspective, what are the major climate threats to Lima? How is this been dealt with?
3. How was the experience in Lima with the last climatic events (2016/2017)? Was the city prepared? Were there differences among the districts? Why?
4. In your opinion, was the city under water insecurity during this period? If yes, where in the city?
5. What were the main coping strategies to deal with the impacts? Are there adaptation strategies to deal with the impacts in the future?
6. Do the strategies consider how urban residents can adapt to climate extreme events? How?
7. If not, do you think it would be necessary? What could be done? How could your organization support it?

## Appendix B. Semi-structured interviews – Residents

### Interview Guideline

1. How long have you lived in Lima? Were you in Lima during the last 12 months?
2. Do you have access to water in your household? What is your experience with the water service?
3. Do you remember any issue with your water during the last 12 months? What happened?
4. Were you or your family affected by El Nino 2017? What was your experience? Had this happened here before? Do you think it will happen again?
5. How did you overcome the challenges/impacts of El Nino 2017? What specific measures did you take?
6. Did you receive assistance? From whom?
7. How do you prepare for periods of droughts and/or floods?
8. What you think are your possibilities to deal with the next climatic events?
9. Do you think climate change may affect El Nino? And the droughts?

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