CDMX Resilient Code: *Water Commons* in Mexico City

CDMX Código Resiliente: *Aqua-Commons* en Ciudad de Méjico

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Abstract

Using Mexico City (CDMX) as a paradigmatic example of seriously unbalanced water regimes, our project Resilient Code helps strengthen and communicate CDMX's government implementation efforts toward risk reduction and water resilience in marginal communities. Our project does so by bridging otherwise separate agents in the government towards a common goal: equitable resilience. Resilient Code provides design solutions that link the social infrastructure of PILARES (a network of 300 vocational schools distributed throughout the city) to CDMX's environmental and risk reduction initiatives, to promote water commoning among citizens. This strategic program of soft-bottom up infrastructural solutions began with "water resilience" as a Pilot to enhance public space throughout underserved barrios as a network of "water-commons. ¨ Resilient Code is designed to implement such solutions and reduce environmental risks by complementing socio-economic programs, and to foster the "water-commons" network as result. Resilient Code is socialized through an action driven participatory game-based workshop, and through an online Atlas of Risk Reduction.

Keywords

Soft-Bottom-Up Infrastructure, Water Commons, Equitable, Hydro-Social Risk Reduction, Resilient Code.

Resumen

Tomando la Ciudad de Méjico (CDMX) como un ejemplo paradigmático de regímenes hídricos en serio desequilibrio, nuestro proyecto Código Resiliente ayuda a reforzar y comunicar los esfuerzos del gobierno de la CDMX hacia la reducción de riesgos y la resiliencia hídrica en las comunidades marginales. Nuestro proyecto lo hace enlazando agencias separadas del gobierno hacia un objetivo común: la resiliencia equitativa. Código Resiliente brinda soluciones que vinculan la infraestructura social de PILARES (una red de 300 escuelas vocacionales distribuidas por toda la ciudad) con las iniciativas ambientales y de reducción de riesgos de la CDMX, para promover recursos comunes de agua entre sus ciudadanos. Este programa estratégico de soluciones de infraestructura participativa y blanda comenzó con la "resiliencia hídrica" como piloto para mejorar el espacio público como red de "aqua-commons" en barrios marginales. Código Resiliente se diseña para implementar dichas soluciones, reducir los riesgos ambientales complementando programas socioeconómicos y fomentar el la red de "aqua-commons"como resultado. Código Resiliente se socializa a través de un taller de acción participativa basado en juegos y a través de un Atlas de Reducción de Riesgos en línea.

Palabras clave

Infraestructura Blanda Participativa, Aqua-Commons, Resiliencia Equitativa, Reducción de Riesgo Hidro-social, Código Resiliente.

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Prior to 2008, Lorena worked in Barcelona as project director at Aldayjover where she led projects at different scales including those within the Water Park 2008 international exhibit in Zaragoza. She was also research assistant at the Joan Miró Foundation and the Building Tech Institute of Catalonia (ITEC). Lorena holds a B.Arch in Architecture with honors from the Polytechnic University of Catalonia, UPC (B.Arch´05), a Masters of Architecture in Urban Design from the Harvard Graduate School of Design, GSD (MAUD´11), and a European PhD in Urbanism from UPC (PhD´15)..

Objectives: Infrastructure as Reading Framework

Architects and urbanists have found infrastructure useful as a framework to read, design and adapt urbanized territories. One framework for reading infrastructure is through its use as a parameter determining different levels of urbanization and equity. For instance, *infrastructural obsolescence* is a recurrent scene in postindustrial shrinking cities in the global north. Abandonment, rust and pollution abound here in the form of ruins, soils and water with high levels of heavy metals that require long and costly cleanup to be repurposed.[1] Flint in the US, Duisburg in Germany or Tangshan in China show very different approaches to this process. On the other hand, in today's global south megalopolis, *water infrastructure* is absent or controlled by mafias in these cities' rurban, informally urbanized areas. We discover this in places such as Mexico City, Mumbai, or Cape Town. Unmanaged water there becomes a risk vector exacerbated by climate change, causing landslides, subsidence, floods, extended droughts, or infection diseases for newly landed citizens who do not own the soil they inhabit.[2] Another contrast is presented by *cutting-edge infrastructure*, the driver that rich social-democracies in the global north use to adapt to our present health/climate condition such as COVID-19 early testing or flood mitigation programs. Tokyo in Japan, Boston in the US or Amsterdam in the Netherlands are good examples. In these cities, the hydrological cycle is efficiently managed to enhance city life with water while reducing the risks caused by it.[3] Even in this quick read, water infrastructure allows us to project a concerned x-ray of our inequitable, risky and unpredictable present territories, not only between north and south, but also within each locale.[4] It also speaks for the absence of designed *circular processes* that change our culture and relationship to water, while achieving a most needed socio-hydrological equilibrium.

In this paper, we describe a recent project conducted in partnership between the City of Mexico and a team of MIT graduate students. Our project was conceived through the concept of *water commons,* described later in this paper. We sought to realize water resilient communities through innovative design practices and procedures centered in a low-income Mexico City neighborhood, Iztapalapa. This neighborhood is characterized by extreme income and environmental inequality, as well as insecurity. Our projection of water commons was designed to mitigate this inequality through the development of water retention and absorption systems that simultaneously engaged collective community capacity and development of collective public space, thereby promoting commons through water. Our project sought to recall historical practices of water commons through indigenous urban practices, practices that were ignored or suppressed in the colonial era but that remain effective means of achieving mitigation of flooding and accommodation of water scarcity. Our project approach is also designed as a response to rapid urban growth in the developing world and as a scalable, government-sponsored strategy for improving sustainability in tandem with community capacity.

Background: Infrastructure as Design Framework

When using infrastructure as a framework to design, the promise exists to use our cities as living laboratories not just focused on technologies, but on issues of consumption, behavior and lifestyles to become more responsive to our environment.[5] Design can be used to make these most needed new values visible. This seems more pertinent today than the use of costly infrastructures linked to 'smart', perhaps programmed-for-obsolescence, technology. That is to say, those infrastructures that are designed to become overshadowed by tomorrow's even more profiteering, 'smarter' devices. Instead, it is important to introduce other approaches that find *fitness* between our re-evaluated needs, technology, and our projective

1 Lindsey et al, ¨The Flint, Michigan, water crisis¨, in *Environmental Justice*, (August, 2016): 93-97.

2 R. Ahlers et al, "Informal space in the urban waterscape: Disaggregation and co-production of water services," in *Water Alternatives* 7(1): 1-14.

3 Saskia Naafs, *Amsterdam Rainproof: Every Drop Counts,* (Amsterdam: Waternet, 2014), https://www.rainproof.nl/sites/default/files/rainproof-magazine-engels.pdf (accessed May 21st, 2020).

4 Manuel de Solà-Morales, ¨Four paradigms of a course in the ethics of urbanism¨, in *The Territories of the Urbanist,* coords. Antonio Font, Miquel Corominas, Joaquín Sabaté, (Barcelona: Fundació Politècnica de Catalunya, 2005), 63-69. … *¨We must be able to recognize inequalities in the distribution of the territory itself and work to combat them, work around them, and work to learn from them¨.*

5 Y. Voytenko et al., ¨Urban living labs for sustainability and low carbon cities in Europe: Towards a research agenda¨, in *Journal of Cleaner Production*, (June 2016): 45-54.

imagination to design infrastructure that supports equitable and resilient territories. As Ian McHarg reminded us: "… *a fit environment is defined as that where the maximum needs of a user are provided by the environment as found, requiring the least work of adaptation. Successful evolution contains the least work solution. The achievement of evolutionary success reveals syntropic fitness and health of species and ecosystems. Excessive pathology and morbidity reveal entropic misfit –a system unable to find the fittest environment, unable to adapt it or itself."*[6] Infrastructure should be designed to enhance this fitness. In that direction, Serge Latouche's 8Rs approach to *degrowth* seems extremely useful as a design framework. We should learn to re-evaluate (reassess), re-conceptualize (reframe), re-structure, re-locate, re-distribute, re-duce, re-use, and/or re-cycle when designing. According to Latouche, this 8Rs are needed when developing a resilience of societies, that is, their ability to transform positively and without trauma.[7]

Towards this, we should enhance flexibility in our designs to accept change and transformation by re-circulating, re-purposing or re-using parts. We could recall, for instance, Ildefonso Cerdá's street network in Barcelona designed for horse carts, and its flexible adaptation to cars in the last century. We might also think of the pedestrian and cycling-friendly super-blocks vigorously used during the pandemic, or even their potential to become linear parks in a post-COVID scenario.[8] Another commonly known example is the Trevi Fountain in Rome and its water plaza network that celebrate and reveal water's arrival into the city. Katherine Rinne meticulously allows us to understand the intricacy of such a complex and invisible system, as well as its indispensable role in making metropolitan life possible.[9] Closer to home in Granada, Dede Fairchild Ruggles marvelously studies the *Acequia Real* irrigating the artful Alhambra gardens, but also the parallel cistern network such as the *Aljibe del Rey*, filled by the *Aynadaman Acequia* that provided common water in the Albaicín, still needing women as *water carriers* of freely provided water.[10] As public ways and collective artifacts, these examples tell of resilient networks that have lasted from centuries to millennia enhancing *urbs* and *ex-urbs* life. They find the right fit between available technology, design and imagination, providing *common* services through *collective* public spaces, as a right that comes with our citizenship.

To be sure, when well-designed, infrastructure moves beyond an engineered service to become a cultural platform for our collective use and well-being. Exemplary networks allow us to understand infrastructure as multipurpose public platforms affecting scales that move beyond its area of passage or location. In its systemic nature, infrastructure has the potential to reduce or enhance present vulnerabilities beyond its proximate context, as Manuel de Solá-Morales explains in his case for urban acupuncture.[11] This means that we can do more with less, but also affect many. Medellín (Colombia) presents a powerful example of this approach.[12] In our project for one of Medellín's marginal barrios, *Anticipating Infrastructure* (2015[13]), we learned that infrastructural insertions and participatory design reduce users' vulnerabilities to socio-economic risk and landslides. By including future users in decisions, implementation and governance of public space, we can also adjust the timeframe for completion within the existing political term limits. Political time is as important as budgets or community consensus! Elsewhere in Colombia, in our Cartagena project *Swampification* (2017[14]), we found that within equal socio-economic neighborhoods in the flood-risk prone region of the *Ciénaga de la Vírgen*, one could imagine public spaces instigating a new culture sensible to water, moving from fear to respect and maintenance, while reducing use, future invasions and violence. As with Barcelona, Rome or Granada, Latin American cities also make visible the fact that infrastructure, specially water provision and roads, have been used for centuries as mechanisms to allow, control, or constrain growth.

6 Ian L. McHarg, *Design with Nature*, 25th Anniversary ed. (New York: J. Wiley, 1992), 7.

7 Cinzia Figus, Serge Latouche. It is not enough to protect the environment. People must learn respect, Expo Milano 2015, (November), http://www.expo2015.org/magazine/en/culture/serge-latouche.-it-is-not-enough-to-protect-the-environment.html (accessed May 21st, 2020).

8 Arturo Soria I Puig, "Ildefonso Cerdá's General Theory of 'Urbanización'," *The Town Planning Review*, Vol. 66, No. 1 (Jan., 1995), 37.

Maria Rubert de Ventos, ¨La calle postcovid: la mitad de asfalto, el doble de árboles y más transporte público¨, *El Periodico*, May 25th 2020, opinión.

9 Rinne Katherine Wentworth, *The waters of Rome: aqueducts, fountains, and the birth of the baroque city*, (New Haven: Yale University Press, 2010).

10 Dede Fairchild Ruggles, *Water and Community in Islamic Granada,* (MIT AKPIA Fall Series Lecture, 2019).

11 Manuel de Solà-Morales, *A matter of things*, (Rotterdam: NAI, 2008), 24-25.

12 Alejandro Echeverri and Francesco M. Orsini. "Informalidad y urbanismo social en Medellín." *Sostenible?* 12 (2011): 11-24.

13 Lorena Bello Gómez and Jota Samper, *Providing infrastructure for informal settlements* in Medellin, Colombia. (MIT School of Architecture and Planning: Spring semester 2015).

14 Lorena Bello Gómez, ¨Swampification ¨ in *Swamps and the new imagination*. (Cambridge: MIT Press, 2020).

Motivation: Soft-Bottom-Up Infrastructure as Adaptation Framework

It is precisely its intrinsic relationship to growth that allows us to use *infrastructure as an adaptation device*. To keep transforming our urbanized territories, to become more resilient to change without trauma –as Latouche so well explains.[15] For that, depending on our geographies, we will need to adapt our cities to counterbalance more recurrent and polarized heat waves, droughts, and fires together with more floods, cyclones, and sea-level rise. This will affect population differently based on location and wealth, but both inequality and migrations are expected to increase due to climate crisis.[16] Many stellar projects exist that use infrastructure as an adaptation framework. The *Riverway* flood control design by Frederick Law Olmsted in Boston shows that design is a powerful agent in shaping infrastructure to diminish urbanization's environmental impacts. Anne Whiston Spirn explains that the *Riverway* became a linear park for its citizens allowing for the movement of people, cars, and the settling of many institutions along its sides, while managing the flow of the Muddy River. Just as important, this ambitious project was the result of a participatory process with public hearings together with public-private investors.[17]

Like Olmsted, we will need to shape infrastructure to respond to, and adapt towards, more equitable and circular urban processes. This would ask for a *re-conceptualization* strategy towards adaptation. For that, we could *re-evaluate* design projects to start counterweighing 'hard' top-down with 'soft' bottom-up infrastructures to *reduce* the gap between the polarized 1% and the other 99% in both our territories and society. As a *re-distribution* strategy we must embed equal access to services in our design as a way to deploy a most needed territorial equity, within persistent conflicts of environmental justice and ethics.[18] In other words, to reduce consumption by reusing and recirculating as much as possible! But we should also anticipate that risk-reduction and resilience ideologies could be used to displace and *re-locate* the already disempowered and that we could plan to protect them.[19] Therefore, *adaptation infrastructure* is not only green and grey, but the one that follows Latouche´s 8Rs!

Our hypothesis is that we can propose and design this 8R *soft-bottom-up infrastructure* in this most needed adaptation and that we will test it through geographical embeddedness, evaluation and refinement.

15 Serge Latouche, *A fairwell to growth,* (Cambridge, UK: Polity Press, 2009).

16 Bruno Latour, *Down to earth: politics in the new climatic regime*, (Cambridge, UK: John Wiley & Sons, 2018).

17 Anne W. Spirn, "Poetics," in *Nature, form, and meaning*, *Landscape Journal* (. *Special issue:*V7, i.2, 1988): ii. See also: Anne W. Spirn, "Constructing nature: The legacy of Frederick Law Olmsted," in *Uncommon ground. Rethinking the human place in nature* (New York: W. W. Norton, 1996), 102-110.

18 Manuel de Solà-Morales, *Four paradigms of a course in the ethics of urbanism,* (2005).

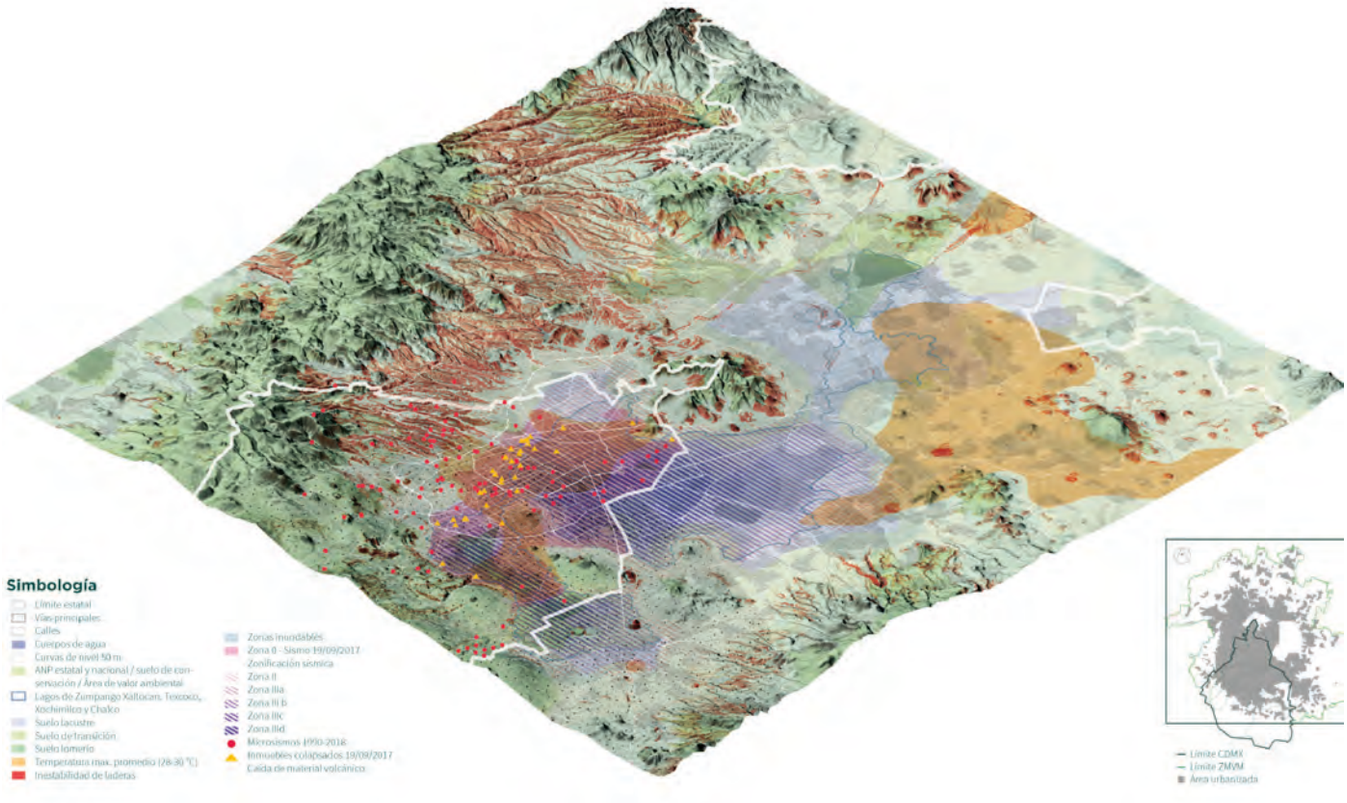
19 Larry Vale, "The politics of resilient cities: Whose resilience and whose city?" *Building Research & Information*, (2013): 1-11; See also: Diane Davis, "From risk to resilience and back: new design assemblages for confronting unknown future." *Topos, Garten + Landschaft*, (June 2015): 57-59.

20 Lorena Bello Gómez and Sarah Williams. *Resilient code: Mexico City (CDMX) a proactive toolkit to foster equitable resilience* (MIT School of Architecture and Planning, Fall 2019).

The Project: Landing with CDMX Unserved Communities

Our collaborative work with Mexico City's Secretaries of Risk Reduction, Education, and Environment provided a good opportunity to test this approach through soft-bottom-up infrastructure. Answering the Leventhal City Prize Call for Equitable Resilience in February 2019, our team proposed an alliance between different actors in CDMX to address risk reduction in Mexico City´s most underserved communities (Figure 1). Following several meetings and a one-day workshop with all the proposed participants in May 2019, team members committed to find a common project that could enhance environmental resilience in CDMX's multi-risk territory. Even though we did not win the Leventhal Prize, the Call served to catalyze our collaboration. During our first encounter, we learned from current initiatives in risk-reduction. Our summer research at MIT was followed by a two-week intensive workshop with students in CDMX at the end of August. The work continued at MIT during the Fall, and selected projects were developed by students during a CDMX January internship. Afterward the project continued as an Independent Study during the Spring semester of 2020.[20]

During the summer research, we studied many of the past and current city efforts to respond to CDMX risk-prone environmental conditions, now further stressed by



[Fig. 1] CDMX Multi-Risk Megalopolis. Authors: Dirección de Resiliencia de la CDMX. SGIRPC (Information from INEGI 2015, SGIRPC 2019, Atlas Nacional de Riesgos 2019).

climate change. These efforts are important resources for those interested in this topic. In 2004, the city published its first "*Climate Action Strategy"*, followed by many additional updates on "*Programs, Strategies and Visions* for Mexico City".[21] After being selected for the *Rockefeller 100 Resilient Cities Initiative* in 2013,[22] the city published the first "*CDMX Resilience Strategy"* in 2016 to strengthen long and short term disaster mitigation and preparedness plans with strategies to address water and mobility problems (figure 2).[23] The Secretary of Environment and the Public Space Authority have funded programs to implement such actions.[24] "*Towards a Water Sensitive Mexico City: Plan for Flood Mitigation"* was published the same year to manage rainwater though public space in a decentralized manner.[25] This proposal used previous studies such as the "*Program of Integrated Water Resources"* and the "*Water Plan for the Future of CDMX"* issued respectively in 2012 and 2014.[26] In a push towards risk-reduction, the new government headed by Claudia Sheibaum launched the "*CDMX Risk Atlas"* in March 2019. For the first time, this tool made risk information accessible to all CDMX citizens –regardless of its impact on the value of land.[27] In parallel, the "Agency of Digital Innovation", ADIP, was also created to enhance transparency and to reduce waiting time/corruption in public transactions; and to facilitate access to otherwise "siloed" information such as the cadaster.[28] Mayor Sheibaum also launched the PILARES vocational schools to reduce violence and unemployment in the city's most underserved neighborhoods, through a social infrastructure of community spaces to provide access to health, education, culture and sports specifically for vulnerable populations. During her campaign, the Mayor also promised to enhance *water resilience* in the city by recovering a lost hydrological balance.[29]

In sum, Mexico City has pursued a sincere and substantial push toward sustainable design and planning during the past decade, but much work remains. Our mission was to understand which urban design and infrastructure strategies could contribute best to enhancing equity and resilience to climate in CDMX underserviced communities.

21 SEDEMA, *Climate action program* (Mexico: CDMX City Council, 2014), http://www.cms.sedema.cdmx.gob.mx/storage/app/media/PACCM-2014-2020.pdf (accessed May 28th, 2020). SEDEMA, *Climate action program. Progress report 2016*. Climate change and clean development mechanisms projects teams (Mexico: CDMX City Council, 2016), http://www.data.sedema.cdmx.gob.mx/cambioclimaticocdmx/images/biblioteca_cc/PACCM-ingles.pdf (accessed May 28th, 2020). Guillermo Velasco et al, *Local strategy for climate action*. (Mexico: Centro Mario Molina para estudios estratégicos, 2014) https://sedema.cdmx.gob.mx/storage/app/media/programas/cambio-climatico/ELACCM-2014-2020-completo.pdf (accessed May 28th, 2020).

22 Rockefeller Foundation, *100 Resilient cities initiative*, https://www.100resilientcities.org/cities/mexico-city/ ,(2013) (accessed May 28th, 2020).

23 CDMX Resilience Office, *CDMX resilience strategy. Adaptive, inclusive and equitable transformation* (Mexico City: 100 Resilient Cities, 2016), http://100resilientcities.org/wp-content/uploads/2017/07/CDMX-Resilience-Strategy-English_2.pdf (accessed May 28th, 2020).

24 SEDEMA, *Secretary of Environment Programs* (Mexico: CDMX City Council, 2020), https://sedema.cdmx.gob.mx/programas/programa/programa-de-sistemas-de-captacion-de-agua-de-lluvia-en-viviendas-de-la-ciudad-de-mexico (accessed May 29th, 2020).

25 Deltares, Urbanisten et al., *Towards a water sensitive Mexico City* (Mexico: Autoridad de Espacio Público, 2016) https://www.deltares.nl/app/uploads/2018/01/20160629_WS-CDMX_final-version-report-smsize.pdf (accessed May 29th, 2020).

[Fig. 2] CDMX Resilience Strategy. Authors: Dirección de Resiliencia de la CDMX.

We were also interested in seeing which strategies might reduce barriers for resilience implementation. Could soft-bottom-up-infrastructure be the way to go?.

To continue our *geographical embeddedness*, we looked into the work of other scholars and prepared a two-week workshop in Mexico City with MIT students in August 2019. UNAM (Universidad Nacional Autónoma de Mexico) is an important research center, with many scholars who have dedicated study to Mexico City's water situation. Within their studies we found the research work of Jorge Legorreta and Manuel Perló extremely useful to understand the human-caused process of urbanization and subsequent degradation of water in the closed basin of Mexico City. From Legorreta, we found: "*El Agua and Mexico City: From Tenochtitlan to the 21st Century Megalopolis"* (2006)*; "Rivers, Lakes and Springs of the Valley of Mexico"* (2009)*;* "*Rainwater, the Key to the Future in the Valley of Mexico"* (2009)*; or "The Rivers of the City of Mexico: Past, Present and Future"* (2013)*.* And from Perló we looked at: "*The Modernization of Cities in Mexico"* (1990), "*The Porfirian Paradigm, History of the Drainage of the Valley of Mexico"* (1999), "*War for Water in the Valley of Mexico"* (2005); and "*The Crisis of Water and the Metropolis"* (2018). These two scholars' prolific works were critical for our learning. The work of Diane Davis and Jose Castillo's *"The Flexible Leviathan¨* was also critical to understand fixed problems in informal barrios such as Iztapalapa, while Gustavo Madrid´s work and "*Hydric Plan for Miguel Hidalgo,"* showed us concrete examples contributing to a decentralized rainwater strategy system at the neighborhood scale. Besides, the *Quebradora Park* in Iztapalapa (by UNAM´s Taller Hídrico and coordinated by Loreta Castro Reguera and Manuel Perló) showed a potential example of water decentralization in an informal community.[30] Several other architects and urbanists have dedicated their work to the problem of water in Mexico City as well: Alberto Kalach, Ana Isabel Ruiz Remolina, Iñaki Echeverría, and ORU (Office for Urban Resilience) among others. Our team reviewed, assessed, and discussed all of these strategies as we formulated our own design and planning ideas.

26 SACMEX, *Plan integral de agua* (Mexico City: CDMX City Council, 2012), http://www.agua.unam.mx/sacmex/assets/docs/PGIRH_Final.pdf (accessed May 29th, 2020); see also: SACMEX, *Plan agua*, (Mexico City: CDMX City Council, 2014). https://www.cmic.org.mx/comisiones/Sectoriales/infraestructurahidraulica/Plan_Agua_para_el_Futuro/PLAN%20AGUA%20PARA%20EL%20FUTURO%20CDMX-01abr-14.pdf (accessed May 29th, 2020).

27 http://www.atlas.cdmx.gob.mx/indicadores/

28 Agencia Digital de Innovación Pública (ADIP), CDMX City Council, https://adip.cdmx.gob.mx/ (accessed May 29th, 2020).

29 Aquatech, "Mexico City mayor pledges water for all by 2024," June 18th, 2019. https://www.aquatechtrade.com/news/urban-water/mexico-city-mayor-pledges-water-for-all-by-2024/ (accessed May 31, 2020).
See also, PILARES program: https://pilares.cdmx.gob.mx/ (accessed May 31st, 2020).

30 Diane Davis and Jose Castillo, *The flexible Leviathan: reconsidering scale and fixity in Iztapalapa, Mexico City* (Cambridge, US: Harvard University Graduate School of Design, 2016).
Gustavo Madrid, *Plan hídrico: estudio hidrológico en la delegación Miguel Hidalgo* (Mexico: Miguel Hidalgo, 2016).

From our reading of these existing efforts, we targeted *water resilience* as a powerful vector to address inequality and environmental risks in CDMX's marginal underserviced communities. These risks include landslides, flooding, droughts, subsidence and *socavones*, or cracks in the earth. Due to the current climate regime these events have become more recurrent in Mexico City. Unfortunately, these calamities add to the fragile existence of marginal dwellers who already face socio-economic problems such as poverty, unemployment, violence, oppression from narcotic traffickers, land tenure insecurity, and more. The absence of water management and poor provision in these marginal communities not only makes visible the huge inequalities between rich and poor, but also a system that is in complete disequilibrium. As Bruno Latour mentions, it is important to land and— while keeping the holistic view of the problem— start acting in these *Critical Zones* whose fragility has been pushed by the climate regime and that would be soon ruined if we did not intervene.[31] After much analysis and fieldwork, we "landed" as its citizens in the marginal communities of Mexico City to measure, make visible, and target solutions that provide actions to act and adapt to this new water regime.

Towards that end, we kept asking ourselves how to generate a cohesive urban strategy that respected past scholarship and practice, but that also introduced critical thinking about the feasibility of its implementation. We needed to reassess the water cycle. A decentralization strategy to re-distribute services while harvesting water seemed like a good option, but we found the existing city programs weak on community empowerment, as well as containing little effort to bring about behavioral change in water culture to, reuse or recycle as much water as possible at the individual level. After our research and fieldwork, we used the Fall semester 2019, back at MIT, to reframe the possibility of implementing water resilience with projects that could enhance the following items: experimentation and learning; participation and user involvement; leadership and ownership; evaluation and refinement towards behavioral change in water consumption, and management at the individual and intermediate scale. We started by reassessing the problem.

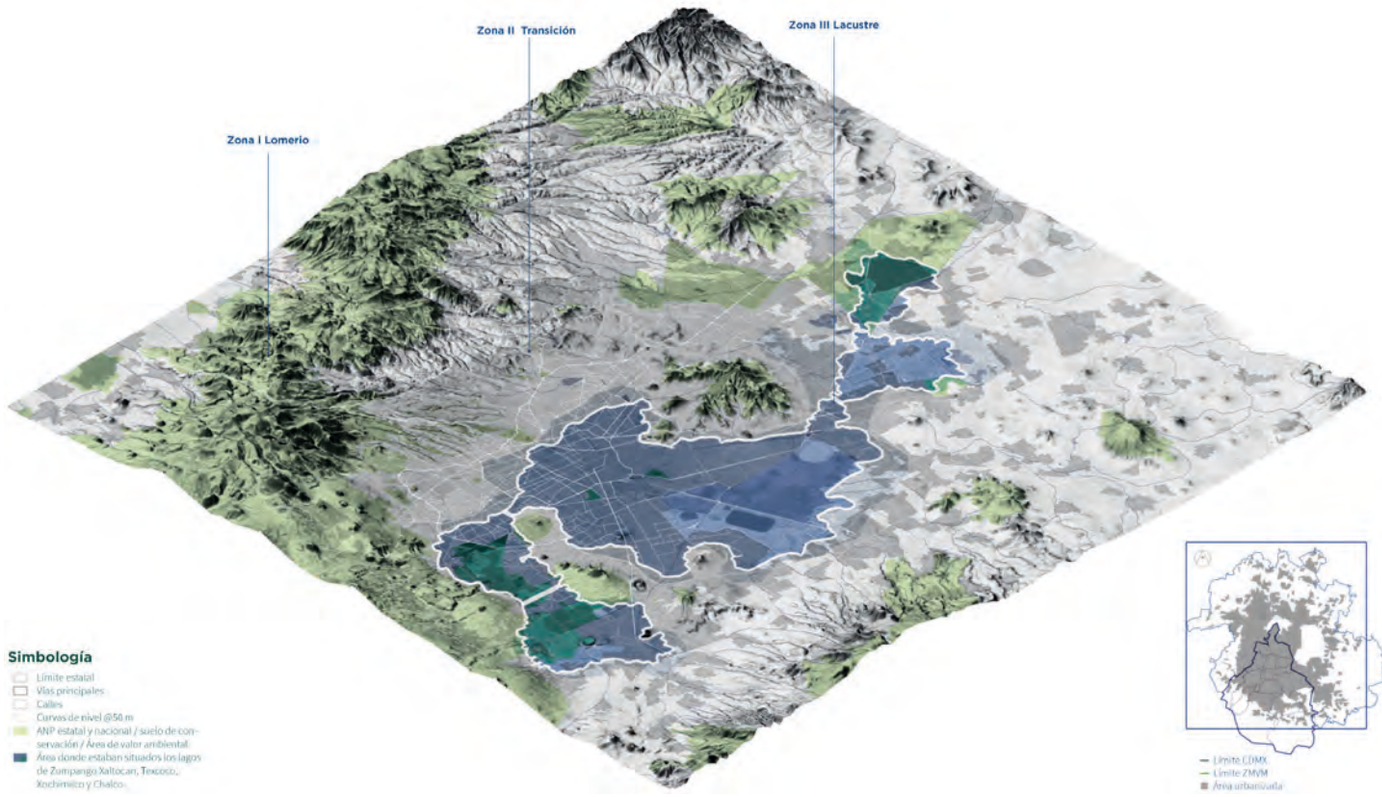
Water as linking Vector: Resilient Code

Water, as is well known, connects many of Mexico City's environmental problems. Given its original geographical setting on a salty lake, Tenochtitlan might have evolved with a city-form designed to accept and accommodate water. Amsterdam, Venice, and Suzhou enhance their relationship with their aqueous environments, as did the original city of the Mexicas. Instead, Mexico City evolved like Los Angeles into a mechanical city that brings drinking water from afar, or that pumps it from beneath. While quickly draining away rainwater mixed with the waste debris of 22 million dwellers, the city irrigates a valley to the north without treatment, at least until recently.[32] In a radical Anthropocene alteration, the Mexico City basin, originally envisioned for flood control and agriculture, was instead urbanized. As result, thirsty urbanites keep depleting their aquifers while their city sinks beneath them. This sinking does not prevent the city from getting flooded as subsidence breaks and modifies slopes of drainage pipes. It also damages foundations and soils, amplifying the risk of liquefaction from the earthquakes that shake this former lake bed from time to time. Mexico sits at the intersection of four tectonic plates, and the city has gone through two recent deadly earthquakes in 1985 and 2017.[33] Droughts have also become more extreme. Last May, 2019 the combination of wildfires, the city's geographic location within a volcanic active area, and the enclosed nature of the city's valley produced an environmental emergency that kept Mexicans indoors for a couple of days. The crisis was worsened by the CO^2 emissions of a 22 million, busily commuting metropolis. Few have ever been in more horrendous traffic than at 6pm in Mexico City.

31 Bruno Latour, Down to Earth, (2018).

32 INEGI, *Censo de Población y Vivienda* (Mexico: INEGI, 2010).

33 Jorge Legorreta, *La ciudad y el agua,* (Mexico: UNAM, 2006).



[Fig. 3] CDMX Original Water Lakes. Authors: Dirección de Resiliencia de la CDMX (Information from "Medium-scale Redevelopment Districts as a Model for Sustainable Water Management in Mexico CIty", DRCLAS, 2019).

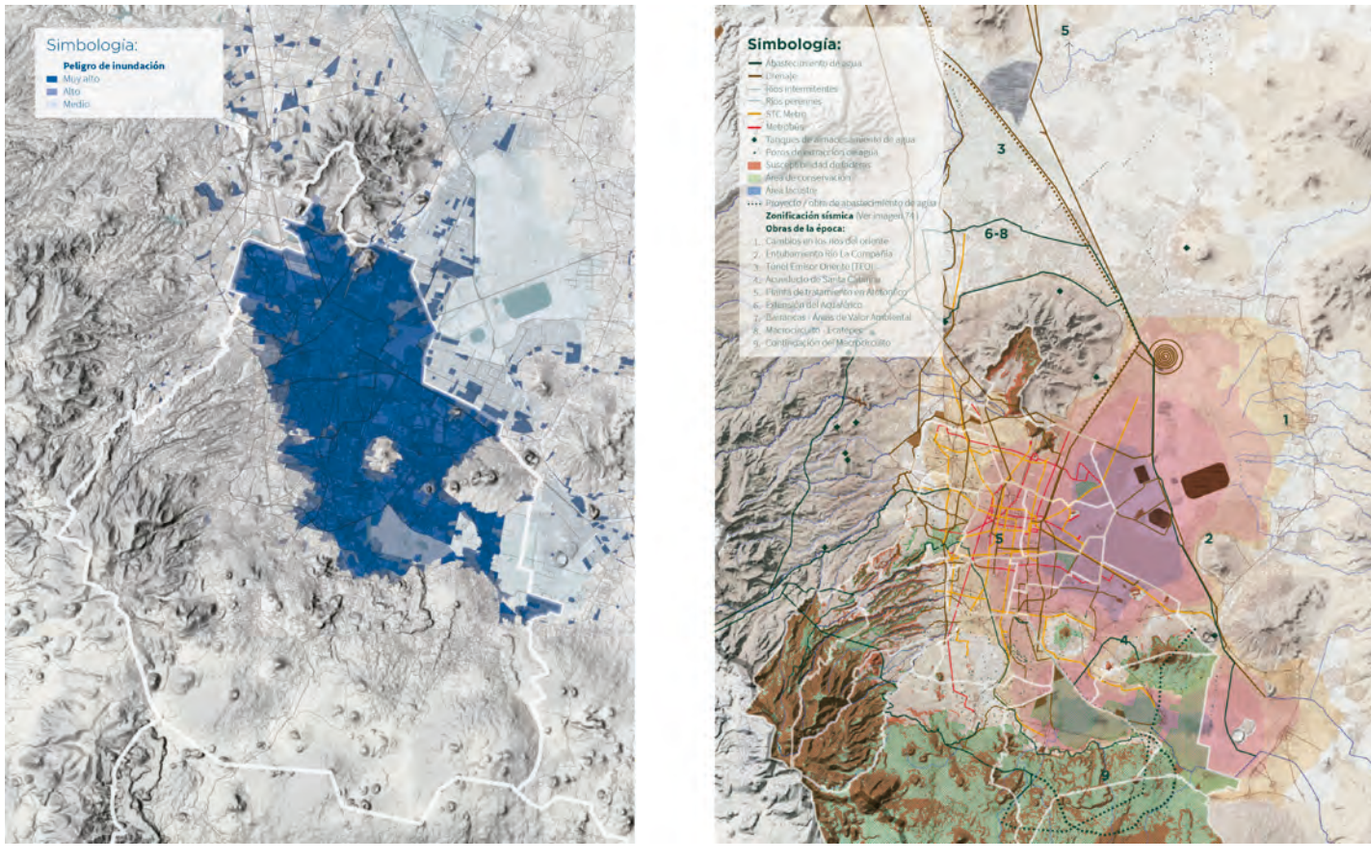
This above bitter and frightening condition worsens when one examines the numbers. Mexico's water travels for 120 kilometers along what is known as the *Cutzamala-Lerma* system. This water is elevated 940 meters to reach the 2240 m altitude of the endorheic basin in order to be distributed. This energy-intensive system distributes on average 20 m^3/s, with a high loss level of 41.4%, while the city drains out 20 m^3/s of rainwater at the same time. Amazingly, the surface area of 19 Manhattans (1100 km^2) of rainwater is drained out and into a valley to the north, just to irrigate the surface of 15 Manhattans (900 km^2) in return. One of the world's largest treatment plants in *Atotonilco* entered operation in 2018, but for more than 100 years this *Mezquital valley*, as mentioned previously, was irrigated with untreated water. Over 1600 pumps have kept stressing the aquifer to the point where the city center has sunk 9 meters in the last 100 years, while other parts of the lacustrine soil keep sinking 30/40 cm/year on average. This differential subsidence and inadequate solid waste management have caused drainage infrastructure to lose the ability to evacuate rainwater. To address these problems, complex and costly infrastructure projects such as the *Emissor Oriente* tunnel has been built. Already in an underperforming state, Mexico City's complex drainage system cannot cope with torrential rains and floods. These have increased in the last 10 years, and are predicted to increase even more in the context of climate change (figures 3, 4).[34]

Into this complex situation, our team, comprised of students and faculty in Architecture and Planning at MIT, proposed to start by scripting a new Resilient Code for the informal communities of Mexico City. The formal city, the "lettered city"–in Angel Rama's words– written by *letrados* and designed within the law, already had a *código*.[35] The informal city, one with exactly the same form but written outside the law, was also in need of a twenty first century code that would help restore water resilience.[36] To that end, Resilient Code links the social infrastructure of PILARES, mentioned previously, to the government's environmental and risk reduction initiatives, by providing design solutions that respond to CDMX's Risk Atlas. Moving from risk-description to risk prevention action, this program provides examples of how governments, together with their underserviced communities,

34 Manuel Perlo and Loreta Castro Reguera, *La crisis del agua y la metropolis,* (Mexico: Grupo Siglo XXI, 2018).

35 Angel Rama. *La ciudad letrada*, Serie Rama (U.S.A.: Ediciones Del Norte, 1984).

36 Jose Castillo, "The promise of Neza. Building a city of 1.2 million inhabitants one house at a time," *Re-Inventing Construction,* Ilka & Andreas Ruby eds., (Zurich: Ruby Press, 2010), 388-403.



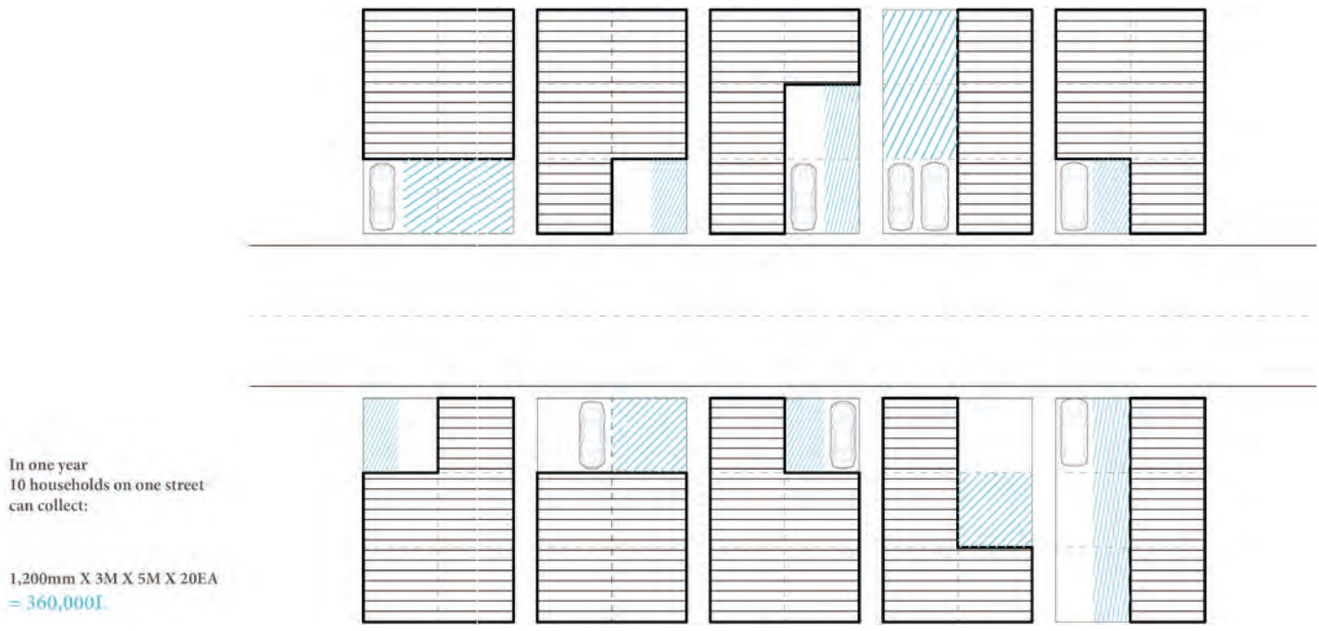
[Fig. 4] CDMX Water Infrastructure and Flooding Risk. Authors: Dirección de Resiliencia de la CDMX (Infromation from INEGI 2015, Atlas de Riesgo de la CDMX, SGIRPC 2019, DRCLAS 2019).

could develop, implement, and communicate water resilience projects based on both environmental and socio-economic needs.

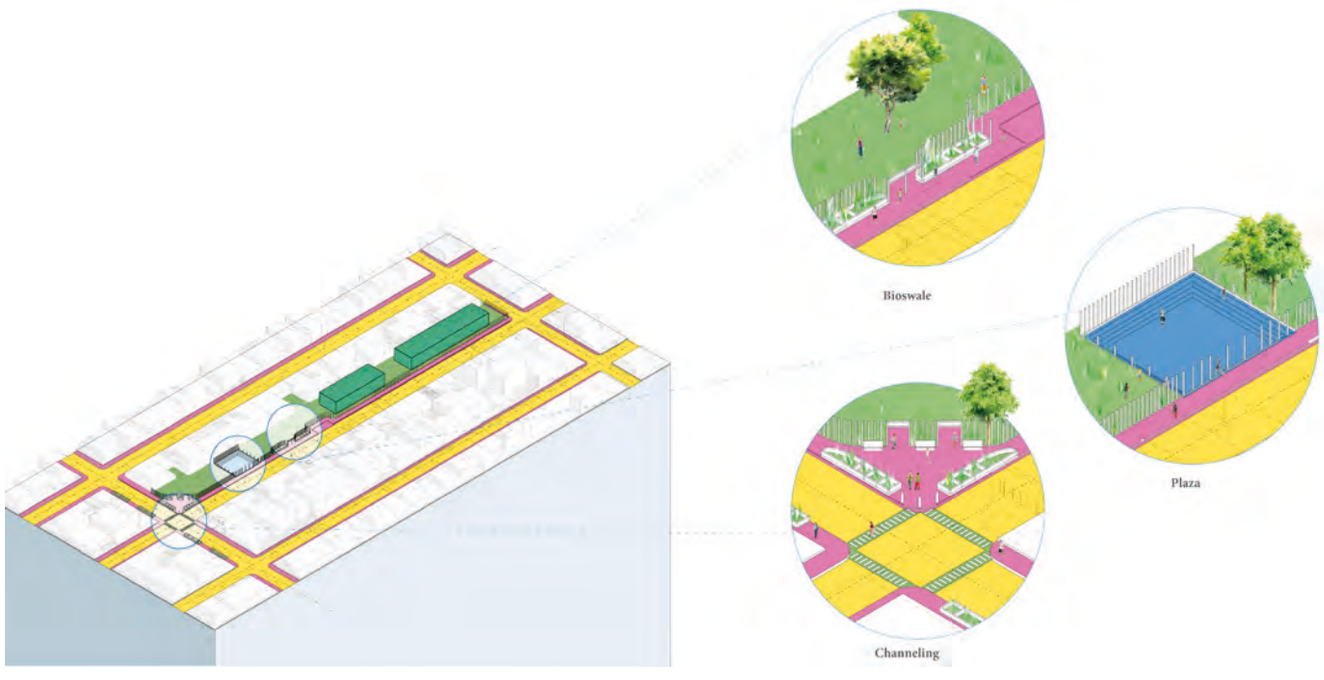
Resilient Code helps ideate, design and communicate CDMX's common/private space potential to reduce environmental risk to water stress. It is intended as a water resilience program, providing design solutions that could be modified and implemented through several measures: participatory workshops at PILARES for adults; an online web interface; and a game-based workshop for children. Following the former idea of a soft-bottom-up infrastructure, the project proposes to start with a network of small interventions that would allow communities to start, by changing their water culture and behavior first. In this first phase, our project will ideally guarantee future public acceptance of these interventions, with the help of demonstration projects, communication strategies and participatory workshops. In a second, projected phase, our work will shift to an intermediate scale. These future projects will help bridge a hard-top down hydraulic infrastructure with a water-sensitive bottom up network to help restore the city's water cycle as a whole. In an acupunctural manner, we propose to begin the process of restoring a big problem, through small interventions that can be quickly implemented. We have named this soft-bottom-up water infrastructure strategy *Water Commons.* The term reminds us that water is a right for all, and that we all need to contribute to save it in one way or another.

Conceptual frame: Water Commons

Water Commons is the umbrella term for the first water resilience strategies proposed as the first Pilot of our Resilient Code program. These strategies, as previously noted, are intended to reduce environmental risk in CDMX's underserviced barrios at both the micro and intermediate scales. The Water Commons Pilot strategies concern the capture, conservation and reuse of the local water resources. They are designed to help capture CDMX's wasted rainwater, and to reduce water stress during periods of drought and storms. Water Commons as a Pilot program starts with a micro-scale approach to environmental regeneration that is based on



[Fig. 5] Water Commons, Household Scale. Source: MIT Resilient Code Class. Authors: Mengqi He, Melika Konjicanin, Jaehun Woo.



[Fig. 6] Water Commons, Neighborhood Scale. Source: MIT Resilient Code Class. Authors: Mengqi He, Melika Konjicanin, Jaehun Woo.

land use, geographical, morphological and hydro-meteorological characteristics. This approach enables us to develop tools of small bottom-up interventions in partnership with citizens and local community groups. These interventions include rain tanks, rain gardens, parkway retrofits, greywater systems, infiltration trenches and permeable paving. Thinking about implementation, we proposed tools and actions that would allow for experimentation and learning; participation and user involvement; leadership and ownership; evaluation and refinement towards behavioral change in water consumption, and management at the individual and intermediate scale as is explained below. Resilient Code proposes to provide a micro-scale Water Commons to the PILARES centers' users first, to enable these users to begin changing their water use and behavior.

In a second phase, we propose an urban design commons to address residents' immediate urban environment-based needs to improve the water resilience of

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Water Commons in Mexico City

CDMX Código Resiliente:
Aqua-Commons en Ciudad de Méjico

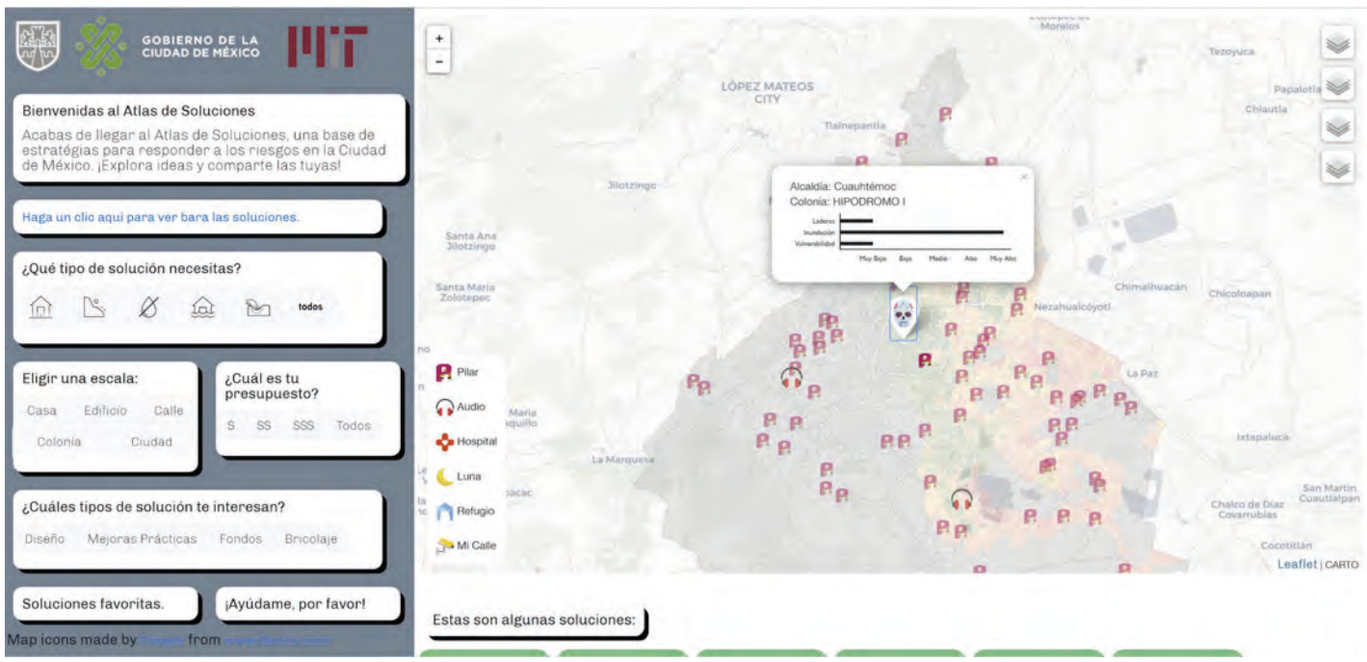
public space. What are these urban design commons? We propose to co-design implementation strategies on the site of public buildings (hospitals, markets, schools, parks, and sports centers). These strategies will generate demonstration projects with high visibility to promote these types of interventions in the future. This network of projects will also create a critical infrastructure of logistics spaces and emergency shelters during a disaster. We propose for these projects to be co-created with community members based on the PILARES site with the help of a participatory design workshop. In parallel, an online *Atlas of Solutions* supports the network's actors (government, NGOs, community, multi-laterals) that work in these communities, giving them a database of implementable solutions and a pathway for executing projects described in the toolkit of code. A game board *Reacciona* promotes play for children at PILARES, public schools and public space to engage them to be more alert to risk and to start changing their water behavior. This game was further resolved by students back at MIT, and by the *Dirección de Resiliencia* back in CDMX. The Atlas of Solutions was renamed the *Atlas of Risk Reduction*. It continues to be developed with the CDMX Risk Reduction Secretary via Zoom at the current time.

Water Commons Design: A Toolkit and Manual

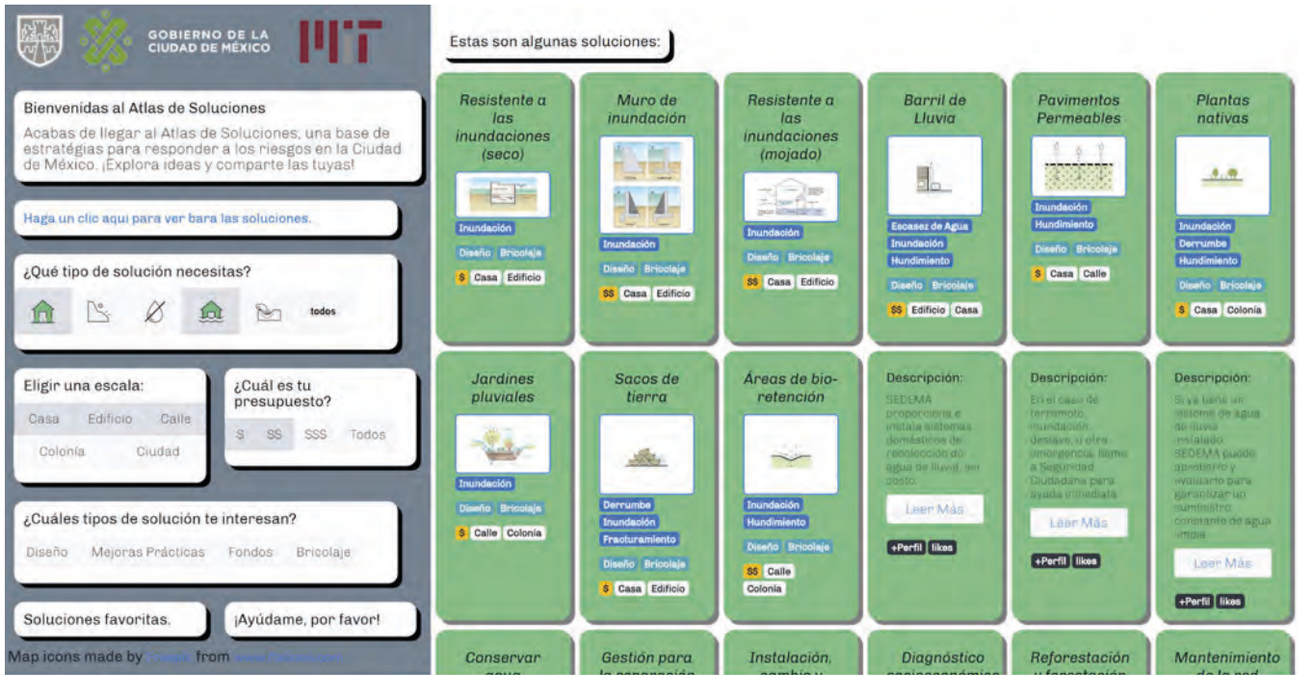
At both the individual and intermediate scale, design solutions propose to promote a behavioral change in water culture. A new soft-bottom up infrastructure network is proposed to slow down rainwater runoff, store, purify and/or filter it when possible. To learn how to design with water a deep understanding of soil characteristics, and nature-based solutions is needed. *Resilient Code* selects the best options at the individual and intermediate scale level and finds the way to communicate its benefits better. The information is gathered in six booklets to facilitate implementation for those who do not have internet access. In any case PILARES centers give free access to the internet to all citizens. (figures 5, 6)

Water Commons Interface: Atlas of Solutions

An online interface is designed in order to promote public access to information and to make available not only the designed solutions but to provide costs, organizations and experts at hand to implement water commons. Actions are



[Fig. 7] Atlas of Solutions Interface. Source: MIT Resilient Code Class. Authors: Jonathan Hoagland Leape, Lenna Johnsen.



[Fig. 8] Atlas of Solutions Water Commons. Source: MIT Resilient Code Class. Authors: Jonathan Hoagland Leape, Lenna Johnsen.

introduced to keep citizens learning from individual experiences in order to keep improving the solutions. The program is also based in the idea of empowerment and autonomy of each individual to contribute to the solution. This relocates and distributes efforts in order to obtain a desirable goal. (figures 7, 8)

Water Commons Public Engagement: Reacciona Game, Participatory Workshop

As a method which easily allows the participation of a large number and wide range of players, gaming has its role to play in meeting the proposed challenges. Play is well-known for its ability to distil complex information into accessible formats and can thus be used effectively to distribute knowledge and raise awareness. Moreover, as an inherently participatory and immersive experience, gaming has the potential to activate residents' sense of ownership as well as their agency in impacting the spaces around them. *Reacciona* is designed with that aim. It is introduced to kick start the participatory workshop that can be produced at PILARES or other public institutions to promote the projects. (figures 9, 10)

[Fig. 9] Reacciona Game. Source: MIT Resilient Code Class. Authors: Hannah Hunt Moeller.

[Fig. 10] Participatory Workshop Pamphlet. Source: MIT Resilient Code Class. Authors: Braxton C. Bridges, Emmet Zane McKinney, Sydney Pedigo.

Discussion and Conclusions

While much attention has been placed in Mexico City to drain the region's rainwater as efficiently as possible, a new culture to harvest rainwater seems paramount. The hydrological water system in the city has for long been dysfunctional. The consequences of this dysfunction have increased the risk of droughts, floods, and earthquake response, as well as caused health driven illnesses among the region's citizens. While the risks of earthquakes and earth cracks affect Mexico City as a whole, water provision makes visible the vast inequalities between rich and poor in the city. While access is key to fostering equality in the city, water resources have also shown the limits to growth in this megalopolis of 22 million dwellers. Growth through expansion or densification does not seem feasible amidst this heavily human-altered, or anthropic, condition of the valley. However, a more equitable and sustainable redistribution strategy of rainwater could alleviate the problems that the city currently faces due to droughts and floods, while also seizing the opportunity to implement public spaces in the most underserviced neighborhoods in the city. As result, the city´s water cycle could be improved as a whole, in a win-win-scenario. Only if societies and territories are more equitable and sustainable, will they be able to survive more recurrent environmental crises.

In our water commoning project, we propose a soft bottom-up infrastructure as a first small step, on what is a long *camino* of future environmental and design challenges for Mexico City. Our project provides a major contribution to sustainability design and community practice in Mexico, through its meshing of top down and bottom up initiatives. Our partnership with multiple City of Mexico agencies leveraged government capacity to improve neighborhood conditions in partnership with developing community skills and organizations, to provide for sustainable maintenance and growth of water communing infrastructure. Different from past water infrastructure initiatives that were highly capital intensive, that suppressed or ignored community input, and that required fixed and continuous input from city agencies that could not be sustained, our project pilots a means by which communities can determine their own water future while mitigating risk and promoting growth of common spaces and facilities that promote collective democracy.

Our project is a significant contribution to sustainable community design practice for several reasons. First, risk is likely to increase; Mexico City is likely to experience increased water stresses in the future with climate change and increased

desertification and exploitation of aquifer resources. Our project mitigates water stresses and places control of water resources in the hands of communities. Second, infrastructure limitations in Mexico City are likely to continue due to capacity and funding. Our project's soft infrastructure enables water retention and mitigation at the site level, without costly large-scale infrastructure requiring state support. Thirdly, governmental capacity, resources, and volition to achieve water goals are highly variable in Mexico due to ongoing political shifts and a political climate that favors short-term rather than long-term gain. Our water commoning project engaged high-level government resources to catalyze a community-capacity driven project that could be sustained in the longer term at the local level, even if governmental interest flagged or was otherwise compromised. Lastly, continuing urbanization pressures in the Mexico City region mean that water stresses are likely to be exacerbated at ever greater scales due to urban expansion. Our project thus provides a model for future urbanization to incorporate sustainable design practice at the inception of a community rather than as a retrofit of a long-standing settlement.

Water commoning is very promising, but our project was not without its limitations and barriers. Due to capacity limitations on the MIT end, we were only able to sustain our engagement for a short period of six months before students assumed other responsibilities and faculty were taken up by other obligations. Attempts to institutionalize student involvement post-graduation through sponsorship by government agencies ran into funding and capacity limitations. The lack of follow-up due to COVID reduced our ability to continue engagement with the Iztapalapa community during the summer of 2020, and inhibited our ability to provide additional capacity after the immediate term of the project was complete. However, Mexico City´s Resilience Office has the children´s game ready and designed in a large format and is waiting for normalcy, post-COVID, to implement it in both PILARES and public spaces. In tandem, the Risk Secretary has continued advancing the Atlas of Solutions platform that now also includes pandemics. Therefore, we are confident that our multi-lateral implementation approach will enable local communities to continue development of water communing methods in the near future.

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