Fig. 1

MEXICO CITY
MEXICO

2021 Exploring Urban Resilience Pathways

International Master CITY RESILIENCE Design and Management

EDU

barcelona

Author: Małgorzata Kamińska

About the report and the collection

Exploring Urban Resilience Pathways

This report is part of a collection wishing to provide a global overview about different cities' experience in resilience, and how this is evolving. The series is titled "Exploring Urban Resilience Pathways" and each report is prepared by one student of the Int. MSc. in City Resilience Design and Management (URNet-UIC Barcelona). During the first semester, students develop these reports as a learning outcome for their acquired analytical skills: to find, understand, organize and communicate critically different perspectives, approaches and models of urban resilience implementation, in a chosen city.

The aim of each report is thus to offer an easy-to-read overview about how adaptive capacities have been evolving in a selected city. The reports explore the past and current mechanisms through which each city responded to overlapping shocks and stresses. Nowadays current City Resilience Strategies – launched and supported by the Rockefeller 100RC program – are included within these analyses, representing the ultimate trend of understanding and implementing city resilience. Finally, current COVID19 pandemic responses are the final lens through which resilience mechanisms are discussed, to understand the alignment of resilience with other key urban goals, and ultimately respect to urban living.

What is interesting to learn from this series of reports, is that each of them critically discusses how cities managed adaptive responses to different treats, and how the concept of resilience evolved. Although the scope of these reports is ambitious and the analysis could result complex, the presentation has been designed to be easy to read and accessible to the general public. Each report of this collection maintains a standard structure, facilitating the reading and the reports (and cities) comparison.

Hope this initiative contributes to spread the understanding about how resilience has been framed and implemented in many cities across the globe.

Lorenzo Chelleri, Ph.D.
Director of the International Msc. in City Resilience Design and Management

MEXICO CITY **MEXICO**

2021 Exploring Urban Resilience Pathways

SUMMARY

Mexico City (CDMX), the capital of Mexico is the heart of Mexico City Metropolitan Area (ZMVM) that consists of 224 municipalities. There are 9 mln people living in CDMX and almost 22 mln in ZMVM, which makes it one of the largest metropolises in the world. A huge number of population, constantly growing in the uncontrolled urbanisation processes results in spreading of informal settlements, social inequalities and resource scarcity.

Because of its geographical conditions, the city often faces natural disasters. It is located in an active seismic zone, in a valley that trappes air pollutants between mountain ranges. Montaneous location and elevation differences also result in a variety of climates and precipitation patterns, therefore both floods and droughts are common. Flood risk is also exacerbated by man-made environmental conditions - urban development on a drained lakebed. Drainage has also led to changing soil characteristics and as a consequence - poor water quality, aquifer depletion and land subsidence.

Centuries of policy of taking control over environment and putting forward large infrastructural solutions, such as drainage systems and aqueducts, led to catastrophic effects as the city grew far beyond systems capacity. To leave this development pathway, a set of policies and programs that address challenges through various integrated actions was needed. The implementation of actions proved successful thanks to horizontal cooperation between city government departments and vertical cooperation on a regional level. In the beginning of the 21st century, an abrupt, adaptive transformation has started, changing the city's development path. This report investigates the road that CDMX has gone, from the first Aztec settlements on the island, through colonisation, large drainage project and uncontrolled urbanisation, to a new resilient hub.

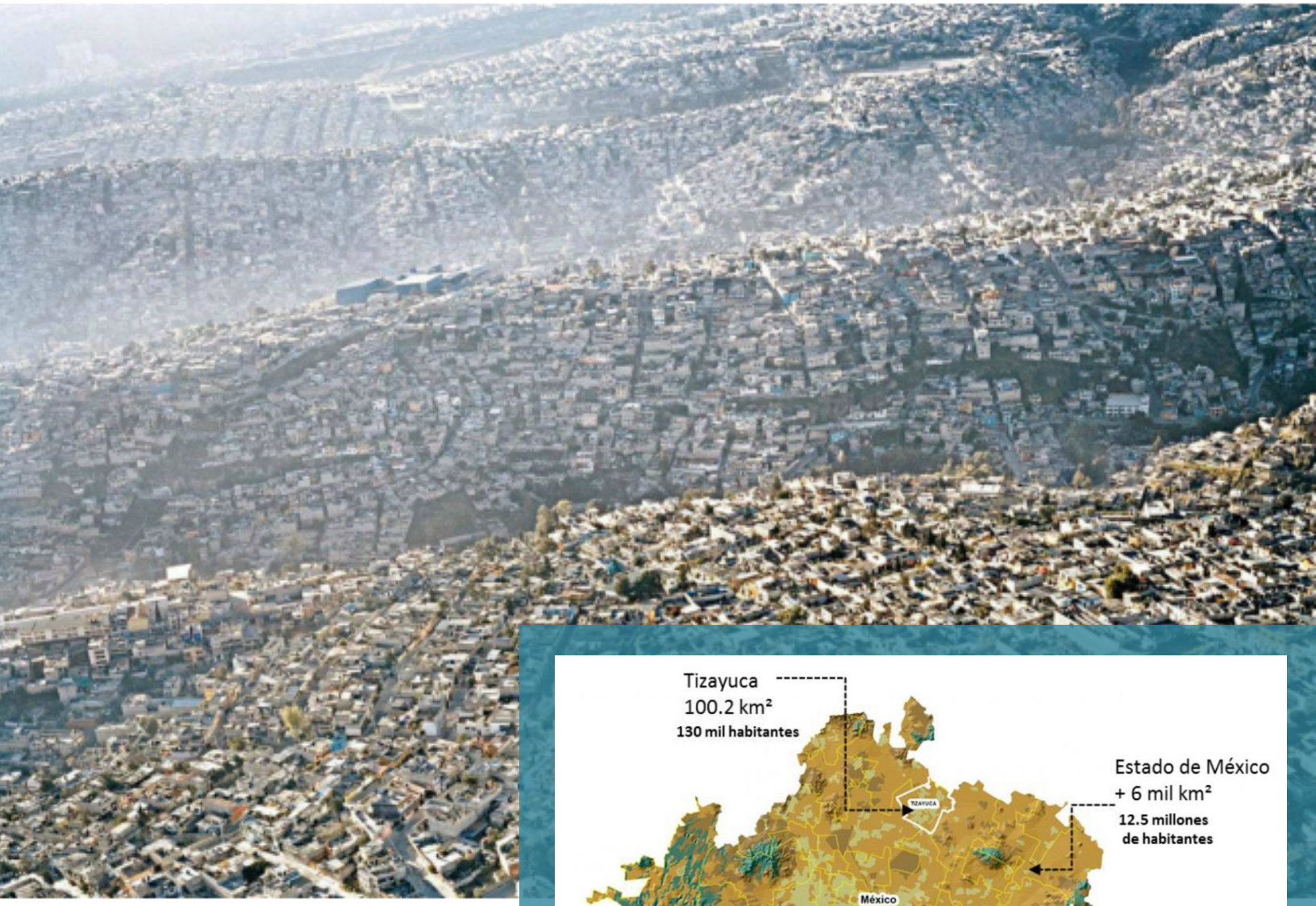

Fig.1 *The aerial view of CDMX*

Fig.2 *CDMX and ZMVM map*

TABLE OF **CONTENTS**

LIST OF **ABBREVIATIONS**

100 RC	100 Resilient Cities
CDMX	Ciudad de México (Mexico City, formerly: Federal District)
ZMVM	La Zona Metropolitana del Valle de México (Mexico City Metropolitan Area)
SEDEMA	Secretaria del Medio Ambiente (Secretariat of the Environment)
MCR2030	Make Cities Resilient 2030

INTRO
MEXICO CITY

Once a lake, now one of the largest metropolises in the world, CDMX is facing numerous environmental and socio-economic challenges. To understand them, it is crucial to know the geographical and historical context of the city and track its complex development path.

CDMX is located on the sediments of Texcoco lakebed consisting of clay, silt and sand and on the volcanic rocks such as basalts and andesites (see: Fig. 3) in the active Trans-Mexican Volcanic Belt stretching E-W through Mexico (Ferrari et al, 2012; Salinas et al, 2016). This makes the city exposed to natural hazards, including earthquakes and landslides.

The first urban development in the Valley of Mexico dates back to the 14th century when Tenochtitlán, the Aztec capital, was established on an island on the Texcoco lake. The first settlers created strong and complex relationships with water, comparable to those of the contemporary Netherlands. As the water surface would rise each rain season causing flooding, they developed a deep hydrological knowledge and built a system of dams to divide brackish water from freshwater and control their levels. One of their ingenious inventions were *chinampas* - floating gardens, artificial islands that were an extension of arable land on a water surface, highly productive thanks to decomposting organic waste building the island and the moisture from lakewaters (Britannica, n.d.; Salinas, 2016). Figure 4 explains their construction.

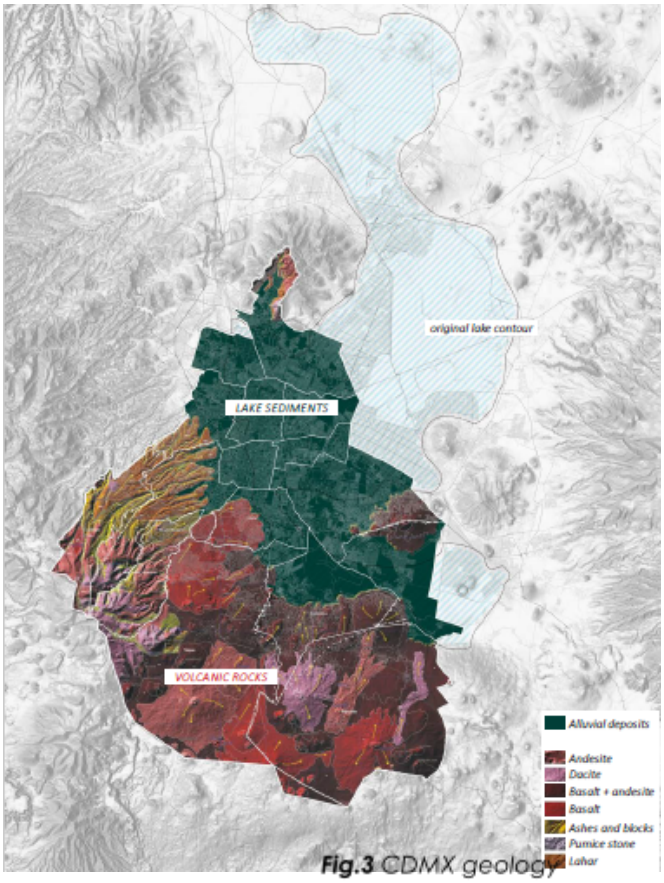

Fig.3 CDMX geology

This symbiotic relationship lasted until the 15th century, when the Aztecs got colonised by the Spanish Crown. However, Spaniards lacked the Aztec understanding of water. While trying to change the urban form of Tenochtitlán into a renaissance European city, in response to floods in the beginning of the 17th century, they built channels to drain the lake and remove the natural threat (Salinas et al, 2016).

In 1900 the works on *el Gran Canal del Desagüe* (the Great Sewage Canal) were inaugurated (Archivo General de la Nación, 2022). This is a marking point of when people have taken control over the Mexico Basin environment. Rapid expansion of the city on the drained lakebed caused overexploitation of the aquifer below the ancient lake sediments, as it could not

be recharged by slow infiltration of lakewaters through poorly permeable clay sediments. Since then the pressure of urban infrastructure on the emptying aquifer causes continuous land subsidence at an alarming rate (Chaussard et al, 2021). Its geographical location and the consequences of lake drainage lead to paradoxical relations with water, making CDMX struggling with both its lack and abundance.

However, CDMX is hit not only by environment related shocks and stresses. Inequality, poverty, and wealth concentration were recognised as the most severe social stresses in CDMX (Matus Kramer et al, 2016). These are significant factors holding back CDMX on its resilient development path.

Another important challenge is the relation between CDMX and ZMVM. Significant socio-territorial inequalities between urban centres, suburban zones and rural zones within the region, lack of recognition of their roles and improper governance are recognised as the largest obstacles in implementing policies (Aguilar et al, 2018), therefore fostering regional coordination is the first pillar of the resilience strategy (Matus Kramer et al, 2016).

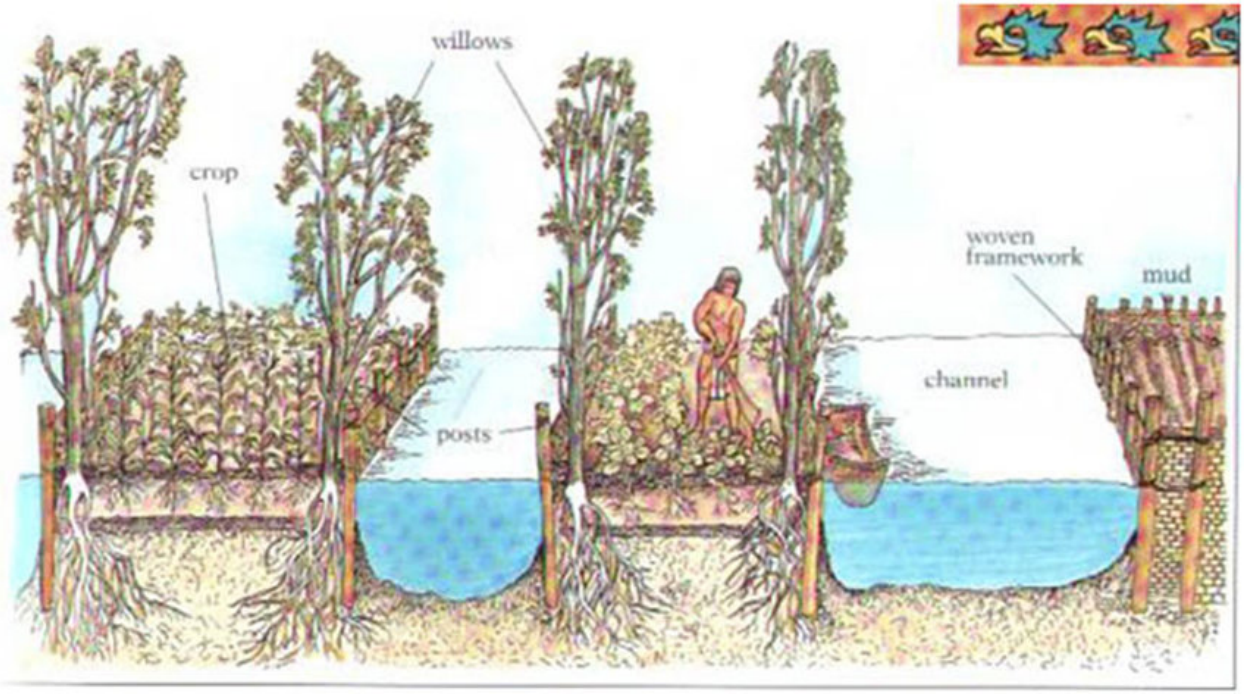

Fig.4 *Chinampas construction*

CDMX Resilience Vision

"Mexico City creates an equitable society using an all-embracing adaptive process in which various stakeholders, sectors, and vulnerable groups foster a transformation to face the main social, economic, and environmental challenges of the 21st century" (Matus Kramer et al, 2016)

Equality

Inclusion

Adaptive transformation

CITY PAST
ADAPTIVE PATHWAY

Resilient Tenochtitlán

The relationship with water shapes CDMX from the very beginning of human settlement in the Valley of Mexico. Controlling, regulating and adapting to water has been an inherent part of planning and policymaking for centuries. This story is an interesting example of how the city followed the principles of resilient development, being forced to address numerous severe shocks and stresses, not only water scarcity and abundance, but also social issues.

The story begins in Tenochtitlán, the citadel built on an island on the shallow, brackish Texcoco lake. Feeding on highly productive *chinampas*, civilization was expanding. Complex and advanced systems of dams protected them from the floods and supplied freshwater that was separated and prevented from mixing with saline waters. Those were the very first measures of addressing challenges of flooding and water accessibility. However, even so many years before introducing the concept of resilience, they seemed to understand that a resilient system needs to be redundant. They dominated neighbouring populations to make them pay tributes and this way secured their own resources and freshwater supplies both from the inside and outside of the city (Tellman et al, 2018).

Fig.5 *A mural presenting Tenochtitlan*

Lake drainage and urban expansion

The balance of this system was destabilised by Spanish colonisation in the 16th century. The capital of New Spain was established on the remnants of Tenochtitlán, but the founders lacked understanding of Aztec engineering solutions and had to face recurring flooding. Later political and planning decisions resulted in exacerbating problems by causing positive feedback loops. For instance, deforestation to provide construction materials led to soil erosion and increased runoff, raising the water level in the lake and consequently - flood risk. Additionally, new shocks appeared - epidemics of typhus and smallpox, proving the need of improving water sanitation. Those factors led to implementing modern drainage and sewer systems and lake shrinkage. It was followed by a rapid urban development on the new land of drained lakebed, facilitated by national industrialization policies and land reforms following the Mexican Revolution in 1910-1929 (Tellman et al, 2018).

Until the late 1800s, CDMX relied mostly on external water sources. However, unlike Tenochtitlán, this was a fragile system, vulnerable to infrastructure failures and socio-political tensions. As the technology advanced, shifting the main water provider to the local aquifer seemed to be a reasonable solution. Yet, this political decision turned out to be a maladaptation. As the aquifer was getting drained, unsaturated layers of lake sediments started compressing under the weight of urban development. The infiltration, already largely curtailed due to impervious surfaces of the city, became even more limited as drained and compressed clay layers above the aquifer changed their physical characteristics and lost permeability. The result of aquifer depletion is not only water scarcity, but also low water quality, as progressing land subsidence causes ground cracking and entering contamination from the surface to groundwaters (Tellman et al, 2018).

In the face of severe consequences, pumping from the aquifer under CDMX was ceased in 1954. Systems of pumps and aqueducts were installed and the city once again became dependent on outside sources. However, the solutions were insufficient to meet the city's demand. Importing water from distant sources was also expensive as huge amounts of energy are needed to pump water and transport it. Moreover, subsidence was still continuing, damaging the infrastructure, leading to water losses and lowering the efficiency. A severe drought in 1974 led to lifting the ban on aquifer pumping and drilling new wells, especially in the southern part of the city, which is mostly affected by water scarcity (Tellman et al, 2018).

The uncontrolled growth and increasing number of informal settlements resulting from new development land and early 20th century policies caused not only water shortages from increased demand. It resulted also in other shocks and stresses, such as social inequality, poor air quality and increasing land subsidence depicted on figure 6.

Fig. 6 *Uneven land subsidence*

20th century challenges

To address those issues, the proposal of the Conservation Zone (*Suelo de Conservación*) was presented in 1978 and later implemented in 1992. Its aim was to protect the watershed and improve air quality. Unfortunately, it brought some unexpected trade-offs. The land prices increased, pushing the poor further outside CMDX and deepening social inequalities in a phenomenon nowadays known as green gentrification. Moreover, indigenous and agrarian communities who possess 70% of the Conservation Zone land were highly affected as they become limited in their land and resource use as a result of new policies (Gobierno del Distrito Federal, 2012).

The water issue was also addressed by 1989's Water Conservation Program. The measures included soft infrastructure components, such as replacing conventional toilets with water-saving ones on a large scale, conducting educational campaigns about water use and increasing water tariffs. Unfortunately, impacts of those actions are difficult to assess through the lens of constantly growing population and demand. Leakages and illegal connections to water supply systems are another obstacle in estimating domestic consumption (Tellman et al, 2018).

As shown in aforementioned examples, postcolonial policies were far from a resilient approach. Importing freshwater and discarding lake and sewage water creates high energy consumption,

considerable costs and infrastructure failure risk. These weaknesses of the system were addressed by increasing its robustness through water reuse and recycling. In 1984 The National Program for Efficient Use of Water was launched in ZMVM to reduce water loss and improve system revenues. The measures included protection of the natural aquifer recharge zones, aquifer recharge with storm water and reclaimed municipal wastewater and use of reclaimed wastewater in industrial and service sectors (National Research Council, 1995).

The Valley of Mexico Sanitation Project, approved in 1996 to be financed by the Inter-American Development Bank was supposed to serve a similar goal and increase water reuse and aquifer recharge rates by installing new water treatment plants. However, due to political and economic reasons the project was never launched and today no public information is available (Tortajada, 2006b). This shows another problem of CDMX and ZMVM decision making, management and monitoring, which is lack of transparency.

First steps towards resilience

First policies and projects towards resilient development introduce decentralisation through rainwater harvesting. The 2003 Water Law mandates that new building constructions accommodate practices of rainwater harvesting and promotes this practice in previous buildings (Asamblea Legislativa del Distrito Federal, 2003). This action was supported by project Isla Urbana, which had already installed over 20 000 rainwater harvesting systems and contributed significantly to fighting water crises and supporting vulnerable communities. Its project "*Escuelas de Lluvia*" (Rain Schools) does not only capture water from school rooftops that are larger and more effective than those of residential buildings, but also promotes education about good water use practices (Fig. 7) (Isla Urbana, n.d.).

Fig. 7 *Escuelas de Lluvia project*

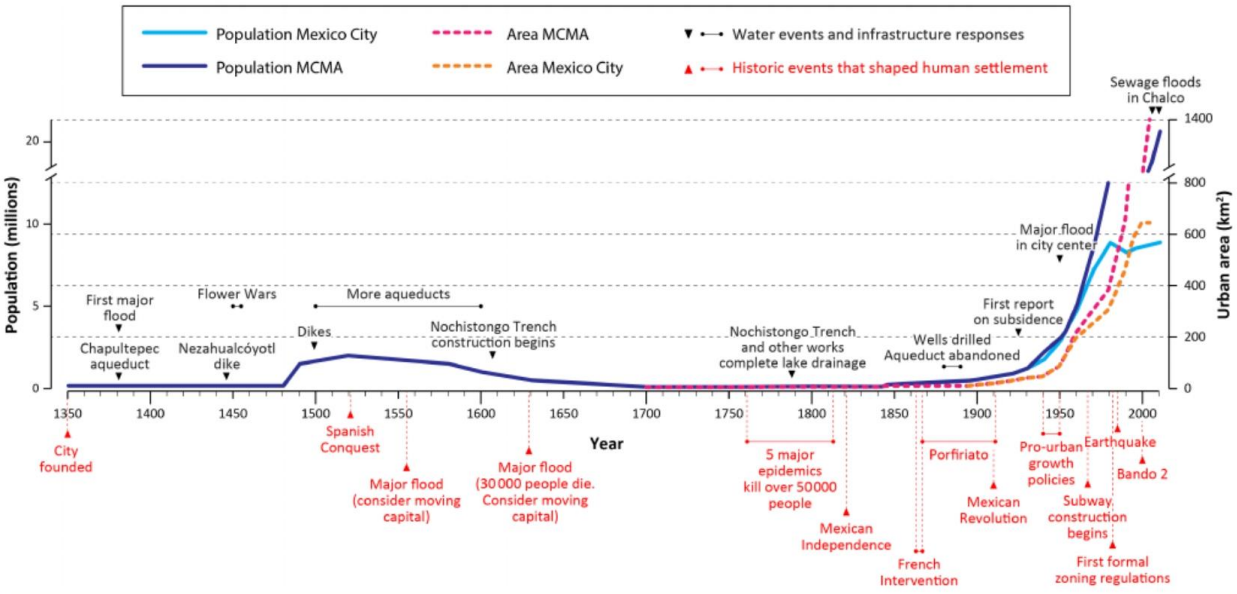

Fig. 8 *CDMX and ZMVM (MCMA) population in response to historical events and disasters*

NOWADAYS URBAN RESILIENCE

Plan Verde

An example of a sustainability plan that was introduced before joining 100RC is *Plan Verde* - the Green Plan (Plan Verde CDMX, n.d.). Launched in 2007, the 15-year plan devotes $1 billion a year to address environmental and social challenges on the city level (The Index Project, n.d.). Although it does not mention resilience *per se*, its objectives and holistic approach are in accordance with resilient development principles, thus it was chosen to be described in the report.

The plan was developed in cooperation with all city government departments based on social consultations conducted beforehand. *Consulta Verde* (Green Consultation) solicited citizen approval of 10 high-impact environmental actions, which were later adopted into 27 strategies and 77 specific goals. The timeframe of the plan goes beyond a traditional 6-year planning (which is the head of government tenure) to enable implementing medium and long-term measures. One of the goals is also to force cooperation between different departments. The plan was not supposed to be another policy under SEDEMA supervision, but a plan for the entire government (Ebrard, 2014).

Proposed solutions aim to tackle a variety of environmental problems while creating synergies to create direct social benefits. The strategies and goals cover seven dimensions (or challenges): **land conservation, habitability and public space, water, mobility, air, solid waste** and **climate change and energy.** Actions include not only infrastructural solutions but also education, to change the perception of common goods and public space and build a resilient community.

The public space strategy aims to create and reclaim urban green spaces, to make them safe, aesthetic and biodiverse. Land use changes into more permeable surfaces can also affect water supply issues, as it enables infiltration and aquifer recharge and greenery can improve public health and wellbeing by providing ecosystem services.

The water strategy increases the adaptive capacity of the system, through actions like the ecological restoration of the upper basin of Magdalena river, the installation of collectors on the riverbanks to capture drainage and the installation of treatment plans (Ebrard, 2014). Moreover, it promotes education to create a culture of water saving. In CDMX there are significant differences in water use between the rich and the poor, ranging from 20 to 600 L/day *per capita* (Tortajada, 2006a). An educational campaign can possibly help to reduce the inequalities not only by teaching people with limited water access how to use it more efficiently, but most importantly by reducing excessive water use in the rich part of the city, which is one of the main causes of aquifer exploitation.

The mobility strategy faces the problems of traffic congestion and poor air quality as well as social issues - many ZMVM residents cannot afford living close to their workplaces, which results in spending hours

on daily commute. “Travel by Bike” initiative aims to create 300 km of bike routes in non-motorized transport corridors to make this means of transport feasible and safe (The Index Project, n.d.). In 2010 EcoBici (see: fig. 9), the first public bicycle system was installed in CDMX and started a new urban culture of sustainable transport (Ebrard, 2014). Additionally, extension of the metro network, creation of 200 km of bus lanes and putting the school transportation program into operation are planned to improve public transport. This way it creates a bridge with the air strategy. *Plan Verde* foresees reducing not only traffic, but also industrial emissions. Due to its geological form, the Valley of Mexico creates conditions for trapping the air pollution as inversions of colder air can be trapped by warmer air in the basin surrounded by mountains (Pacific Northwest National Laboratory, 1997).

Fig. 9 *Public bikes Ecobici*

Another part of *Plan Verde* is solid waste management. It recognises the need of increasing recycling rates through education in the continuously sprawling metropolis and modernising waste management. The initiative also proposes solutions such as including urban gardens and compost piles for 15 middle-class apartment complexes or capturing biogas from a landfill site (The Index Project, n.d.). Those measures could reduce GHG emissions, soil and water contamination and improve human health and wellbeing by reducing the amount of waste close to settlements.

The first Climate Action Program for 2008-2012 that falls into the climate change and energy dimension of *Plan Verde* was successful enough to receive an international recognition that led to hosting the 2010 World Mayors Summit on Climate Change, setting a milestone on the CDMX resilience path (Ebrard, 2014).

Mexico City Climate Action Program 2014-2020

The first document to mention resilience is Mexico City Climate Action Program 2014-2020 (Rodríguez et al, 2014), where resilience is understood as **prevention and mitigation of risks**. These are risks caused by climate change, such as extreme weather events or disease spreading. Resilience is applied for exposure, not vulnerability. It takes an environmental approach and although some actions mention vulnerable groups, in general it does not comprehensively convey the socio-economic aspects. Each action listed under building resilience provides the objective, responsible stakeholders, links with national and local policies, relationship with climate research, measures, costs, goals and time frame (short, medium, long term) which makes the implementation process very clear. The actions include coping, for instance improving monitoring or people relocation as well as preventing from the cause, for example GHG emissions reduction and decreasing deforestation.

CDMX Resilience Strategy

The main document drawing CDMX resilience path is the Resilience Strategy, prepared by CDMX Resilience Office in cooperation with SEDEMA and published in 2016 (Matus Kramer et al, 2016). It follows 7 resilience qualities:

- Inclusive
- Integrated
- Robust
- Resourceful
- Reflective
- Redundant
- Flexible

The vision of resilient CDMX states **Equality**, **Inclusion** and **Adaptive Transformation.**

The strategy is built upon 5 pillars and 17 goals to respond to identified shocks and stresses. For each goal there are defined several actions that list responsible parties, partners, time period (short, medium or long term) and resilience value (see framework on fig. 10). The following part breaks down each pillar to characterise it and assess the feasibility and progress.

Pillar 1: Foster regional coordination

The dynamic relationship between CDMX and ZMVM requires strong cooperation and integrated policy making. Environmental problems need to be approached at least at the level of the Valley of Mexico, resource reliances extend beyond the state borders and 40% of ZMVM residents cross at least one municipal border to get to their workplace. Integration of the fragmented governance structures is crucial to successfully implement resilience policies and ensure including all the vulnerable groups, that

are largely located beyond CDMX boundaries, pushed outside the conservation zone. The first pillar fosters cooperation between different actors though working on common goals, such as conservation of ecosystems or reducing pollution. As proved by *Plan Verde*, this action has high feasibility.

Pillar 2: Promote Water Resilience as a New Paradigm to Manage Water in the Mexico Basin

As it was already stated in the report, CDMX development is based on complex and difficult relationships with water, causing chronic stresses and severe shocks. Contrary to past solutions, focusing mostly on increasing capacity and robustness of the water systems, the resilience strategy proposes decentralisation and improving redundancy through multiple diverse actions, such as education, green and blue infrastructure, rainwater harvesting. It identifies vulnerable groups and links between inequalities and water access. In the comprehensive approach it includes different time scales and a variety of actors.

Pillar 3: Plan for Urban and Regional Resilience

The objective is to recover and expand green spaces, create safe public spaces and ensure equal access to those. It identifies social spatial inequity and marginalisation and manages them through urban planning and design. Affordable housing connected to transportation networks and workplace hubs is another measure to address inequality and enhance social cohesion.

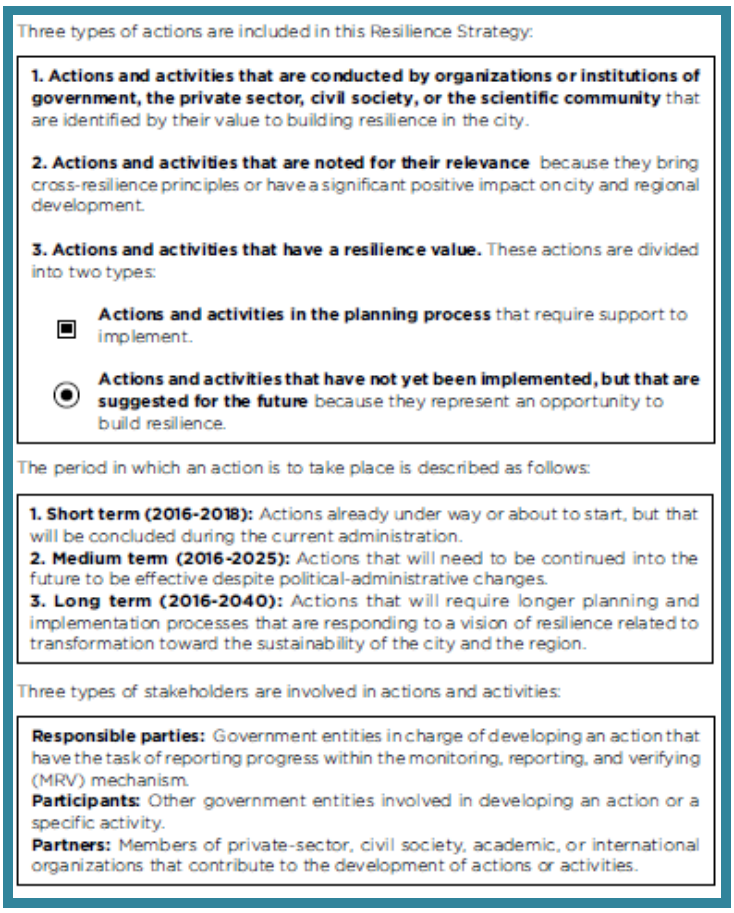

Fig. 10 *Resilience strategy actions framework*

One of the goals is to increase protection of conservation areas. As long as it is crucial for human wellbeing through securing water supply, reducing pollution and providing other ecosystem services, it presents some trade-offs that might be contradictory to the Pillar 3 vision. Although informal settlements in the Conservation Zone are being mapped and regularised (see: fig. 11), those actions can result in deepening social divisions (Connolly, 2017). The strategy lacks a proposal of how to achieve inclusion of these communities.

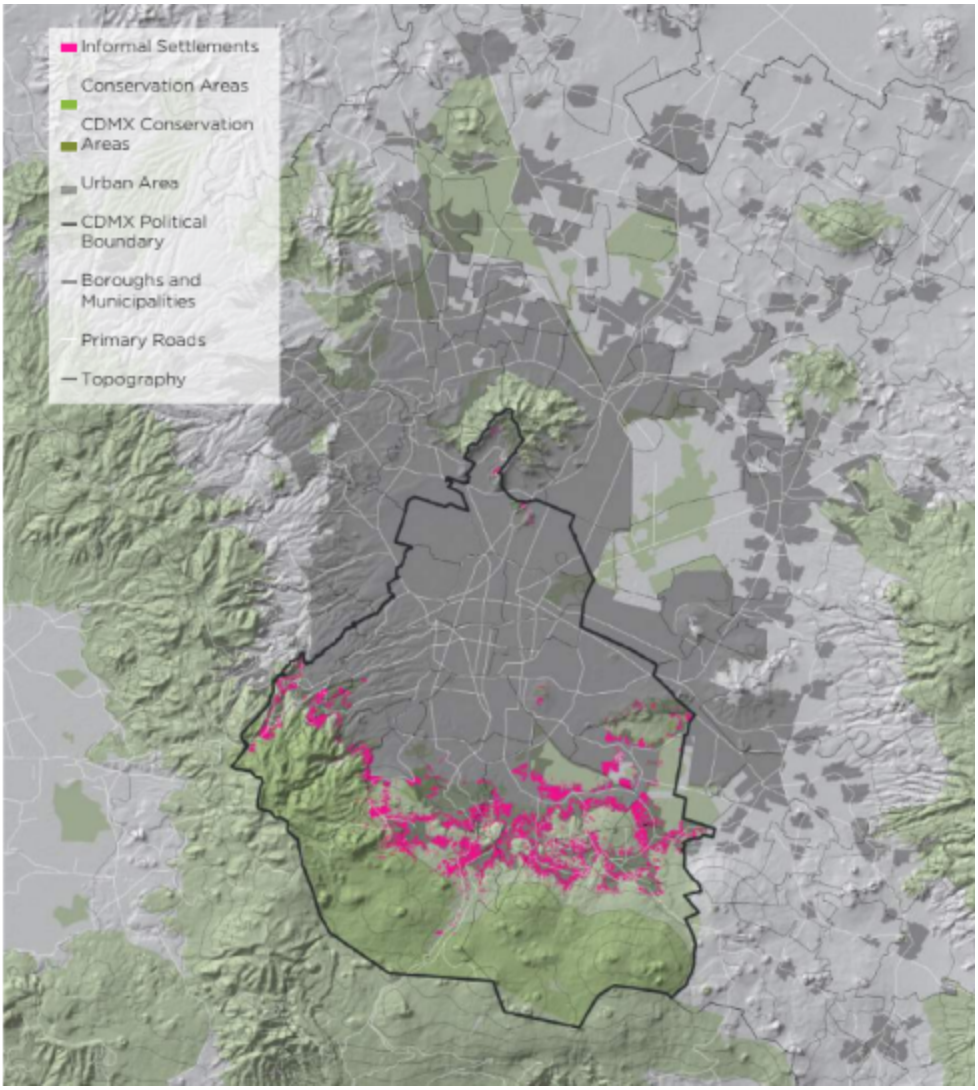

Fig. 11 *Conservation areas and informal settlements*

Pillar 4: Improve Mobility through an Integrated, Safe, and Sustainable System

In the metropolis of 22 million inhabitants, where for years infrastructure was created in favour of private vehicles and still 30% of daily commutes are made with cars, mobility is a huge challenge for air quality, public health and wellbeing and inclusivity. The past policies aiming to reduce the number of cars on the streets were not sufficient (Romero et al, 2015), therefore CDMX proposed integrated policies that do not only extend to regional level, but also aim to enable paradigm shift, from private vehicle mobility to public transport and bikes. This pillar also tackles emergency preparedness, by adapting public transport to climate change and improving mobility in case of disasters such as earthquakes.

Pillar 5: Develop Innovation and Adaptive Capacity

CDMX is exposed to numerous risks that will continue to become more severe and frequent with climate change and population growth. For such a huge metropolis, emergency preparedness and dynamics of response is crucial. Similarly to Pillar 1, Pillar 5 conveys implementation of resilience. Strengthening technical capacities in the public sector and encouraging implementing resilience in the private sector developments while building community resilience should change the way of modern planning and designing. If successfully enforced, Pillar 5 guarantees making resilience an integrated step of planning instead of a separate concept.

To sum up, the CDMX Resilience Strategy is a well designed and prepared document. It includes not only direct responses to shocks and stresses but also actions to facilitate implementation on different levels, which is a huge challenge itself, as can be seen for instance in the failure of The Valley of Mexico Sanitation Project. A large drawback is lack of budget allocation, but the example of *Plan Verde* shows that it does not determine poor performance, especially if the responsibilities are distributed. If properly supervised by the city government, the strategy is highly feasible and has a potential to make systemic changes and mainstreaming resilience.

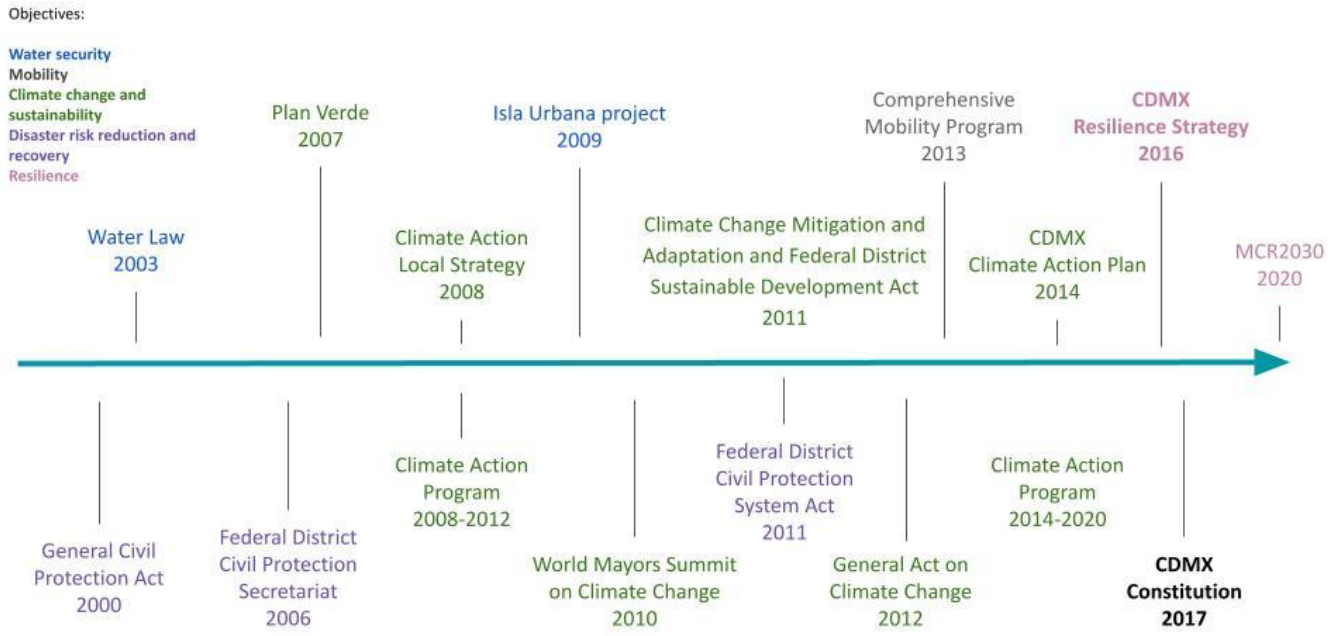

Fig. 12 *CDMX policies, plans and projects development*

DISCUSSION AND CONCLUSION

Getting off the beaten path: how to achieve adaptive transformation to enter the desired development pathway?

After the collapse of Aztecs and establishing the New Spain capital on Tenochtitlán ruins, the lack of knowledge and understanding of draining systems led into the rigidity trap of floods and droughts. The decision of not moving the capital and instead draining a lake, released settlers from the trap, but the centralised system made them fall into the scarcity trap, as the city was expanding, resources were shrinking and infrastructure started failing to meet the increasing demand. CDMX remained in this place for centuries, as policies were focused mostly on improving robustness, instead of decentralising and making the system more redundant. Centralisation of development and resources provision had an inevitable effect on the social sphere, deepening the inequalities and causing unrest.

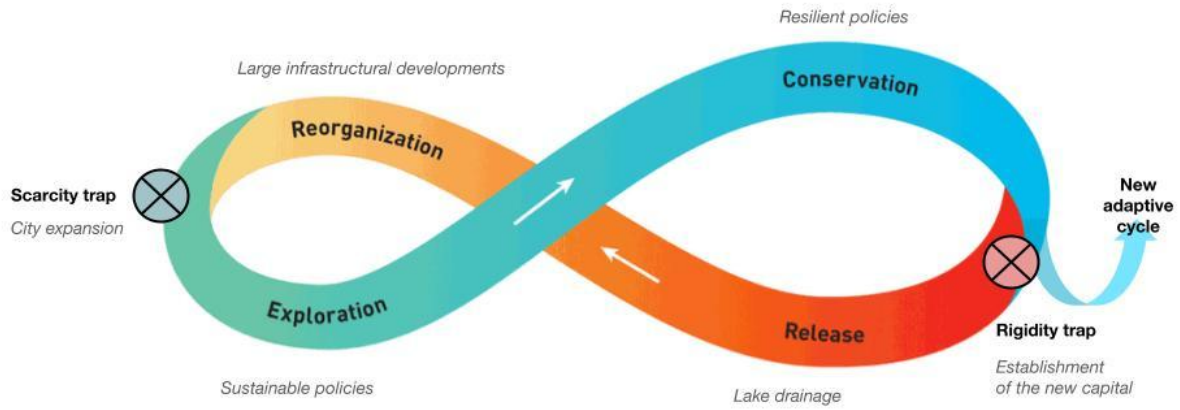

Fig. 13 *Adaptive cycle of CDMX*

In the 1980s the global trends were shifting towards sustainability, promoted among others by the World Bank. Although CDMX has implemented them to create new urban policies, there was little enthusiasm and still traditional planning was followed (Mancebo, 2007). An evidence of that is the failure of The Valley of Mexico Sanitation Project that could help the city make a huge step towards sustainable development and improve water security and public health. However, in a place with such a long history of taking control over environment and development, often through rapidly undertaken programmes with no regulatory framework, there was needed much more than an outside incentive. CDMX needed a paradigm shift to escape this trap. It did not come until the 21st century. As CDMX became infamous for

being one of the world's most polluted cities, earning a nickname "Make sicko", the authorities saw that drastic changes were necessary. The policies of the 2000s, such as Climate Action Local Strategy, Climate Action Program 2008-2012 and *Plan Verde* enabled those systemic changes. It was the trigger that caused the abrupt transformation of CDMX from an unwanted resilience pathway of corruption, inequalities, car dependence and resource overexploitation, to the green, sustainable and equitable one, as presented on Elmqvist's diagram (fig. 14).

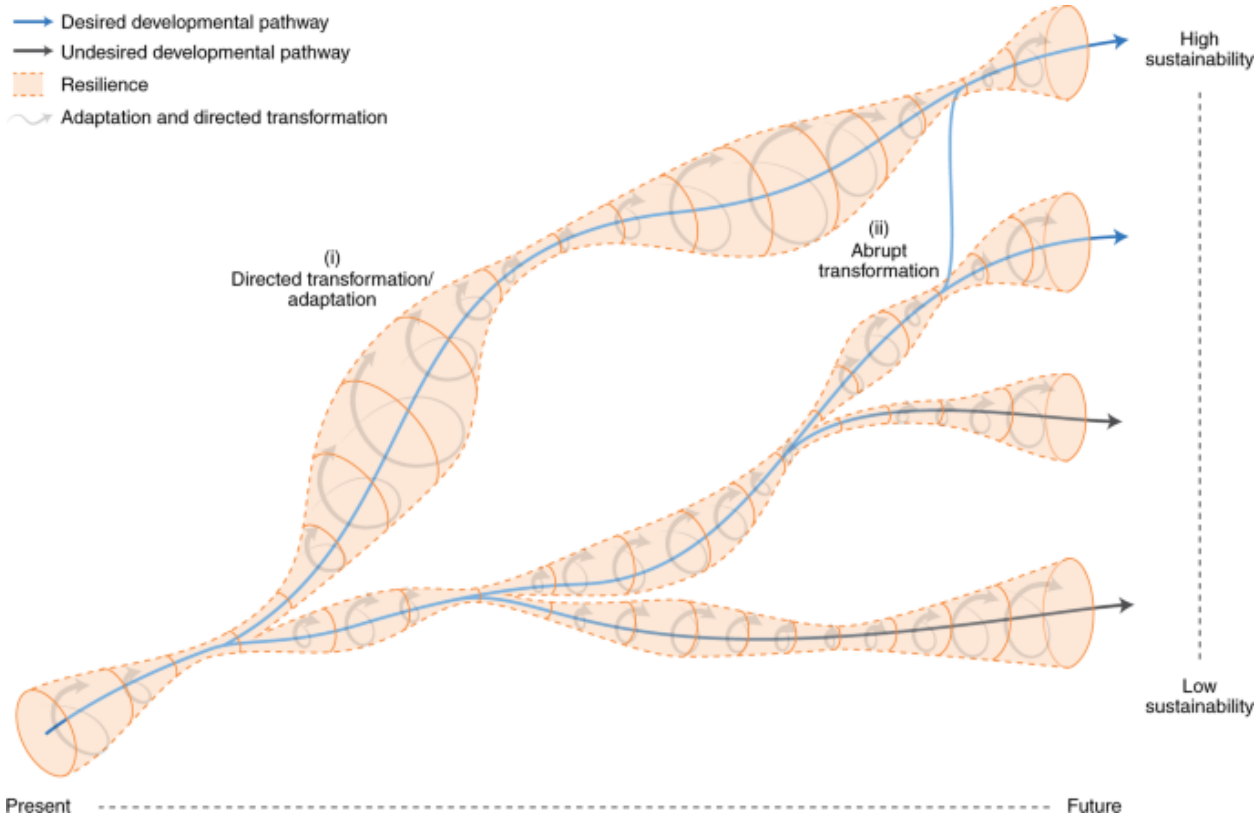

Fig. 14 *Development pathways*

Upon those foundations there was established the paradigm of resilience. In the CDMX Resilience Strategy, it was developed by identifying shocks and stresses to find solutions, and introduced at different spatial and time scales, addressing not only consequences but also roots of the problem. Resilience is treated not as an additional point, but as a base of policymaking. It enforces horizontal cooperation by developing multisectoral participation within its Resilience Council and vertical cooperation within ZMVM, combining top-down and bottom-up approach by encouraging social participation. What is also important, and could be seen also in *Plan Verde*, is the integrative approach, with actions touching upon different dimensions and addressing various challenges at once to create a comprehensive and coherent plan. Moreover, it is recognised that resilience is not only about existing

and built environment, but also community. Supporting vulnerable groups is an important point in the strategy, however it could specify better different kinds of vulnerabilities. For instance, it fails to distinguish indigenous communities that contribute to 9,3% and 15,8% of population in CDMX and the State of Mexico, respectively (INEGI, 2020).

The flexible, redundant and integrated approach, presenting different actions to achieve certain goals, seems reasonable through the lens of past unsuccessful policies. An example for that might be the program "*Hoy no circula*" - non driving day. It started in 1989 to address the problem of air pollution. The licence-plate based restrictions aimed to reduce the number of cars on the streets during weekdays by 20%. The program was expanded through following years, but studies show that it did not bring the estimated effect (Romero et al, 2015). As the system is partly based on the numbers on plates, some drivers bypass the restrictions by buying a second car to be able to drive every day. Vehicle registrations and automobile sales shows that in fact the program led to an increase in the total number of vehicles in circulation, especially the older ones. There is no evidence of an increased use of public transport, people might rather choose taxis instead of public transport on the days when they are not allowed to drive their own cars. Yet, the ProAire program, embedded into the resilience strategy proved to be successful and resulted in lowering air pollution and prolonging life expectancy. The crucial difference is that ProAire supplements the non-driving program with private vehicle alternatives, such as safe and accessible public transport and cycling infrastructure.

In spite of heading in the resilient and sustainable direction, CDMX is often trapped in stigmergy, which makes it difficult to change certain development paths. The range of choices available today is limited by decisions taken in the past, in certain political, cultural, economic context, often coming from lack of knowledge and understanding (Tellman et al, 2018). This includes large infrastructural solutions, such as drainage and water supply systems as well as smaller scale measures. Even simple solutions, that can be easily implemented in other places, are challenging. A good example is green infrastructure that is often used to regulate water systems by controlling runoff and increasing infiltration. In case of CDMX, the physical characteristics of soil has been already changed because of anthropopressure and implementing permeable surface might not be enough to let the water infiltrate and recharge aquifer. Another problem is the feedback loop that makes it difficult to implement new greenery. More and more common heat waves cause larger evaporation on the soils with no green cover and change their chemical characteristics to more saline and saline soil is much more difficult to implement new greenery.

Nevertheless, the city where even a new green square can be a challenge was chosen as one of three MCR2030 Resilience Hubs in the Americas and the Caribbean (UNDRR, 2022). It was found to have successfully established governance systems dedicated to improving resilience. Moreover, it shows that CDMX aims to be an active member and role model in the resilience network not only through 100RC but also other interregional forms of cooperation.

Although it was distinguished by UNESCO for its resilience against the COVID-19 pandemic (Expansión Política, 2021), for such a large system as ZMVM it is still too early to assess the adaptive transformation capacity to apply new measures while following the same objective, sometimes referred to as "bouncing forward". An example that could be better evaluated is the response to the 2017 earthquake. Research

conducted 42 months after the event shows that CDMX managed to increase the seismic resilience of buildings in post-disaster recovery (Tena-Colunga et al, 2017). Not only buildings, but also critical infrastructure got heavily damaged resulting in the largest water crisis known in CDMX (López, 2017). Thanks to the measures taken to decentralise the water supply system, i.e. rainwater harvesting systems implemented by Isla Urbana, the city could face this crisis (Isla Urbana n.d.).

CDMX is exceptional in terms of the number of shocks and stresses. But for the cities facing pandemics, climate change and growing urbanisation rates, this might soon become a new normal. For this reason, CDMX was reasonably chosen as a new resilience hub. It is a manifestation not only of the significance of the seven resilience principles listed in its strategy, but also ways of their successful implementation. It proves that if such a rapid paradigm shift, from anthropocentric through sustainable to resilient, can be done in a metropolitan area that hosts more citizens than many counties, it is possible in any other city.

The main lesson learned from the CDMX resilient pathway, starting with *Plan Verde* and continuing until now in 100RC and MCR2030 network, is that it is not enough to know shocks and stresses and answer them with specific actions. Whenever a new paradigm appears, the greatest challenge is its implementation. By putting a strong emphasis on regional cooperation and enforcing participation of all the government departments, the city managed to go beyond sustainability. Even though it is still far from the most sustainable and liveable place in the world, the way that it has gone through is enormous. What can be seen now is an effect of only around 20 years of real actions towards sustainability and resilience, which is not a long time in a metropolis context. And considering that it is still a beginning of the way, if the next governments keep following it, CDMX has a potential to become a true role model of resilient development.

Bibliography

1. Aguilar, A., Guerrero, F. (2018). The city-region of Mexico City: Social inequality and a vacuum in development planning. International Development Planning Review. 40. 51-74

2. Archivo General de la Nación (2022). El Gran Canal de Desagüe del Valle de México: un proyecto que duró casi tres siglos y medio en concretarse https://www.gob.mx/agn/es/articulos/el-gran-canal-de-desague-del-valle-de-mexico-un-proyecto-que-duro-casi-tres-siglos-y-medio-en-concretarse?idiom=es

3. Asamblea Legislativa del Distrito Federal (2003) Ley de Aguas del Distrito Federal. http://www.aldf.gob.mx/archivo-d0c1ac48ef930701568a2cbd52e7d29e.pdf

4. Britannica (n.d.) https://www.britannica.com/topic/chinampa

5. Chaussard, E., Havazli, E., Fattahi,H., Cabral-Cano, E., Solano-Rojas, D., (2021). Over a Century of Sinking in Mexico City: No Hope for Significant Elevation and Storage Capacity Recovery, *JGR Solid Earth*. 126.4.

6. Connolly, P., Wigle, J., (2017). (Re)constructing Informality and "Doing Regularization" in the Conservation Zone of Mexico City. *Planning Theory & Practice*. 18:2: 183-201

7. Ebrard M. (2014, January 17) From "Make-Sicko" back to Mexico City: The Greening of Mexico's Distrito Federal. https://www.americasquarterly.org/fulltextarticle/from-make-sicko-back-to-mexico-city-the-greening-of-mexicos-distrito-federal/

8. Expansión Política (2021). https://politica.expansion.mx/cdmx/2021/04/15/unesco-reconoce-resiliencia-de-la-cdmx-frente-a-sismos-y-covid-19

9. Ferrari, L., Esquivel, T., Manea, V., Manea, M., (2012). The dynamic history of the Trans-Mexican Volcanic Belt and the Mexico subduction zone. *Tectonophysics*. 522–523: 122–149.

10. Gobierno del Distrito Federal (2012). Atlas geográfico del suelo de conservación del Distrito Federal. Secretaría del Medio Ambiente, Procuraduría Ambiental del Ordenamiento Territorial del Distrito Federal, Ciudad de México, México.

11. INEGI (2020). https://www.inegi.org.mx

12. Isla Urbana (n.d.). https://islaurbana.org/

13. López J. (2017, October 5) Sismo provoca crisis de agua histórica en el Valle de México, https://www.excelsior.com.mx/comunidad/2017/10/05/1192854

14. Mancebo., F. (2007). Natural hazards and urban policies in Mexico City. *Revue de Géographie Alpine. Journal of Alpine Research*, 95-2

15. Matus Kramer, A., Sánchez, A., Mendoza, D., Rivadeneyra, F. (2016). CDMX Resilience Strategy: Adaptive, Inclusive and Equitable Transformation

16. National Research Council (1995) Mexico City's Water Supply: Improving the Outlook for Sustainability. *Washington, DC: The National Academies Press*

17. Pacific Northwest National Laboratory (1997). Basin Traps Air Pollution In Mexico City: International Study Has Implications For U.S. Cities. *ScienceDaily*

18. Plan Verde CDMX (n.d.). http://www.planverde.cdmx.gob.mx/ecotips/73-miscelanea/297-plan-verde-en11-parrafos.html

19. Rodríguez, G., Becerra Delgado, M., Ramírez, I., Skwierinski Durán, A., Haro González, M., Ramírez M., et al. (2014). Programa de Acción Climática Ciudad de México 2014-2020 (Mexico City Climate Action Program 2014-2020

20. Romero, D., Vera, M., Gómez, E. (2015). El programa "Hoy no circula" como política de movilidad fallida, que puede provocar migración, una mirada en retrospectiva de 25 años.

21. Salinas, E., Boer, F., van de Pas, B. & Espínola, V. (2016). Towards a Water Sensitive Mexico City: Public space as a rain management strategy.

22. Tellman, B., Bausch, J., Eakin, H., Anderies, J., Mazari, M.,Manuel-Navarrete, D. Redman, Ch. (2018). Adaptive pathways and coupled infrastructure: seven centuries of adaptation to water risk and the production of vulnerability in Mexico City. *Ecology and Society.* 23.

23. Tena-Colunga, A., Hernández-Ramírez, H., Godínez-Domínguez, E.A. (2021). Mexico City during and after the September 19, 2017 earthquake: Assessment of seismic resilience and ongoing recovery process. *J Civil Struct Health Monit* 11, 1275–1299

24. The Index Project (n.d.). https://theindexproject.org/post/plan-verde

25. Tortajada, C. (2006a). Water Management in Mexico City Metropolitan Area. *International Journal of Water Resources Development*. 22 (2): 353–376.

26. Tortajada C. (2006b). Who Has Access to Water? Case Study of Mexico City Metropolitan Area. Human Development Report Office

27. UNDRR (2022). Three Resilience Hubs in the Americas and the Caribbean. https://reliefweb.int/report/brazil/three-resilience-hubs-americas-and-caribbean

List of figures

Fig. 13 Adaptive cycle of CDMX. Retrieved from: Gunderson, L. & Holling, C. (2003). Panarchy: Understanding Transformations In Human And Natural Systems. Bibliovault OAI Repository, the University of Chicago Press. 114.

Fig. 14 Development pathways. Source: Elmqvist, T., Andersson, E., Frantzeskaki, N. et al. (2019) Sustainability and resilience for transformation in the urban century. *Nature Sustain* 2, 267–273