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Governance Assessment of the Flood's Infrastructure Policy in San Pedro Cholula, Mexico: Potential for a Leapfrog to Water Sensitive

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Abstract: Climate change together with population growth and land-use change have increased the risk of urban floods. Urban floods cause severe damages to cities and their inhabitants, and they are expected to increase over time. Consequently, urban adaptation is required to shift from traditional infrastructure (grey) to multifunctional infrastructure (blue-green) for improved flood management. Until recently, studies on the role and adoption of blue-green infrastructure have centered around large cities in developed countries, including Melbourne and Rotterdam, among others. Meanwhile, middle-sized cities in developing countries have received less attention. According to the Urban Water Management Transition Framework (UWMTF), cities in developing countries can learn from the experiences of developed cities and leapfrog to more 'water sensitive' practices. Although leapfrogging is context-dependent, our understanding of factors that support leapfrogging remains embryonic. This paper contributes to the scholarly understanding of the governance factors that support and limit leapfrogging. By applying the Governance Assessment Tool through semi-structured interviews and reviewing secondary data, this research assessed the implementation of flood protection infrastructure in San Pedro Cholula, a middle size city of Mexico. This work found the most supportive quality for delivering multifunctional infrastructure, was the extent of the governance system. The governance support extent was rated as moderate-low considering the platform for change is limited to government actors, which has further reinforced traditional approaches to infrastructure. In addition, the necessary governance features of coherence, flexibility and intensity were assessed as constraining change, with flexibility being the least supportive governance factor and ultimately hindering social actors' participation and innovation. While the contemporary governance arrangements of San Pedro Cholula are not yet conducive to promoting a leapfrog in the delivery of urban flood infrastructure, the analysis has pointed to three catalytic factors to underpin a leapfrogging situation: trans-disciplinary science; cross-sector partnerships; and, innovation experiments.

Keywords: governance assessment; leapfrogging; middle-size cities; water governance

1. Introduction

Urban flood recurrences have been increasing in the world due to various factors such as climate change, population growth, changes in land use and aging or inadequate infrastructures [1]. Due to climate change, it is expected that storms, followed by floods increase over time [2]. Therefore,

climate change is a challenge that requires an appropriate adaptation across the different political and jurisdictional scales [3]. Cities are the areas that require our attention. It is expected that 6 billion people live in cities by 2030. Therefore, cities are required to provide water services in a more efficient manner [4]. Cities cover 1% of the earth's surface, but they produce 80% of the GDP and 54% of the population lives in them [5]. Cities are recognized as one of the most effective leverage points for achieving the SDGs [6]. However, "cities are complex social–ecological–technological systems where numerous actors and processes interact, often across geographic, institutional and governance scales" [6]. This complexity creates challenges when implementing strategies for climate change adaptation.

Adaptation means both anticipating the negative impacts of climate and taking advantage of opportunities that might arise. Proper anticipation can save money and lives [7]. Climate change adaptation requires strategic investments to deliver sustainable solutions in the long-term [8]. However, adaptation depends on the cultural, technological, economic and governance context [3]. Adaptation processes require the understanding of the different social scales, the social construction of such scales and their institutions [3]. Therefore, adaptation can be considered more a governance issue than a technological one [9].

In this sense, urban water scholars have long called for change in the sector. Scholars have claimed that 'stationarity' is dead [10] and that uncertainty, flexibility and adaptability is required within the urban water moving forward [11]. In this vein, Brown et al. [8] proposed a heuristic device to identify key features of more sustainable urban water practices. The concept of "water sensitive cities" was developed based on the idea that nowadays the largest part of the population lives in urban environments and it is necessary to find a more sustainable water management [8]. It proposes a transitional framework that allows benchmarking at the macro-scale by establishing a typology of six city states [8]. The final goal in this transition is to reach a Water Sensitive City state (WSCs). Figure 1 below shows this transition.

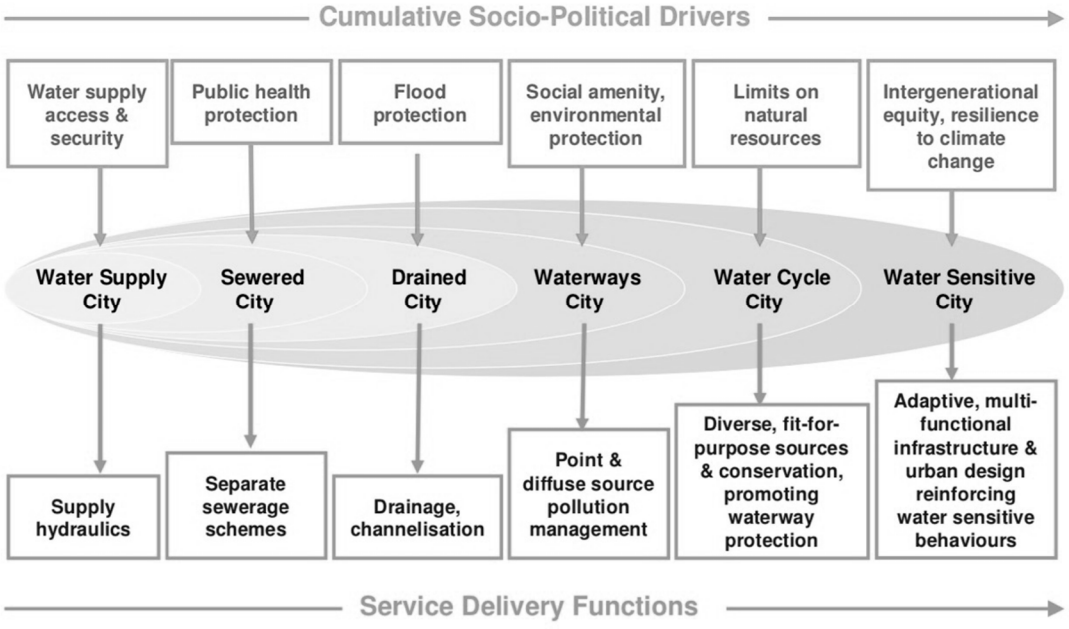

Figure 1. Urban Water Management Transitions Framework [8].

Water sensitive city is a term within urban water management in which the adaptation of a city against extreme climate events is a key aspect that requires the interaction of different disciplines such as water science, urban planning, urban design and engineer among others [12]. To reach a WSCs, institutional changes that reinforce shifts within the pillars (normative, cognitive and regulative) of institutional practice, must occur [8]. Although this framework was developed in Australia, it is

believed that it is applicable in Europe [8] and other parts of the world [13]. "The water sensitive city is a sustainability ideal type and a state to be aspired and worked toward; as there are no cities anywhere in the world so far classified as 'water sensitive'" [12]. Australian cities are generally classified in the "waterway city" stage [12].

One key element of a WSCs is the implementation of multifunctional infrastructure also known as blue-green infrastructure (BGI) and which is a step forward from grey infrastructure. When building infrastructure against extreme climate events, such as floods, grey infrastructure is traditional flood infrastructure, which includes stormwater drainpipes, curb inlets, culverts, etc. This infrastructure aims to remove the rainwater from the flooded area and to distribute it to the closest water body [14]. Although this grey infrastructure has proved to be effective in many cases, it also has negative aspects: (a) Changes the local hydrological cycle, (b) increases peak flows, (c) increases risks downstream, (d) changes groundwater and surface water levels and (e) with the increase in extreme weather conditions, the capacity of the infrastructure is becoming inadequate [14]. BGI is perceived as a better approach to responding to climate change and flood challenges. Green infrastructure is related to the incorporation of green spaces while blue infrastructure is related to aquatic ecosystems. BGI can be defined as a strategic and planned infrastructure network designed to deliver ecosystem services, to protect biodiversity and to provide multiple social services [14]. BGI can be classified in natural water features such as ponds, rivers, lakes or wetlands or man-made features such as green buildings, streets or places; green spaces such as parks or multi-functional public facilities such as libraries, schools, museums, etc. [14].

The concept of "water sensitive city" has been accepted worldwide and related projects have been developed in Asia [15], Europe [16], and Latin America, including Mexico [17]. However, the implementation of BGI projects also known as water sensitive projects is different in each case. In Australia, they used to imply greenfield construction, while in Europe, a redevelopment in the urban area [12]. In Mexico, the very few projects have implied redevelopment of public spaces, such as the lineal Park La Viga or the parks Vicente Guerrero and Quebradora [18–20]. The implementation of BGI projects outside Australia and Europe is expected to be more challenging, as many countries lack important planning strategies and economic resources [12]. To understand better these challenges, this research has focused on Mexico.

One of the main assumptions of the Urban Water Management Transition Framework is that cities can skip some of the stages to reach a WSCs faster. This means that the transitional process is not necessarily a linear one [12]. This concept is called leapfrogging (it will be explained in the next section) and has caught the attention of both developing and developed countries as well as international organizations such as World Bank (WB), UN-Habitat and the International Water Association (IWA) to create a strategy that responds more efficiently to the water challenges that climate change represents.

> *The concept of "leap-frogging" provides an exciting alternative route, with particular relevance for cities with poorly developed water management systems. These cities now have the invaluable opportunity to avoid the environmental, social and economic vulnerabilities that come from managing the water cycle in a segmented way. By leapfrogging from one state to another, cities can skip parts of the transition pathway and proceed directly to more sustainable infrastructure. This idea relies on experimenting with innovative technology and tailoring existing ideas to a local context [15].*

Leapfrogging is a worthwhile policy goal [21] that leads to a redesign of public infrastructure. People are generally excited with decentralized water solutions. For example, the idea of multi-functional spaces that combine urban ecology with a safe and usable space is appealing to society [22]. The cases in Melbourne, Rotterdam, Portland and Lotz regarding stormwater management from a water sensitive city perspective are an inspiration [15,22]. To study this water management transition, we analyze the flood infrastructure policy, since the transition from mono-functional (grey or green) to multi-functional infrastructure (blue-green infrastructure) is a key element. Until now, the studies of climate change impacts and water sensitive projects have been directed towards large cities,

while little attention has been paid to middle size cities [23]. Middle size cities concentrate a large part of the world population and have more limited resources and more limited expertise than large size cities [16]. Also, in the face of rapid urbanization, there are many emerging and middle-sized cities that warrant further exploration, this study may provide the foundation to understand the challenges of more flexible infrastructure delivery in this type of cities.

Broadly, this research focuses on examining the water governance context of middle-sized cities in Mexico to assess their readiness for leapfrogging to more sustainable urban stormwater management. The paper contributes empirical insights regarding the governance challenges by assessing the governance context of the flood infrastructure policy through the development of green, grey and blue-green infrastructure in middle size cities in Mexico. It is often argued there are systemic issues that often need addressing before such 'leapfrogging', cities or countries may have path dependent institutions and governance mechanisms that prevent such innovative technology adoption. Therefore, this research will assess the governance factors that support and restrict the implementation of BGI to leapfrog by asking the following question: How does the governance context affect the implementation of BGI for leapfrogging towards a WSCs? The next section will explain the concept of leapfrogging in a more detailed manner.

2. The Leapfrogging Concept

First leapfrogging concept was developed in the 1980s [24] and most leapfrogging studies have focused on the automobile industry, semi-conductor industry, wind turbine industry and communication technologies in countries such as Korea, China, South Arabia and India [24–27]. However, from an environmental perspective, it was argued that previous analysis had a narrow focus with simplistic assumptions [27] and/or an overoptimistic perspective [21]. To date, most of the leapfrogging studies present ambiguous objectives, have simplistic assumptions about enabling technologies and the requirements for leapfrogging are underestimated [21]. The few developed studies show that key factors for leapfrogging are different in each case [24]. Therefore, researchers state that: "The capacity for leapfrogging clearly varies from country to country, and from industry to industry" [24]. According to some authors leapfrogging trajectory in developing countries is far more multidimensional than assumed in the existing leapfrogging literature [27].

The literature on sustainability transitions through leapfrogging is "embryonic" [27] and scarce [28]. There is not yet a coherent conceptual basis for prospective analysis and there is a weak theoretical background [27]. Few studies have been developed. Among the most relevant are: Low carbon energy technology [24], new energy technologies [26], wastewater treatment in China [27], river basin management [29] and urban water transitions in Indonesia [30–32].

Leapfrogging might be more challenging than current approaches generally suggest, especially when we are considering a sustainable path [21]. In water studies, there is no clear evidence yet that leapfrogging is possible. Therefore, it is still valid to ask if leapfrogging is realistic [21]. "Innovations to leapfrog the transition with a non-sequential vision for different stages of water cycle management are essential" [12]. "Whether and under which conditions such a leapfrogging would be possible is highly contested" [27]. It is relevant to understand the supportive role of environmental leapfrogging [24]. Currently, there is a project in Porta Vila, Vanuatu. This case has the support of the Asian Development Bank, and it is expected that Porta Vila might be able to leapfrog the Drained City state by implementing practices from a Water Cycle City approach [15].

In order to leapfrog towards a WSCs, the implementation of many different projects, including both centralized and decentralized systems [8] and formal and informal governance approaches [9] appear necessary. However, centralized and decentralized systems operate at different scales and the governance of these systems is different from traditional arrangements, involving different stakeholders to work together [33]. Leapfrogging not only depends on technological capabilities but involves areas such as policy and organizational structures. In short, leapfrogging is dependent on the institutional context [27]. "Institutions provide a fundamental framework that can enable or inhibit the innovations

required for leapfrogging" [24]. "The role of policy processes and institutions in leapfrogging strategies need to be better understood—particularly which policies have been successful in developing critical absorptive capacity" [24]. The challenges of water management in cities under a climate change context are overwhelming and highlight the relevance of solving governance challenges [34]. These 'governance challenges' typically have fragmented scopes, viewpoints, and responsibilities" [34].

In terms of water sensitive city literature, "leapfrogging is a phenomenon in which less developed cities [. . .] can adopt more advanced approaches to address pressing sustainability issues" [31]. It is believed that developing countries have the opportunity to leapfrog since they have lower levels of investment in traditional water infrastructure and the institutional practices are less entrenched. Hence, developing countries can be more receptive to water sensitive practices, since path dependencies and institutional restrictions are not so strong [30]. Three catalysts for leapfrogging have been identified: (a) Trans-disciplinary science, (b) cross-sector partnership and (c) innovation experiments [30]. Trans-disciplinary science means that the proposed solutions should not come from mono-disciplinary approaches, but they should envision holistic solutions with a shared vision among the different stakeholders that include knowledge from different fields and scales. Cross-sector collaboration states the relevance of partnerships between the different stakeholders. This includes academia, business sector, government and civil society. Finally, innovation experiments are important because they provide the opportunity for learning by doing and doing by learning. They also provide the opportunity for knowledge sharing and the possibility to adapt existing solutions to local contexts [30].

One way to study leapfrogging is by analyzing the transition from green and grey infrastructure to BGI, and the analysis of the flood infrastructure policy provides an opportunity for this. BGI can play an important role against floods. It provides the possibility of cost-effective flood management by increasing storage capacity on public and private properties to retain the stormwater runoff. It also decreases evapotranspiration and filtrates water. In this way, BGI can prevent the collapse of drainage systems and mitigate flood risks downstream [14]. A key aspect of BGI is its multi-functionality due to the interrelationship of the projects between the vegetation and the water cycle. In this sense, appropriate BGI is an urban park that absorbs runoff water excess and provides recreational opportunities [14]. It is under these circumstances that water sensitive urban design (WSUD) approach plays a relevant role. The WSUD addresses water quantity and quality issues in urban areas through integrated and natural solutions that include BGI when building infrastructure and landscapes in the cities [14].

Besides the positive aspects of the BGI, its implementation is very challenging. "Transforming urban water practices to more sustainable systems is widely regarded as a water governance challenge" [31]. This challenge implies the involvement of different social, political and economic actors since the transition implies a move from traditional single-service delivery models to a more complex design that is integrated and flexible [31]. Related institutional challenges are lock-in in traditional practices, lack of long-term planning, insufficient policy coherence and lack of resources [14]. Acknowledging the relevance of the governance factors from an institutional perspective, this research contributes to the understanding of the governance factors that can support and limit leapfrogging in middle-sized Mexican cities. To do so, we have selected the city of San Pedro Cholula. This city has a museum built according to the principles of a water sensitive approach and non-governmental actors are promoting the creation of more water sensitive projects, such as multi-functional parks and streets. The next section will describe the case study.

3. Case Study San Pedro Cholula, Mexico

Exposure to floods has increased in Mexico [35]. Due to its geographical position, Mexico is subject to extreme weather phenomena such as a storm or tropical cyclones that provoke destructive floods every year [1]. However, multi-functional infrastructure has only been constructed recently. Most of it is located in Mexico City [20]. An example is the Parque Lineal Paseo de la Viga, which is considered the first water sensitive public space [17]. The park is in the localities of Venustiano

Carranza and Cuauhtemoc. The park is where a water body used to be located and it was part of the water system that reached the locality of Xochimilco (one of the most important lakes in Mexico City) [18].

San Pedro Cholula was selected as the case of study as this middle-sized, flood prone city has implemented or plans to implement grey, green and BGI. San Pedro Cholula is located 125 km from Mexico City and 13 km from Puebla city, the capital of Puebla state. In 2015, San Pedro Cholula had a population of 129,032 inhabitants and a density of 1684 people per square km [36]. Together with the other 10 municipalities, it constitutes the Puebla Metropolitan Area. This is the fourth largest metropolitan area in Mexico with 2.3 million inhabitants [37]. According to the 2015 flood risk study; although San Pedro Cholula was scored as low risk, in the last years atypical rainfalls have become more frequent and they have provoked serious floods in San Pedro Cholula [38,39] and other municipalities of the metropolitan area such as Cuautlancingo and Coronango [40]. The annual rainfall varies between 817 and 1050 mm per year [39]. One of the most affected areas is the *Barrio de Santiago,* where the accumulation of water has reached a level of 50 cm [39]. This problem has become very common and 2019 was not the exception. The interviewed non-governmental actors reported a major flood event in September. The problem has become so common, that some houses have increased the level of their entrance to avoid floods inside the houses. Figure 2 below shows this.

Figure 2. The red box shows the elevated entrances that decrease the flood impacts.

San Pedro Cholula is faced with common challenges similar to other middle size cities in Mexico: moderate to high percentage of water supply services and sewage [41], lack of wastewater treatment infrastructure [42], inappropriate flood infrastructure to deal with the raining season and a decreasing percentage of water availability. San Pedro Cholula still has centralized infrastructure and institutions, as it will be explained below. These characteristics will place the city in the early stages of the Urban Water Management Transition Framework (Figure 1). Actually, the city is part of the watershed that feeds into the third most polluted river in the country, the Atoyac river [43,44]. Figure 3 shows the location of the city.

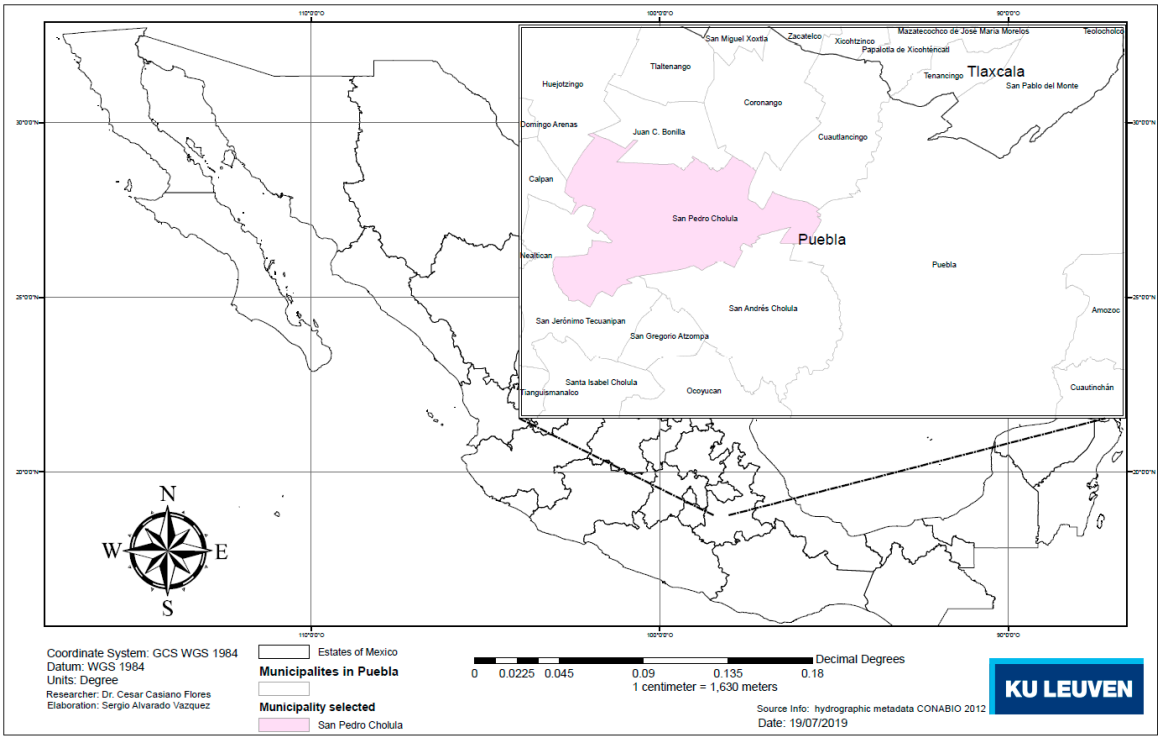

Figure 3. San Pedro Cholula location.

Due to the effects of climate change, it is expected that this region will suffer negative impacts [45,46], floods being one of the most important. As it is well known, floods cause billions of euros of damage every year and due to climate change, their impact is expected to increase [47]. The government has implemented some traditional grey infrastructure projects, such as storage reservoirs [48]. Among the most important latest infrastructure projects against the city floods are the construction of rainwater collectors and water reservoirs. The latest rainwater collector was finished in 2013. This rainwater collector is 8.1 km long and it conducts the water from the city to the Atoyac river [49]. In the case of water reservoirs, the latest important project in the municipality was the water reservoir in Figure 4 (top-left). This project took place in 2017 [50] and the plan of the government is building a total of five [51]. Still, the aforementioned projects have not solved the flood issues. Every year during the raining season the city of San Pedro Cholula struggles with flash floods due to the runoff from the Zapotecas mountain, the increased water level from the Rabanillo river and the lack of proper infrastructure in the city. The municipal government is currently financing a flood risk study. However, this study does not consider BGI. The proposal is the construction of more traditional stormwater storage reservoirs around the mountain and more rainwater collectors. The most innovative project in the city from a water sensitive city perspective is the Museo Regional de Cholula that opened in 2017. This museum is located beside the Cholula's pyramid. The structure of the project is described as the largest public building that catches, uses and treats rainwater. This museum helps to decrease flood issues by catching rainwater and due to its closed water cycle, wastewater is treated locally and reused. This project was presented at the 16th International Architecture Exhibition in Venice [52]. Figure 4, contains images of the museum.

Figure 4. Museo Regional de San Pedro Cholula, own source.

In general, the flood infrastructure projects that are taking place in San Pedro Cholula can be classified in three categories. Grey infrastructure, which includes traditional water reservoirs and rainwater collectors, green infrastructure, such as reforestation projects and the multi-functional (blue-green) infrastructure, which includes the Museo Regional de Cholula and the *barrio* (neighborhood) project. The *barrio* project is located in the *barrio* of Santiago and has been an initiative of the neighborhood, since the government has not solved their flood issues. The idea of this project is to build a multi-functional street and a multi-functional park, where a traditional storage reservoir was built. The museum's water infrastructure was built in 2016 by Centro DIA. Figure 5 contains images of the street and the area where the water sensitive projects will take place. Figure 6 shows the location of the aforementioned projects in the city.

Figure 5. Street and land where social actors want to implement the water sensitive projects, own source.

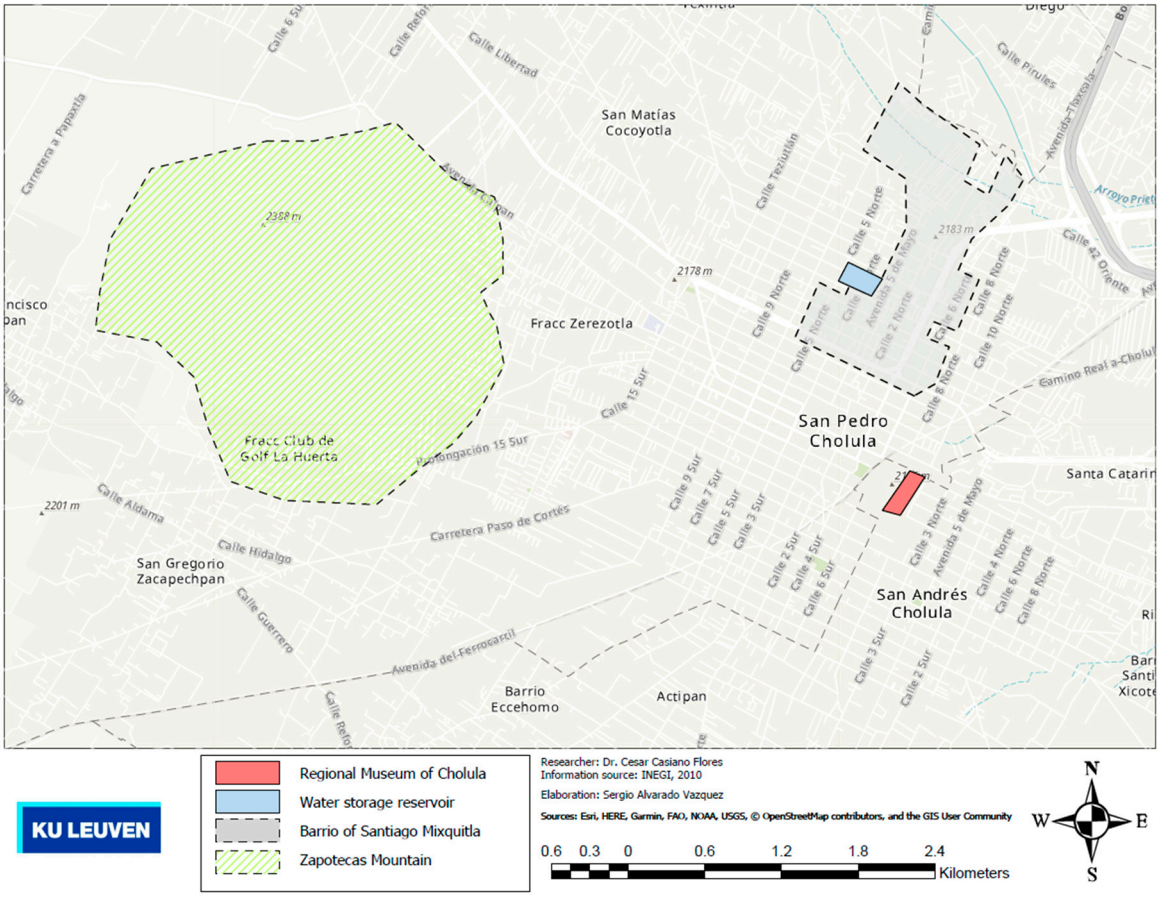

Figure 6. Location of the projects in San Pedro Cholula.

Besides these infrastructure projects, there is a well-organized flood emergency brigade, which, depending on the severity of the emergency, can also include the other two higher government levels (state and federal). As part of the flood actions, the brigade collects garbage from the drainage and opens the drain covers when streets are flooded. The brigades share information at the metropolitan level. Currently, the main actions take part in the capital city, Puebla. They have continuous communication with all the government institutions involved in flood emergencies via WhatsApp. When a flood event takes place, the first response comes from the municipal level, in case the flood emergency surpasses its capacities, they can ask the support of the higher government levels. According to the government actors, there are two main reasons for floods: garbage obstructing the curb inlets and the limited drainage capacity.

4. The Governance Arrangement for Flood Infrastructure Policy

The flood governance arrangement in Mexico includes an important number of actors. According to article 83 of the National Water Law, the CONAGUA (National Water Commission) through its delegations or Basin Organizations are responsible for the classification of flood risk areas in order to implement the required protection projects. It is also in charge of operating the infrastructure that can help to prevent floods such as dams. The legal responsibilities of CONAGUA are derived from the National Water Law, the Secondary Regulation Law of CONAGUA, the National Plan of Development and the National Water Plan [53]. Other flood-related legislation at the national level is the General Law for Human Settlements, Territorial Organization and Urban Development which last reform was in May 2019 [53]. At the state level, the flood-related legislation is the 2015 State Water Law. Although it does not mention explicitly a flood policy, it requires pluvial plans and infrastructure from urban developers and in its article 76 states that rainwater will be caught and conducted to the public network

to be treated and if possible, reuse. It is the responsibility of the water utility to attend any contingency related to hydro-meteorological phenomena. Other state legislations are the 2013 State Protection System Law which regulates the state and municipal government actions in case of emergencies or disaster and the 2017 Territorial Organization and Urban Development Law, which highlights the relevance of hydro-meteorological phenomena and integral water management for the metropolitan areas. At the municipal level, the Secretaries in charge of the flood policy are Secretary of Infrastructure and the water utility.

According to the Mexican water governance system, the CONAGUA plays the leading role to mitigate the impacts of hydro-meteorological risks such as floods in Mexico. CONAGUA has built a large infrastructure network to store and regulate water floods. While CONAGUA has played the primary role in infrastructure building, the environmental risks have required coordination with other governmental agencies [35]. Among those are the CENAPRED (National Centre for Disaster Prevention) which is in charge of flood warning systems [35] and the FOPREDEN (Fund for Natural Disaster Prevention) which instead of financing preventive measures, it has become a mechanism to finance the reconstruction of flooded areas [54]. River beds and their surrounding areas are the responsibility of CONAGUA, while land use and urban policies are under the authority of the municipalities, actually, some municipalities contribute to flood protection projects [35]. The 2030 Water Agenda in its initiative 9, recommended agreements between CONAGUA and CONAFOR (National Forestry Commission) to coordinate reforestation programs as part of the water, land use and territorial strategies. This proposal has been developed since CONAFOR already contributes to the watershed management through its reforestation policy [35].

To deal with catastrophic events, the Mexican government created the SINAPROC (National Civil Protection System) in 1986. The SINAPROC allows multi-institutional coordination where governmental agencies and non-government actors participate. Among the governmental agencies are CONAGUA, SINAPROC, CENAPRED (National Centre for Disaster Prevention), the USMN (Unit of National Weather Service) and SEGOB (Ministry of Internal Affairs) [35].

In the case of the grey infrastructure projects, the three government levels are involved. Usually, the municipal government proposes a project based on the federal government programs' guidelines, called rules of operation. The federal program that supports the creation of rainwater infrastructures such as rainwater collectors or infiltration wells is called PROAGUA (Program for drinking water, drainage and wastewater treatment). When the infrastructure project is being built, it is common to have the support of the CEAS (Water and Sanitation State Commission) and CONAGUA. There are also cases where the CEAS builds rainwater collectors with the support of CONAGUA. This happens when municipalities do not have the capacity or the resources to plan and build this type of project. Once the project is finished, CONAGUA and CEAS turn over the municipality the responsibility of the new infrastructure. In general, CONAGUA designs, authorizes and finances different types of flood protection projects proposed by the lower government levels. In some circumstances, CONAGUA itself carries out projects of maintenance, the rectification and dredging of rivers.

The relation of the municipal government with CONAGUA and with CEAS is mainly through the SOSAPACH (municipal water utility), the Secretary of Infrastructure and the Secretary of Urban Development. The SOSAPACH is responsible for cleaning both the drainage infrastructure and sewage covers as well as the substitution of the wastewater drainage line. SOSAPACH also conducts a campaign to encourage people to keep the sewages clean. Pluvial water infrastructure at the municipal level is the responsibility of the Secretary of Infrastructure. The Secretary of Infrastructure is financing a study to identify the flood-prone areas. According to the study, one of the main causes of floods is the runoff water from the Zapotecas. Therefore, the main objective of the Secretary is to build regulating reservoirs and to connect the existing rainwater collectors by building new ones. In this way, the water from the flooded areas can be sent to the Actiopa, Rabanillo and Ametlapanapa rivers. For the regulating reservoirs, they are not considering any BGI project.

The Secretary of Urban Development considers flood issues to play a secondary role and are not part of their responsibilities. Still, when they authorize new urban developments, they require information about flood-prone areas or sewage infrastructure. Then they request this information from the SOSAPACH or CONAGUA, depending on the area and the jurisdiction of each case.

In the case of the green infrastructure projects, the CONAFOR (National Forest Commission) has its programs and the lower government levels or social actors have to align with their rules of operation. The programs that are aimed at reforestation and the construction of individual terraces are part of the Component III (Forrest restoration and productive reconversion). CONAFOR reforestation projects are also part of the government strategies against climate change. The projects can only take place in those areas that have been previously identified and approved by the federal government. Currently, there is no project in the Zapotecas mountain. However, the municipal level through the Secretary of Ecology is planning rainwater catchment projects and to do so, they plan to ask the federal government for support. Those projects will involve reforestation and the creation of individual terraces. The infrastructure that they are planning has to be rustic and therefore cannot be grey infrastructure. Grey infrastructure is not allowed by the management program of the Zapotecas mountain.

Besides the actors mentioned above who are directly involved at the municipal level, there is another important government actor at the state level. It is the Module of Information about the Atoyac River (MIRA). The MIRA is located in Puebla city, it provides information to citizens and authorities of Puebla state about water issues and solutions from a watershed perspective. The MIRA is certified by the federal government as an environmental education center. The MIRA includes the Metropolitan park. This park located in Puebla city has rainwater catchment systems. In the case of the multi-functional infrastructure (the museum and the *barrio*), non-government actors play the key role.

5. Theoretical Framework for the Governance Assessment

This research will employ the Governance Assessment Tool (GAT) to assess how the governance context affect (support or restrict) the implementation of BGI to leapfrog. The GAT is part of the frameworks that consider the relevance of contextual factors when implementing a policy [55–61]. Contextual consideration requires context-specific answers, rather than "panaceas" or "universal remedies" [57,62,63]. The GAT is based on the Contextual Interaction Theory (CIT) [64–68]. It is a framework that can be applied when there is a multi-level setting with interdependency among the actors. This means that different levels should act as semi-autonomous units and power must be diversified [69]. This interdependence must at least be classified as a "legislatively initiated coordination" [69] even if it is not fully implemented.

Previous applications of the GAT have delivered valuable outcomes for the understanding of the Mexican water governance context [43,44,70–73]. The GAT considers governance as "beyond merely government", it is a context for decision-making and implementation; which can be both supportive and restrictive for those processes. Governance here assumes the existence of five dimensions [74]. GAT divides the descriptive-analytical elements and the semi-normative qualities of the governance context. The five descriptive-analytical elements are called the "dimensions of governance", which are multi-level, multi-actor, multi-faceted, multi-instrument and multi-resourced based. These five dimensions describe the governance regime [56] and they are attributes upon which the governance quality is assessed. The "semi-normative" characteristic implies that the normative contents of the qualities are derived from and thus are dependent on the policies under assessment. The four semi-normative qualities are: Extent, coherence, flexibility and intensity. Together, the dimensions and the qualities measure how supportive the context is for the implementation of the policies under study. The four criteria are defined by the questions they pose [74]:

Extent: Are all elements in the five dimensions, which are relevant being addressed, taken into account?

Coherence: Are the elements in the dimensions of governance supporting, rather than contradicting, each other?

Flexibility: Are multiple roads to the goals, depending on opportunities and threats as they arise, permitted and supported?

Intensity: How strongly do the elements in the dimensions of governance urge changes in the status quo?

The questions around each of the dimensions allow a systematic analysis of the governance context. The combination of the five dimensions of governance and the four qualities make up the GAT 'matrix' model [68]. This matrix model has been employed to assess the governance context for leapfrogging. Table 1 presents the matrix. The matrix has been applied to interview stakeholders and to evaluate the governance context.

Table 1. Water governance matrix.

	Qualities of the Governance Regime			
Governance Dimension	**Extent**	**Coherence**	**Flexibility**	**Intensity**
Levels & Scales	Is there a participation of all the relevant government levels?	Are the government levels working together?	Is it possible that given the issue at stake lower or higher government levels take the lead?	Is there a government level or levels promoting the innovative projects?
Actors & Networks	Are all relevant actors involved?	Are government and non-government actors working together and trust each other?	Is it possible to include new actors to create social capital and to support each other's task?	Is there a non-government actor or a coalition of actors promoting the innovative projects?
Problem Perspectives & Goal Ambitions	Are the different perspectives being considered?	Are the key actors sharing a similar goal and vision?	Are there opportunities to re-assess goals?	How different are the goals from the status quo?
Strategies & Instruments	Are all the instruments and strategies being considered?	Are their overlaps or conflicts among the different strategies and instruments?	Are there opportunities to combine different instruments or strategies?	Are the current strategies and instruments appropriate for the innovative projects?
Responsibilities & Resources	Are responsibilities clearly assigned with sufficient resources?	Is there collaboration across institutions to support each other responsibilities' and to combine resources?	Is it possible to pool responsibilities and resources without jeopardizing accountability?	Are the resources sufficient to implement the measures needed for the intended change?

6. Methodology

This research proposes an in-depth case analysis. This setting allows paying attention to details overviewed by statistical analyses [75]. Case studies complement theory and allow generalizations of theoretical propositions [76]. In depth case studies of urban water transitions can help to understand the dynamics of water transitions [77]. Actually, case studies have been the pillar of transition studies and they are important to enhance the explanatory capacity of transition frameworks [77]. The methodology applied in this research is based on the GAT. The GAT has an institutional perspective and it includes contextual considerations [74]. The GAT enables a systematic analysis of the governance context to diagnose to what extent it restricts or supports policy implementation. To do so, interviews with policy

implementers is a key aspect. Due to the objective of this research, the interviews were conducted with the actors involved in the implementation of grey, green and BGI infrastructure projects. A total of 18 interviews from 11 agencies took place in June 2019. Each interview lasted an average of one hour. At the municipal level, most of the respondents were the heads of the secretariats and in some cases, they assigned the director or head of the department that they considered appropriate. At the state and federal level, the interviews were conducted with the directors or under directors/heads of departments who in some cases included part of their staff. With the state government, the interviewed actors belong to the infrastructure department (planning and implementation) department. While with the federal government the interviewed actors belong to the infrastructure department of CONAGUA and in the case of CONAFOR, the officials in charge of Componente III and reforestations. The interviews with non-government actors were conducted with the coordinators of the *barrio* project and for Centro DIA with the director and founder of the firm. Table 2 shows the affiliation of each actor interviewed.

Table 2. Affiliation of the interviewees.

Federal Government	State Government	Municipal Government	Non-Government Actors
National Water Commission CONAGUA	Water and Sanitation State Commission CEAS	Secretary of Urban Development, San Pedro Cholula	Coordinators of the *barrio* water sensitive project
National Forest Commission CONAFOR	Module of Information about the Atoyac River MIRA	Secretary of Ecology, San Pedro Cholula	Reforestation activist
		Secretary of Infrastructure, San Pedro Cholula	Other water social activists
		Water Utility of San Pedro Cholula SOSAPACH	Urban Developers professional association
			Centro DIA -Water Sensitive Project Designers

Table 3 below, shows how we operationalized Table 1 in order to assess the three catalyst factors of leapfrogging under the GAT framework. The GAT assessment matrix has shown its academic relevance in previous publications, where they were used to evaluate the implementation of the wastewater treatment plant policy in Mexico [44,70].

The evaluative quality is assessed based on the interviewees' answers. To assess each cell of the matrix, each stakeholder response was analysed individually, then compared and/or complemented with the rest of the stakeholders' answers and data from secondary sources. The results are considered reliable because the majority of the stakeholders consistently reported in similar and complementary ways. As in previous GAT applications, the degree of the quality in each dimension is compared with the rest to find a general assessment per quality [44]. The quality can be assessed as: High support, Moderate support, Moderate-low support and Low support. When most of the governance dimensions are assessed from moderate to high, the quality is considered supportive, otherwise it is restrictive. Moderate is when most of the categories are from moderate-low to high. Moderate-low is when most of the categories are assessed from moderate-low to low and it is low when there is an overwhelming majority of low degree in each category of the quality. The next section will present our assessment results.

Table 3. Water governance assessment rubric for leapfrogging.

	Qualities of the Governance Regime			
Governance Dimension	**Extent**	**Coherence**	**Flexibility**	**Intensity**
Levels & Scales	**High:** All levels are involved in the implementation of BGI projects **Moderate:** Some levels are involved in the implementation of BGI projects **Low:** The levels are involved in the implementation of mono-discipline projects	**High:** All levels work together and trust each other to implement BGI projects **Moderate:** Only some levels trust each other to implement BGI projects **Low:** The levels work together and trust each other to implement mono-discipline projects	**High:** All levels are willing to move up and down levels in order to support the implementation of BGI projects **Moderate:** Some levels are not willing to move up and down levels but they support the implementation of BGI projects **Low:** The levels are not willing to move up and down levels and they only support mono-discipline projects	**High:** All levels are working together to support behavioral change in favor of BGI projects implementation **Moderate:** Some levels are working to support behavioral change in favor of BGI projects implementation **Low:** The levels are not working to support behavioural change
Actors & Networks	**High:** There is cross-sectorial collaboration among stakeholders to implement BGI projects **Moderate:** Most stakeholders participate in cross-sectorial collaboration to implement BGI projects **Low:** There is no cross-sectorial collaboration among the stakeholders	**High:** There is a cross-collaboration to implement BGI projects. It is institutionalized, stable and there is trust **Moderate:** There is cross sectoral collaboration to implement BGI projects but it is not institutionalized **Low:** There is no cross-sectorial collaboration. The institutionalised implementation is mono-disciplinary	**High:** The stakeholders network facilitates the inclusion of new actors, shift leadership and social capital creation, in favor of the BGI project implementation **Moderate:** Most stakeholders in the network facilitate the inclusion of new actors, shift leadership and create social capital, in favor of the BGI project implementation **Low:** The stakeholders' network restricts the inclusion of new actors, shift leadership and social capital creation in favour of the BGI project implementation	**High:** There is a cross-sectoral coalition of stakeholders to support behavioral change in favor of BGI projects implementation **Moderate:** There is a fragmented coalition of stakeholders that support behavioral change in favor of BGI projects implementation **Low:** Stakeholders do not support behavioural change in favour of BGI projects
Problem Perspectives & Goal Ambitions	**High:** Cross sectorial and trans-disciplinary perspectives are considered **Moderate:** Most cross sectorial and trans-disciplinary perspectives are considered **Low:** No cross sectorial or trans-disciplinary perspectives are considered	**High:** The cross sectorial and trans-disciplinary perspectives support each other **Moderate:** Most cross sectorial and trans-disciplinary perspectives support each other **Low:** There is no cross-sectorial and trans-disciplinary perspective. Perspectives only support mono-discipline and sectorial implementation	**High:** It is possible to reassess goals during the implementation of BGI projects **Moderate:** It is not possible that the goals can be reassessed during the implementation of BGI projects **Low:** It is not possible to reassess the goals. Those goals only support mono-discipline and sectorial implementation	**High:** No changes in the stakeholders' perspectives are required to implement BGI projects **Moderate:** Changes are required in some of the actors' perspectives to achieve the implementation of BGI projects **Low:** Changes are required in all the stakeholders' perspectives to implement BGI projects
Strategies & Instruments	**High:** Innovative strategies, including pilots are considered by the stakeholders **Moderate:** Innovative strategies, including pilots are considered only by most of the stakeholders **Low:** None stakeholder considers innovative strategies, including pilots	**High:** The institutionalized instruments and strategies support innovative strategies and create synergies **Moderate:** The institutionalized instruments and strategies support limited innovative strategies **Low:** The institutionalized instruments and strategies do not support innovative strategies. The strategies and instruments only support mono-discipline and sectorial implementation	**High:** The stakeholders have the opportunity to combine and use different instruments in a pragmatic manner to implement BGI projects **Moderate:** The stakeholders have the opportunity to combine and use different instruments to implement BGI projects as long as the law allows it **Low:** The stakeholders do not have the opportunity to combine and use different instruments to implements BGI projects	**High:** Stakeholders consider there is no need to change their strategies from current practice to implement BGI projects **Moderate:** Stakeholders consider that minor changes in their strategies from current practice are needed to implement BGI projects **Low:** Stakeholders consider that major changes in their strategies from current practice are needed to implement BGI projects

Table 3. *Cont.*

	Qualities of the Governance Regime			
Governance Dimension	**Extent**	**Coherence**	**Flexibility**	**Intensity**
Responsibilities & Resources	**High:** All stakeholders have assigned responsibilities with sufficient resources to implement BGI projects **Moderate:** Most stakeholders have assigned responsibilities and resources to implement BGI projects **Low:** Responsibilities and resources are assigned to implement mono-discipline projects	**High:** The responsibilities and resources of each stakeholder are clear when supporting cross-sectorial and trans-disciplinary implementation of BGI projects **Moderate:** Some responsibilities and resources conflict with each other to implement cross-sectorial and trans-disciplinary projects **Low:** The responsibilities and resources assigned are clear but they do not support cross-sectorial and trans-disciplinary projects	**High:** The stakeholders can pool their responsibilities under effective accountability mechanisms to implement BGI projects in a pragmatic manner **Moderate:** Most stakeholders during the implementation of BGI projects can partially pool some of their assigned responsibilities with effective accountability mechanisms in a pragmatic manner **Low:** The stakeholders cannot pool their assigned responsibilities with effective accountability mechanisms to implement BGI projects in a pragmatic manner	**High:** The stakeholders consider there are the enough resources for the implementation of BGI projects **Moderate:** The stakeholders consider there are few resources that support the implementation of BGI projects **Low:** The stakeholders consider the available resources only support mono-discipline projects

7. Governance Assessment of the Flood's Infrastructure Policy in San Pedro Cholula

This governance assessment section is organised considering the governance quality and its relation with the five governance dimensions.

7.1. Extent

7.1.1. Levels & Scales: Low

The levels are involved in the implementation of mono-disciplinary projects. The federal, state and municipal government levels participation is limited to well-established mono-disciplinary programs. The three government levels carry out two types of actions that can help to decrease flood risks: reforestation and the creation of traditional hydraulic infrastructure. In the case of hydraulic projects, CONAGUA is the main actor. They have established programs to finance the construction of infrastructure against floods. The new administration of San Pedro Cholula that took office in 2018 has not submitted any projects yet. However, the municipal authorities have expressed their interest in participating in federal programs. For example, the Secretary of Infrastructure wants to submit the projects to CONAGUA. They expect that CONAGUA authorizes and finances their projects according to the rules of operation. The projects are traditional grey infrastructure.

For the reforestation projects, the main actor is the federal government. CONAFOR pays for reforestation services to recover and to increase green areas. In most of the cases, CONAFOR also provides the trees to government and non-government actors who are interested in reforestations. The Secretary of Ecology expects to work with CONAFOR. They intend to build terraces and regulatory reservoirs in the Zapoteco mountain to decrease the runoff water and to increase water storage capacity.

The Secretary of Urban Development is indirectly related to CONAGUA. This secretary requests to the urban developers a document called *factibilidad*. The *factibilidad* is issued by the CONAGUA, it is an authorization from the federal government that states that the specified area does not have restrictions to be urbanized or can present a risk to the inhabitants. This could happen if a project is authorized inside a riverbank area.

The Museo regional was a state government project. The state government selected the firm that renovated the museum building. The selected firm hired Centro DIA. Centro DIA develops closed water cycle projects. The project developed by Centro DIA was accepted by the government actors since it was not feasible to develop a traditional project due to the lack of sewage and water supply

infrastructure in the area. The project included drinking water fountains that are supplied by filtered rainwater. The *barrio* project is expected to be trans-disciplinary still, it has not included government actors yet. Some non-government actors do not expect direct participation from any government level. In this sense, they expect limited government participation where they only issue the required permits for the project.

7.1.2. Actors & Networks: Moderate-Low

Only non-governmental actors are willing to participate in cross-sectorial collaboration to implement BGI projects. The involvement of the actors is fragmented, each network of actors has its own projects. While vertical government relation is well organized, the involvement between the different government institutions at the horizontal level to support cross-sectorial collaboration is less organized. Some government actors mentioned that they would like to have a closer collaboration at the same government level.

Except for the mono-sectorial projects of reforestation, there is no collaboration between government and non-government actors. In general, government actors point out that no non-government actors have expressed interest to support them with their projects. Non-government actors report a similar situation regarding government actors. One of the non-government actors stated that she has worked on reforestation programs with the support of the university where she works or other universities. She considers that in many cases the government reforestation campaigns are "only for the picture". Meaning that the government cares more about publicity than real results.

7.1.3. Problem Perspectives & Goal Ambitions: Moderate-Low

Only non-governmental actors consider the implementation of innovative strategies or pilots. When it comes to the creation of infrastructure against floods, only the perspective of the government is considered. Due to the alignment with the federal government perspective, the different government actors share a common perspective and goal, which do not include innovative projects. The perspectives of government and non-government actors are different. Some differences are due to the limitations of the legal framework. One example is rainwater gardens, which are currently not considered in the municipal urban law. One of the *barrio* project coordinators emphasizes the need of legislative reform to support the creation of green infrastructure together with grey infrastructure.

The museum case by itself shows the different perspectives of the non-government and the government actors. The building of the museum used to be the Psychiatric hospital of Cholula. In the beginning, the state government wanted to construct a hotel, as part of a tourist project that would include shopping centers and restaurants. This area has a cultural, historical and spiritual meaning for the inhabitants of Cholula. The expropriation of the area by the state government resulted in a serious social conflict that included legal demands and protests from the citizens against the government. The situation escalated to the level that leaders of the movement were sent to prison [78]. The initial idea of the government was to build traditional water infrastructure. Actually, press reports state that the original project included a swimming pool, hydro massages and douches [79]. This is very different to what Centro DIA did at the end. Centro DIA managed to convince the state government to accept a more innovative project. Rainwater catchment systems are not common in government construction, just very few places have it. In those cases, it is related to certifications that the government has tried to obtain. In summary, as one non-government interviewed actor stated "the expectations of the government and society are different" and social perspectives are not being considered in government projects.

7.1.4. Strategies & Instruments: Moderate-Low

Innovative strategies are considered only by non-government actors. Government actors do not consider innovative strategies. Under the current governance system, it is very difficult to consider a different type of instruments outside the rules of operation. Sometimes there are projects at the

metropolitan level, which are more integrated, but the resources are already assigned to specific purposes. As one non-government actor stated: "many actors have a limited vision". It seems like, besides the rules of operation, this situation also hinders the combination of instruments. The Secretary of Ecology expects that its actions in the Zapotecas mountain can help to reduce the cost of the project in the downstream area. The project is expected to cost around 10 million euros. However, the collaboration between Ecology and Infrastructure is still pending. Social actors are open to considering different strategies and instruments. Due to the early stage of the *barrio* project, social actors think that this is the right time to try to combine different resources and instruments available.

7.1.5. Responsibilities & Resources: Moderate-Low

Only a few stakeholders have assigned responsibilities and resources to implement BGI projects. The government actors agree that in general their responsibilities are clearly defined by the law. This clarity also includes their participation in mono-disciplinary federal programs. Regarding the resources for the mono-disciplinary strategies, the majority of the government actors consider that most of the time they have the resources that are needed. Only in some cases where big infrastructure projects take place, additional resources are required. Still, the water utility company considers that it would be positive if more people were willing to pay their water service, so they could have more resources to invest in infrastructure projects. Among the three government levels, the municipality is considered the actor with fewer resources. In the case of the *barrio* project, the barrio project actors are positive that they can access different types of private or even some government resources to finance parts of their strategy. One of the *barrio* project actors even assured that she already had negotiated with a company to finance the *barrio* project for the next 10 years. However, this still has to be discussed with other non-government actors.

7.2. Coherence

7.2.1. Levels & Scales: Low

The levels work together and trust each other to implement mono-disciplinary projects against floods. The government levels are aligned and work together when it comes to CONAGUA and CONAFOR programs. This alignment is derived from the rules of operation that regulate federal programs. The alignment is a requirement of the federal government to approve and to finance water-related projects, reforestation and terraces construction. The municipal authorities acknowledge this situation and their projects are based on the federal rules of operations. Currently, under the supervision of the Secretary of Infrastructure, the municipality is financing a study that can allow them to access the CONAGUA federal programs. In the case of flood infrastructure projects, the common procedure is: the municipality designs the project based on CONAGUA's rules of operation. Then the project is part of a tender process where CONAGUA evaluates the proposals. Once the selected proposal is accepted, depending on the agreements the construction process starts and its construction is monitored by CONAGUA or the lower government levels. Besides the projects of the Secretary of Infrastructure, SOSAPACH also applies to CONAGUA programs, such as PRODDER. PRODDER is a program that finances water utilities' projects using funds obtained by CONAGUA via taxes. Some government actors with long experience in the government consider that there has been a progressive improvement in the alignment with mono-disciplinary federal projects.

In the case of reforestation, the alignment with the federal government policy is important to obtain the trees. CONAFOR provides approximately 70% of the trees that the municipalities plant. In the case of the museum, this was an initiative of the state government who never thought about the project innovatively. However, Centro DIA changed the project to create a BGI project. In the case of the *barrio* project, the social actors are aware that if they want support from the different government levels, they need to adapt the project according to the rules of operations of the government programs.

7.2.2. Actors & Networks: Moderate

There is no institutionalized cross-sectorial collaboration. The institutionalized implementation is mono-disciplinary. There is institutional trust among government actors. However, this level of trust decreases when it comes to law enforcement. For example, there are complaints about the lack of law enforcement at the municipality level. There are constructions in flood-prone areas. When it comes to the collaboration between government and non-government actors there is less trust. One of the interviewed non-government actors stated: "the community does not trust the government". Some government actors consider that this is in part due to the poor results of the previous administrations or their failure to communicate what they are doing.

7.2.3. Problem Perspectives & Goal Ambitions: Low

There is no cross-sectorial and trans-disciplinary perspective. Perspectives only support mono-disciplinary and sectorial implementation. Government and non-government actors have different visions and goals. In the case of the government actors, the current governance system promotes the creation of synergy through the CONAGUA and CONAFOR programs' rules of operation. However, this is a mono-disciplinary synergy and it is not extended to the participation of non-government actors.

The projects dealing with floods show different visions and goals. While the government actors want to connect the rainwater collectors to the rivers around the city, the social actors want to keep the water in the area to filtrate it to decrease water scarcity. In the *barrio* project, several social actors believe that synergy could be created due to all the aspects of the project. This should include different types of actors in the upstream area of the watershed, the social actors directly affected by the park and the street projects. Their idea is to create synergy with the project. In this sense, one factor that decreases the creation of synergies is the different perspectives. Many times the government does not see these opportunities in a trans-disciplinary perspective. For example, when building a park, the government asked the contractor for a rubber speedway in a flood-prone area. This ended up creating bigger flood issues, instead, they could have asked for materials that allow rainwater infiltration. Currently, social actors also believe that the museum could support the creation of a shared and more integral vision. However, this requires the involvement of the current government authorities. Myths still exist about the quality of the rainwater for drinking purposes. People believe it is highly polluted water. In the case of the museum, the rainwater for human consumption is even certified. In this regard, society and authorities could become more aware of the benefits of rainwater.

7.2.4. Strategies & Instruments: Low

The institutionalized instruments and strategies do not support innovative strategies. The strategies and instruments only support mono-disciplinary and sectorial implementation; which are the strategies and instruments based on the federal programs. The three government levels must follow the federal programs' rules. If a municipality or a state does not align its policy with the federal government, they cannot access the federal resources. The Secretary of Infrastructure plans to build traditional water reservoirs and rainwater collectors, but rainwater catchment systems, water sensitive infrastructure or green infrastructure are not being considered.

When comparing the strategies of the government and the non-government actors, it is clear that they are very different. While the government continues with business as usual practices, the non-government actors are looking for more innovative ways to deal with floods. However, these strategies are not institutionalized. In the words of a non-government actor: "while the government wants to send the water away, we want to keep it". Another difference regarding strategies concerns the garbage campaign and actions. While the government is proud of these, non-government actors consider them limited and not really solving the problem.

7.2.5. Responsibilities & Resources: Low

The responsibilities and resources assigned are clear, but they do not support cross-sectorial and trans-disciplinary projects. The federal actors are the ones with the most resources. As far as the federal programs are concerned, the responsibilities are clear and the resources of the three government actors complement each other. This is the spirit of the programs' rules of operation. However, collaboration across institutions at the same government level is less developed. Certain discrepancies were pointed out between the different secretaries. It seems that the municipal government is prioritizing grey infrastructure over green infrastructure and this creates tensions between the Secretaries of Ecology and Infrastructure. The collaboration between Urban Development, Ecology, SOSAPACH and Infrastructure is perceived by the municipal actors as less collaborative than the multi-level one. Even Urban Development and Cadastre have discrepancies regarding some properties' characteristics and owners.

When it comes to the inclusion of non-government actors, the situation is more complicated, since most cases it is not considered by the current legislation. In many cases, the rules of operation limit the non-government actors' responsibilities to monitoring the development of the project and its appropriate implementation, but they do not allow direct participation in the planning stage and the subsequent actions. In this sense, the legislation also limits collaboration.

7.3. Flexibility

7.3.1. Levels & Scales: Low

The levels are not willing to move up and down levels and they only support mono-disciplinary projects. The lead comes from the federal government and the lower levels have to align with it by following the federal rules. The different government actors consider that they support each other. CONAFOR supports actors who are mainly interested in planting trees and considers that there is less interest in rainwater catchment system projects such as the terraces. When social actors evaluate government actors, they consider that it is the capital of the country, a large city, the one who is leading the innovative approach. Some actors consider that this is in part due to the high degree of water stress and floods that the city faces. Actually, according to non-governmental actors, Mexico City has the most advanced water management legislation. Centro DIA has developed water sensitive projects in Mexico City, being one of them in the Iman park. Social actors are aware of the federal programs and they realize their vision is different from the government actors. Therefore, they consider that it would be challenging to get government support.

7.3.2. Actors & Networks: Low

The stakeholders' network restricts the inclusion of new actors, shift leadership and social capital creation in favor of the BGI project implementation. It is not possible to involve new actors in the mono-disciplinary government programs. The rules of the programs establish who and how each actor participates and this cannot be changed during the implementation of the project. In the case of CONAFOR, once the agreement has been signed, it has to be respected. For funding aspects, just under special circumstances, the terrace projects can be modified, but this should not exceed 5% of the authorized budget. These limitations are put in place to avoid corruption or overpricing.

In the case of the *barrio* project, one of the coordinators expects to include the relevant actors since the project is actually ambitious. The final aim is to create what they call an *eco-barrio*. This *eco-barrio* will include not only water management but waste management, local consumption, etc. They have started an awareness program in the *barrio* to give a positive meaning to water. They want people to see the positive side of the water that provokes floods. Dafné Borromeo, one of the *barrio* project coordinators calls this process "hydro-evangelism". Nowadays, citizens mostly see water as a problem. However, if the water is managed well, it can help to decrease water scarcity issues. Regarding the museum, non-government actors think that the current municipal administration could create an

educational program. The museum could be an ideal location to promote water literacy among the citizens. This could help create social capital in the long-term. However, non-government actors have perceived a lack of interest from the government.

7.3.3. Problem Perspectives & Goal Ambitions: Low

It is not possible to reassess the goals and the goals only support mono-disciplinary and sectorial implementation. According to the government actors, due to the rules of operation of the programs and the process of authorization, unexpected problems or new goals are not part of the process. In case some issues appear, they need to respect the restrictions established by the law. Government actors report that changes in projects are unusual. This situation can also be related to the fact that there is no innovation in programs or projects. So they have accumulated experience for the mono-disciplinary and sectorial projects they implement. In case that changes are required, the state law authorizes an extra budget of up to 25% and forbids any significant change in the project. One government actors stated: "the projects have rules and they must be followed".

For the *barrio* project, the social actors consider that bringing changes to the goals of the project once the project has started, can create extra challenges. This is because the expected number of actors involved will be high and any change will require a new agreement among all the actors.

7.3.4. Strategies & Instruments: Low

The stakeholders do not have the opportunity to combine and use different instruments to implements BGI projects. The current governance context does not support the combination of strategies between government and non-government actors. As mentioned before, government strategies have limited flexibility, the main strategy being the federal programs. Therefore, there is no possibility to take advantage of opportunities that could appear during the implementation process. As stated by a government actor: 'we depend on the rules". In the case of the *barrio* project, the non-government actors are expected to be open to combine opportunities that could appear during the implementation of the project. However, they would like to limit this possibility once the project has started to reduce uncertainty or to avoid new disagreements.

7.3.5. Responsibilities & Resources: Low

The stakeholders cannot pool their assigned responsibilities with effective accountability mechanisms to implement BGI projects pragmatically. Pooling resources between government actors and social actors is limited by the rules of operation. This situation decreases the financial and human resources capacity. Many of these restrictions are enforced to increase transparency and to decrease the chances of corruption. The idea of the government is to have better control to prevent corruption or scams from non-government actors. Some non-government actors perceive this situation as part of the limited government vision, in which the government is focused only on implementing a mono-disciplinary project instead of increasing its potential. The social actors acknowledge that the support of different government levels could provide opportunities to implement an integrated project that will not be limited to traditional flood infrastructure but to support rainwater catchment systems, water literacy, and BGI in general.

7.4. Intensity

7.4.1. Levels & Scales: Low

The government levels are not working to support changes in favor of BGI projects. There is no promotion of innovative projects by government actors. Government collaboration exists for mono-disciplinary projects that are already established by the federal agencies. Regarding the Museo Regional, there was no interest of the state authorities to implement an innovative project there. Nowadays, there is no interest to promote the museum's water infrastructure characteristics.

7.4.2. Actors & Networks: Moderate-Low

There is a fragmented coalition of non-government actors that support behavioral change in favor of BGI projects implementation. The coalition that favors innovative projects is limited to non-government actors. For example, the *barrio* project is led by non-government actors. They agree that to obtain support from the government levels, they should adapt different aspects of the project to apply for funds. For the aspects that are not considered by current programs, they would need to look for financial resources elsewhere. In the case of the water sensitive park that they want to build, one of the most challenging parts is to convince the current landowners to sell their lands. To do so, they currently have conversations with the deputy of their district to obtain political support. The Expropriation State Law (2008) supports the state and municipal governments to expropriate land for public good [80]. This law was already applied by the state government when the museum was created and by the municipal government to obtain the land where they built the water reservoir in Figure 5.

7.4.3. Problem Perspectives & Goal Ambitions: Moderate

Changes are required in all the government actors' perspectives to achieve the implementation of BGI projects. The perspectives and goals of the government actors are based only on the mono-disciplinary federal programs. Therefore, they are not very different from the current *status quo*. Also, government actors are confident and positive about some of their preventive flood actions, the garbage campaign, drainage cleaning, water reservoirs projects and rainwater collectors. However, according to social actors, the aforementioned actions show the limited goals and vision of the government actors. Social actors are aware that the *barrio* project implies a long-term goal; it requires changes in the society and the government; including the changes in the government perspective.

7.4.4. Strategies & Instruments: Low

Stakeholders consider that major changes in their strategies from current practice are needed to implement BGI projects. The current government strategies and instruments are not appropriate for innovative projects. They support business as usual behaviour. According to some non-government actors, the rules of operation of the federal programs should be updated to support innovative projects. Also, urban legislation needs to be updated to support BGI projects. The most innovative law in the Metropolitan area is in the neighboring capital city, Puebla. The law in Puebla already includes some of the new elements such as rainwater gardens.

The current restrictions in the legislation also limit the possibility of non-government actors to look for partnerships with government actors. They acknowledge that government actors will participate only if the federal programs consider the type of projects that non-government actors are proposing.

7.4.5. Responsibilities & Resources: Low

The stakeholders consider the available resources only support mono-disciplinary projects. Government actors are focused on mono-disciplinary traditional projects. They consider they have the required economic, legal and political resources to implement that type of projects. Still, according to the different government actors, the infrastructure projects lack financial resources, specially at the municipal level. Social actors consider that there are enough financial resources, but there is a lack of political will and knowledge on the topic. The concept of water sensitive cities was unknown to the interviewed government actors. Also, urban legislation and CONAGUA programs need to be updated.

Currently, changes initiated by the new federal administration that took office in December 2018 are under way. Among these changes, the resources of the federal institutions are decreasing. For example, CONAFOR had 50 employees last year. Eight months after the new administration took office, this number was reduced to 15. According to CONAGUA, new budget restrictions could also affect riverbanks maintenance. Table 4 below summarizes the governance assessment results.

Table 4. Assessment results.

	Qualities of the Governance Regime			
Governance Dimension	**Extent**	**Coherence**	**Flexibility**	**Intensity**
Levels & Scales	Low	Low	Low	Low
Actors & Networks	Moderate-Low	Low	Low	Moderate-Low
Problem Perspectives & Goal Ambitions	Moderate-Low	Low	Low	Low
Strategies & Instruments	Moderate-Low	Low	Low	Low
Responsibilities & Resources	Moderate-Low	Low	Low	Low
Final assessment:	SupportModerate-Low	Restrictive	Restrictive	Restrictive

8. Discussion of Results and Conclusions

The application of the GAT has allowed a systematic understanding of the governance context and its support for leapfrogging. Through our GAT application, we can identify the status of the three catalyst factors for leapfrogging (trans-disciplinary science, cross-sector partnership and innovative experiments implementation). The most supportive quality of the governance system is extent. However, its degree is moderate-low, since it is limited to the government levels and traditional infrastructure. This can be identified in the dimension of Levels & Scales, where it was ranked as low. At the same time, the qualities of coherence, flexibility and intensity are restrictive.

There is no trans-disciplinary science in the projects supported by the three government levels. The grey and green infrastructure projects are an example of the mono-disciplinary approach. There is a limited vision that does not embrace an integrated vision. When considering the governance qualities, we can observe how the rules of operation that support the multi-level system are focused on a mono-disciplinary perspective that is supported by mono-disciplinary instruments and strategies. The assessment of coherence confirms this situation. The supportive aspect is focused on federal programs. Innovative projects with multi-disciplinary focus are not being considered. The extent is limited by not including innovative approaches considered by non-government actors. The creation of multi-disciplinary projects by the federal government is a possibility to change this situation. The lack of flexibility in the legislation also limits the possibilities to change the mono-disciplinary approach. This situation is also observed in the intensity quality, since the current government efforts only support business as usual practices.

The cross-sectoral partnership is limited, as demonstrated by the assessment of qualities. Resources and responsibilities are still fragmented, even within the grey infrastructure projects. Sewage separation is still very limited. There is no close collaboration in this regard between SOSAPACH and the Secretary of Infrastructure. SOSAPACH only renovates the sewage lines and extends the existing network. No partnership has been created to build both lines (wastewater and rainwater) together. When looking at the extent, we can see that two main networks work on flood projects separately. On the one side, there are the government actors, and on the other side, there are the non-government actors' network. While the multi-governance system can be evaluated positively for mono-disciplinary infrastructure, horizontal collaboration is still a challenge. The governance system is currently limiting the collaboration between government and non-government actors. Therefore, the coherence is also limited since multi-level collaboration is only reinforced, leaving aside other types of collaborations that could create social capital. The lack of flexibility of the governance system also affects the possibility of such collaborations. The restrictions in the federal programs limit the role of non-government actors and the chance to take opportunities that can arise during the implementation process. In terms of intensity, important changes are required to support the collaboration between government and non-government actors. This could include changes to the federal programs and to the municipal laws to strengthen a more integral and long-term vision.

The innovation experiments are not being supported by the current governance system. The case of the museum illustrates this situation. Social actors consider that the museum could play an important role in this regard. Coherence is very limited when it comes to innovative projects. The lack of interest of the authorities plays an important role here. As previously mentioned, the existence of the closed water cycle system in the museum is the result of "fortunate" circumstances instead of government interest. In this sense, it seems like even when the governance system clearly limits flexibility, key actors can make a difference. However, their impact is limited and fragmented. The museum project is completely isolated and there is no connection with the development of the city. In this sense, the Secretary of Infrastructure and Urban Development could play a key role. Without government support, the *barrio* project could face a similar situation.

The limitations of the governance system and its impact on the policies is acknowledged by the non-government actors. Non-government actors consider that government actors do not meet their expectations to solve flood issues. For them, the vision of the authorities is still limited, since in many cases they narrow flood issues to a garbage problem. While non-government actors are familiar with the water sensitive city and the BGI concepts, they are unknown to government actors. Rainwater catchment systems are not really considered as part of the urban policy. Currently, San Pedro Cholula does not consider them, but even in cities where they are considered, such as Puebla capital, the implementation faces challenges. Non-government organizations have pointed out that the government is keeping old practices in the newly built streets. Unfortunately, this is a common situation in the Mexican context. For example, the implementation of the wastewater treatment plant policy is only symbolic [43]. Also, the concept of water basin management which was introduced in 1992 has not been fully implemented and the river basin institutions do not impact the water policy [70]. This is exacerbated by the governance system where authorities change every three years, which implies an ample renewal of bureaucrats. As pointed out by a non-governmental actor; the government changes every three years, this means the learning process repeats itself every three years. This learning process is limited to the importance of cleaning the sewages and building grey infrastructure. Therefore, even if a knowledgeable person was in charge, the government change would imply throwing away this knowledge. An example is the 2030 Water Agenda created by the Mexican government in a very open and participatory process in 2011. However, three years later only a few water authorities knew its existence [81].

Considering the hierarchical nature of the Mexican water governance system, which grants to CONAGUA the primary role in the water policy [82] and the dependency of middle size cities on the federal government, changes in federal programs could increase the possibilities of leapfrogging. Some reforms have already taken place in other water issues. For example, in 2015 a program called PROSAN merged two programs, one that supports the wastewater treatment plants construction and the program that supports the operation of the wastewater treatment plants [70]. This could be a key step to create a governance system that could support leapfrogging. Also, this research shows that the state government role is limited since the policy is mainly implemented by the municipal and federal governments. However, previous research shows that in the Mexican water governance context, the role of the state government can be key to increase collaboration between the federal and the local government, it can provide a more comprehensive vision and a longer term planning, since this government level changes every 6 years [44].

The *barrio* project could become an unprecedented innovative experiment (pilot). Based on the interviews, it is still perceived that trust and collaboration between government and non-government actors will be a challenge, since they are still not sharing the same vision and goals. According to the water sensitive literature, leapfrogging provides the opportunity to take advantage of the lower levels of investment and fixed institutional practices. However, our analysis shows that changing traditional institutional practices requires overcoming traditional governance structures and traditional visions that are not easily overcome. This is even more difficult in a governance system that does not support innovation. It seems that such a vision could only be provided by water management systems that are

more developed. Therefore, we recommend further research on middle/small sized cities with more advanced water management or developing cities where governmental authorities are interested in the water sensitive city transition. This type of research could be relevant to increase our understanding of the governance factors role for leapfrogging.

Under the current governance system, the possibilities of leapfrogging seem unrealistic for San Pedro Cholula. As can be concluded from this research, there is lock-in in traditional practices, lack of long-term planning and insufficient policy coherence. In this case the governance context, does not provide the conditions to support leapfrogging.

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