Mexico City, Mexico

About the IWA Action Agenda for Basin-Connected Cities

The IWA Action Agenda for Basin-Connected Cities builds on the Principles for Water Wise Cities, with a focus on how cities can be active water stewards in their wider water basins. This includes the Drivers for Action such as extreme events, declining water quality, and water availability; followed by the Pathways to Action through assessment, planning and implementation; and the Foundations for Action from developing a vision to building capacity to improving governance. To learn more visit - http://www.iwa-network.org/press/the-action-agenda-forbasin-connected-cities/

About the Basin Stories

The basin stories are documenting some of the best practices and approaches that demonstrate how stakeholders, especially those in urban areas (e.g., city government, water and wastewater utilities, industries) are taking part or contributing to sustainable management of water resources. Greater basin-level collaboration from catchment to consumer is essential for sustainable water management in the face of growing demand on water resources and global change. The stories aim to inspire urban stakeholders to be aware and respond to what is happening in their watershed.

Using green infrastructure to reconnect Mexico City metropolitan area with its lake basin

Contributed by: Charlotte Chambard, Environmental Coordinator at Espacio Entre Tiempo Estudio, with the collaboration of Gustavo Madrid Vazqués, Director of Espacio Entre Tiempo Estudio; Alejandro Alva, Environmental Consultor at the National Autonomous University (UNAM) and Coordinator of Mexico City Water Bodies Network; and Elena Tudela Rivadeneyra, Professor of Architecture at the National Autonomous University of Mexico (UNAM) and Co-founder of Office for Urban Resilience (ORU).

Summary

The Metropolitan Area of Mexico City is an example of city development becoming disconnected from hydrology. Large water transfers to supply the city, groundwater depletion and an extensive drainage system that artificially discharges into neighboring areas have ignored integration with the natural lake basin in which Mexico City sits. The lack of connection with the historical origin of the lake coupled to the rapid expansion of the city has led to flooding, water shortage and loss of biocultural heritage.

To reorient the city's development trajectory towards a more sustainable path, green and blue infrastructure have been recognized as an opportunity to recreate some of the benefits of the lake basin. Bottom-up development by different groups of actors (civil society organization, academics, private companies, international actors, and more recently some local government offices) have demonstrated the potential to rehabilitate key ecosystem functions of the natural water cycle, such as rainwater harvesting, retention and infiltration, groundwater recharge, wastewater treatment and reuse. Benefits of using blue-green infrastructure include local food production opportunities, improved population health, better health and well-being of the population and biodiversity support and conservation. Green infrastructure is now an institutionalized planning tool in Mexico City and will hopefully become a regional planning framework for reconnecting the Mexico City metropolitan area to its lake basin.

Image source: Fodor's Travel

Problem:

- Water scarcity and overexploitation
- Floods and droughts
- Pollution and public health issues
- Loss of natural heritage

Solution:

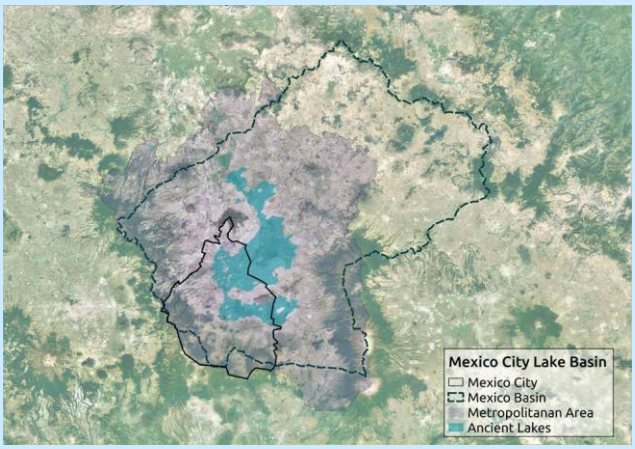
Mexico city's lake basin characteristics are being integrated into urban and suburban growth

Geographic information

Country: Mexico

City population: 21,581,000 (2018)

Basin area: 16,424 km²



Basin name: Basin of the Valley of Mexico

Problem

Urban development

México-Tenochtitlan - now known as Mexico City - was founded by the Aztec Empire in 1324, who built the city on the waters of a vast lake system embedded in a volcanic chain. In doing so, they conquered and integrated pre-existing settlements built by the Xochimilcas at the south of the basin, transforming their unique way of coexisting with the lake through adapted agricultural methods –*chinampas*- into larger and more intensive food production areas to supply and expand the new city.

As the city grew, dikes were built to prevent flooding and control lake flows. Spanish colonization brought the development of artificial outlets to drain the lake systems to prevent flooding and increase the amount of land that could be built on and cultivated. As a result, the lake system disappeared and groundwater became the main source of water for the city's development, which inevitably led to its overexploitation. The depletion of groundwater increased abstraction costs as water needed to be pumped from greater depths and caused the city to sink as the underlying soil structure was compacted, generating damage to infrastructure and in particular to the drainage system. To cope with the city expansion and increased water demand, an extensive investment was made in infrastructure in the 1940s bringing water from the basins of Cutzamala and Lerma across the mountains, over a one-kilometre altitude variation.

Despite this mega infrastructure, flooding is an ongoing issue. Highly concentrated rainfall and an increase in impervious surfaces, combined with continued subsidence, still cause significant flooding and drainage

failures every year. This has justified the need to further develop the drainage system, based on the conventional idea that the water needs to be drained out of the basin as quickly as possible. However, the drainage systems are not separated, so rainwater and residual waters are combined, and this limits reuse and increases treatment costs.

The metropolitan area of Mexico City continues to expand with very limited control, invading the slopes of its volcanic belt and the outskirts of the city. In doing so, it reduces the surrounding natural forest areas, which are the main areas of recharge of its aquifer and main sources of the streams and rivers that flow through the city. These rivers, which once fed into the lake system, are now almost fully channelized as part of the urban area's drainage system.

The reduction of green and blue permeable areas in the outlying mountains and within the urban area affects many neighborhoods in Mexico City's metropolitan area, depriving them of green public spaces recommended for well-being. These neighborhoods are often the same ones that suffer most from flooding and lack of basic water supply and drainage services. The disconnection of the city from its natural surroundings directly affects access to water, health and safety of a significant part of the population.

In summary, the development of Mexico City has been in a constant struggle for and against water, based on a disconnection from the natural hydrological cycle in the basin and an approach where an artificial cycle could be engineered to compensate for water scarcity and the resulting risks. This approach has had very uneven and mixed results. Combined with the effects of climate change, this makes the city and its metropolitan area highly vulnerable to extreme events.

Floods and Droughts

Half of Mexico City is classified as flood-prone (medium to high risk). According to the Environmental Secretariat *Mexico City 2025 Vision* report, climate change is expected to increase damages due to hydrometeorological and sanitary events. Between 1980 and 2013, these events affected almost 50,000 people and amounted to USD 32 million in Mexico City, including damages by inundations, wind, hail and sewage overflow.

Mexico City' basin is one of the most vulnerable in the country according to a drought vulnerability analysis conducted by the Secretariat of Environment and Natural Resources in 2011 (*Análisis espacial de las regiones más vulnerables ante las sequías en México)*. Contributors to drought susceptibility include a high concentration of population and economic activities, combined with limited resources and difficulties in managing increasing water demand.

Directly linked with the droughts occurring in the dry season, forest fires occur frequently in conservation areas surrounding the city. In 2019, there were 445 forest fires affected over 3,200 hectares, causing significant air pollution. Forest fires also contribute to further degradation and reduction of the forest cover of the metropolitan area and often result in informal occupation inducing land use changes to agriculture or built environments.

Water quality and ecosystem degradation

Engineered control of the water cycle in the Mexico City metropolitan area contributes to the degradation of the water quality and loss of water related ecosystems**.** According to statistics from the National Water Commission, in 2019 the Mexico City valley basin had 51.6% of monitoring sites with acceptable or good water quality, 22.6% qualified as polluted and 25.8% highly polluted (the highest rate nationally). In the Mexico City metropolitan area, according to the 2018 statistics, the drainage system covers 98% of the population. However, there is a gap between urban areas that reach 98.5% of coverage and rural areas that have a rate of around 90.2%. Additionally, most of the wastewater treatment plants and septic tanks do not guarantee an adequate treatment rate.

The quality of most urban and peri-urban rivers and water bodies in the metropolitan area is severely deteriorated by the discharge of sewage or poorly treated water and the disposal of solid waste. As the

city grew, urban and peri-urban rivers were used to discharge waste becoming a nuisance and health hazard. These rivers were channeled or piped to join the sewage system (as is the case of the lower Magdalena River in the eastern part of the city). In the remaining open water bodies, the decline of water quality directly impacts local communities.

An illustration of this issue is in the Channels of Xochimilco, well-known for its *chinampas*, a unique pre-Hispanic agriculture system built on the lake. Eutrophication of the system is due to the replacement of spring water by “treated” water from one of the major treatment plants in the south of the city, as well as local wastewater discharge and use of agrochemical products. This is causing the deterioration of this UNESCO World Heritage Site and loss of its traditional agricultural practices. Such deterioration of the surface water not only affects the health and well-being of the population but also leads to the loss of key ecosystems and the possible contamination of groundwater resources. At the same time, the disappearance of the local rivers and water bodies reinforces the disconnection of the city with its basin, erasing with them the cultural remnants of the city’s lake basin.

Water supply

The unsustainability of water services is a direct result of the engineering of basins without a complete understanding of the lake basin system. With the loss of permeable zones and key recharge areas, groundwater resources cannot meet the growing demand. The aquifer of Mexico City Metropolitan Area accounts for more than 60% of the supply but shows a severe degree of overexploitation: in 2020, the National Water Commission estimated it had a deficit of 507 km^3 (*Comisión Nacional del Agua CONAGUA, cálculo de disponibilidad acuífero 901 Zona Metropolitana de la Cd. De México*).

Major water policies to meet growing demand have largely focused on large-scale infrastructure that ignores watershed boundaries. Twenty two percent of water supply comes from the Lerma-Cutzamala transfer and new transfers are being considered, such as the Mezquital Valley project.

It is estimated that 40% of this water supply is "lost", mainly due to leaks and undeclared withdrawals/ abstractions. The high leakage rate is a consequence of the groundwater depletion, soil compaction and subsidence. Seismic activity in the area contributes to the damage of the pipe network, creating fractures and sinkholes. This makes it difficult to obtain an accurate approximation of the various water uses. Of the remaining 60% supplied, a large portion is used for domestic purposes and a smaller portion is used for industrial, commercial and agricultural purposes.

In the Mexico City Metropolitan Area, the drinking water system covers 98% of the population according to the 2018 statistics of the National Water Commission (based on 2015 data). The drinking water coverage figure decreases to 91.6 % when considering the rural areas, highlighting important disparities in terms of services. In addition, due to the variable quality of the water supplied and the resulting lack of confidence in the inequity of tap water, most people use purified water for their consumption. This leads to a capture of the value of water by the bottled water industry and purification services, while utilities lack funds for basic operation and maintenance.

What are the Drivers for Action?

For more information on the Drivers for Action visit the Action Agenda for Basin-Connected Cities

Extreme Events	**Declining water quality**	**Water Availability**
☒Public health hazards	☐ High operating costs	☒ Water supply disruption

☒ Damage to infrastructure	☒ Loss of credibility and trust	☒ Constraints to growth
☐ Economic activities and supply chain disruption	☒ Environmental, cultural and health impacts	☐ Declining quality of life

Solution

The development of green and blue infrastructure in the metropolitan area is a comprehensive solution to reconnect the city and its basin. Green and blue infrastructure is defined as a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to provide a wide range of ecosystem services' (European Commission). Environmental features can be natural or constructed, in urban or rural areas and operate at different scales to contribute to the recovery of some key ecosystem services provided by the lake basin. In addition to the physical effects of green infrastructure interventions, an important co-benefit is the cultural recuperation of the lake basin water system and related ecosystems.

Strategies implemented to reduce water scarcity, control water pollution, and flooding occur at different times in the water cycle and indiscriminately throughout the metropolitan area.

- Rainwater harvesting is used to capture the rainwater from roofs, filter it and store it for domestic use in individual households or public buildings. This provides local water supply while also reducing the amount of water extracted from the aquifer and the rainwater flowing into the drainage systems. *Key projects: Rainwater harvesting programme in Iztapalapa and Xochimilco by the Secretariat of Environment of the City and Isla Urbana.*
- To prevent rainwater falling on *impervious* city streets from flowing directly into the drainage system and out of the basin, the construction of rain gardens and permeable pavement aims to restore the infiltration capacity of streets and public spaces such as parking areas. These systems operate at different scales, from a series of rain gardens with a capacity of a few hundred cubic meters to larger infiltration basins in urban parks. With different layers of filtrating material and appropriate vegetation, these systems also reduce runoff sufficiently to avoid contaminating groundwater. In some cases, these systems have been supplemented with perforated underdrains to further separate stormwater from the sewer system. *Key Projects: Projects implemented under the Miguel Hidalgo Delegation's Hydrological Plan such as the Antonio León Green Street or the Granadas Infiltrating Sports Field.*
- Reforestation and protection of natural areas in the metropolitan area has also been shown to be an effective way to increase aquifer recharge capacity through soil infiltration capacity. In deteriorated areas, green infrastructure features also contribute to erosion control through water retention practices and promotion of infiltration, which also reduces flooding in lower built-up areas. *Key projects: Integral socio-environmental rehabilitation of protected natural areas Cerro de la Estrella, Sierra Santa Catarina, Parque Ecológico y Sierra Guadalupe.*
- Along with aquifer system recharge, it is vital to preserve and restore key water bodies. Protecting and restoring the remaining water bodies in the basin can maintain and increase local retention and flood control capacity as well as make significant contributions to groundwater recharge. The co-benefits of such actions are numerous, from preserving biodiversity, regulating micro-climate, increasing property values, to the health and well-being of residents. *Key projects: 1) Integral rehabilitation programme for the Magdalena and Eslava rivers; 2) Restoration of Texcoco wetland.*
- In parallel with the centralized drainage and wastewater treatment system, the development of smaller-scale decentralized alternatives presents a potential solution to water bodies and groundwater contamination. It could also alleviate the charge of the centralized system and provide services in less accessible areas. The on-site treatment of wastewater with small, constructed wetlands also provides

an alternative source of water in the city. *Key project: Ecoducto Río de la Piedad, artificial wetland system to treat wastewater and reuse it to irrigate a lineal park where the La Piedad River once flowed and is now piped along with the wastewaters.*

- Local food production in the basin ensures a minimum of food security for the metropolitan area and its inhabitants. The agricultural practices contribute to preserving land from being urbanized, while providing great opportunities for research, education and tourism. In the lake basin of Mexico, they also represent cultural remnants of the lake basin culture such as promote *chinampas*, a pre-Hispanic farming system in Xochimilco. These are plots of land surrounded by several channels for drainage, they are also known as floating gardens and are now used for floriculture and vegetable planting. In addition, urban farms and roof gardens often play a role in the cohesion of the community in the neighbourhood where they are developed. And all these elements participate in building alternative supply chains based on proximity and direct exchanges between producers and consumers. *Key projects:*
    - *Chinampa area of Tláhuac and Xochimilco, prehispanic farming systems.*
    - *Chinampa Refuge project and Participative labels projects lead by the National Autonomous University of Mexico.*
    - *Urban farms and eco-places such as the Huerto Tlatelolco, Huerto Roma Verde.*

- Developing green corridors to link the different elements of the green infrastructure will ensure the maximization of the environmental services each provides. Organizing the different existing and potential components as a connected network is what will create a green and blue infrastructure adapted to the territory of the metropolitan area of Mexico. The connection could also sustain alternative mobility practices and the ecological connectivity for key species. *Key projects: Green infrastructure and ecological corridors strategy for the Pedregales, elaborated by the National Autonomous University of Mexico.*

Impacts on stakeholders

Between 2009 and 2020, more than 20,000 rainwater harvesting systems have been installed by Isla Urbana, harvesting 800 million liters each year. This number is now rapidly increasing as the government of Mexico City has decided to partner with Isla Urbana to implement 100 thousand systems in the city's neighborhoods most affected by water shortages.

From 2016 to 2020, rain gardens and permeable pavements implemented in Mexico City have restored the retention and infiltration capacity of approximately 30,000 cubic meters per year. The rehabilitation of the Cerro de la Estrella natural protected area benefits millions of visitors each year.

The 1.6 km lineal park Ecoducto Río de la Piedad captures 50 tons of carbon a year and reclaims 30,000 liters of water a day.

The Chinampa Refuge project, a conservation model for saving *axolotl* ecosystems as well as the traditional agricultural *chinampa* system for Xochimilco has fostered the participation and organization of *chinampa* farmers, currently helping 22 chinampero families subsist on more sustainable practices

Without comprehensive monitoring and evaluation efforts it is difficult to measure the impact of all the different components individually. Although the various numbers cited may seem small in relation to the size of the metropolitan area, the strength of green infrastructure is that it summarizes all efforts towards a common goal and enables a better understanding and valorisation of its benefits.

Pathways for Action

For more information on the Pathways for Action visit the Action Agenda for Basin-Connected Cities

Assessment	Planning	Implementation
☒Investment in data & information systems	☐ Risk-based approach to planning	☒ Integration of natural infrastructure
☒ Linking traditional water management with science	☐ Water allocation mechanisms	☒ Economic and financing mechanisms
☒ Invest in values to motivate water decisionmaking	☒ Stakeholder participation in planning and management ☒ Aligning urban development with basin management	☒ Building partnerships from catchment to tap ☐ Digital Technologies

Lessons learned

Green infrastructure is a strong overarching framework for combining a wide range of initiatives with the same overall objective, fostering cooperation and emphasizing the importance of integrating individual projects in building a more sustainable city.

Fostering cooperation between the different levels of government, civil society organization, academia and citizens is the best way forward. Civil society has been an important driver in creating political interest in green infrastructure and in ensuring its continued development through political changes.

A favorable condition for the development of green infrastructure in the Mexico City metropolitan area is the existence of adequate governance and planning capacity, as well as the corresponding legal and normative framework. In this sense, the recent creation of the Green Infrastructure Directorate within the Secretariat of the Environment of Mexico City is an important first step.

Green infrastructure is also being promoted at the international level as a strategy for climate change mitigation and adaptation. A national road map was developed in 2018 by the Secretariat of Agrarian, Land, and Urban Development and the Secretariat of Environment and Natural Resources, identifying the national efforts needed to integrate this approach. As more and more efforts are devoted to climate change issues, green infrastructure could benefit from more attention and funding opportunities, especially from international organizations.

Next steps

Green infrastructure has emerged in a bottom-up manner without a comprehensive global planning strategy and without the legal and financial conditions to develop further. Although it has become a

strategic tool for Mexico City's Secretariat of the Environment, the governance of green infrastructure needs to be strengthened to include the entire metropolitan area and the Mexico Valley basin.

Ensuring the sustainability of initiatives and their ability to survive changes in government remains a challenge. A challenge that several academic, civil society and private sector organizations have decided to address in their own ways as the initiatives mentioned above have shown. However, greater public participation and cultural ownership would certainly help to ensure the continuity of their efforts. Another area of opportunity for furthering the development of green infrastructure in the Mexico City Metropolitan Area would be to conduct monitoring and evaluation activities. This would create strong evidence of cost-effectiveness of the green and blue infrastructure solutions and robust proof of the various benefits they provide.

In conclusion, there is a need to integrate nature-based concepts and solutions that enable green infrastructure development at different scales, making it an effective tool for natural resource conservation and urban resilience. Awareness and capacity building within public institutions, academia and the private sector will support the implementation of green infrastructure initiatives, from planning and regulation to the construction and maintenance of these solutions.

Resources

- La visión de la Ciudad de México en materia de cambio climático al 2025
- http://www.data.sedema.cdmx.gob.mx/cambioclimaticocdmx/images/biblioteca_cc/La-Vision-de-la-Ciudad-de-Mexico-en-materia-de-cambio-climatico-al-2025.pdf
- Análisis especial de las regiones más vulnerables ante las sequías en México
- http://www.conagua.gob.mx/conagua07/publicaciones/publicaciones/sequiasb.pdf
- Comisión Nacional del Agua (CONAGUA), Sistema Nacional de Información del Agua, Acuíferos, Disponibilidad
- http://sina.conagua.gob.mx/sina/tema.php?tema=acuiferos&ver=mapa
- European Commission, Environment, The forms and functions of green infrastructure
- https://ec.europa.eu/environment/nature/ecosystems/benefits/index_en.htm#:~:text=Green%20infrastructure%20is%20a%20strategically,and%20climate%20mitigation%20and%20adaptation.
- Cosecha de lluvia
- https://sedema.cdmx.gob.mx/programas/programa/programa-de-sistemas-de-captacion-de-agua-de-lluvia-enviviendas-de-la-ciudad-de-mexico
- https://islaurbana.mx/isla-urbana/
- Plan Hídrico Delegación Miguel Hidalgo http://www.eetestudio.com/plan-hdrico-mh
- Ecoducto Río de la Piedad https://www.ecoducto.mx/antecedentes
- Infraestructura verde y corredores ecológicos de los pedregales: ecología urbana del sur de la Ciudad de México http://centro.paot.org.mx/documentos/unam/infraestructura_verde.pdf
- Proyecto integral para la rehabilitación socioambiental y conservación de la biodiversidad en el área natural protegida Cerro de la Estrella https://paolarojas.com.mx/desarrollan-proyecto-integral-cerro-de-la-estrella/
- Sistema participativo de garantía https://cous.sdi.unam.mx/?seccion=8_consumo
- Parque ecológico Texcoco https://www.gob.mx/conagua/es/articulos/rehabilitacion-del-lago-texcoco-202165?idiom=es
- Huerto Roma Verde https://huertoromaverde.org/
- Huerto Tlatelolco http://www.culticiudad.org/
- Implementación de infraestructura verde como estrategia para la mitigación y adaptación al cambio climático en ciudades mexicanas, hoja de ruta - https://www.gob.mx/cms/uploads/attachment/file/484510/05_01_2.1_Hoja_de_ruta_IV_para_difusi_n.pdf
- Chinampa Refuge Project www.o-ru.mx

About us

Charlotte Chambard, Environmental Coordinator at Espacio Entre Tiempo Estudio, with the collaboration of Gustavo Madrid Vazqués, Director of Espacio Entre Tiempo Estudio; Alejandro Alva, Environmental Consultor at the National Autonomous University (UNAM) and Coordinator of Mexico City Water Bodies Network; and Elena Tudela Rivadeneyra, Professor of Architecture at the National Autonomous University of Mexico (UNAM) and Co-founder of Office for Urban Resilience (ORU).

Espacio Entre Tiempo Estudio is a pioneer Mexican company in the design and implementation of green infrastructure projects which successfully implemented this approach in both urban and natural areas of Mexico City. Constructed projects include green streets, rain gardens, infiltrating sports fields and parks in the context of the Hydrological Plan of the delegation Miguel Hidalgo and the Socioenvironmental Rehabilitation of the Natural Protected Area Cerro de la Estrella.

Alejandro has been promoting the restoration and rehabilitation of Mexico City water bodies, rivers and streams since 1999. In particular, he conceived and implemented the innovative and ambitious project Ecoducto, an artificial wetland system to treat wastewater and reuse it to irrigate a lineal park where the La Piedad River once flowed.

Elena has been leading innovative design projects for resilient and water sensitive cities in Mexico and Latin America. In particular, she designed the Chinampa Refuge project for Xochimilco agricultural areas in Mexico City and participated in the conception of the Hydrological Plan of the delegation Miguel Hidalgo.