# Urban Political Ecology in Mexico: Metabolism, conflicts, and the need for transformational pathways in the Valley of Mexico, Guadalajara, and Monterrey

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## Abstract

This article analyzes urban socio-ecological conflicts in the Mexican metropolitan areas of the Valley of Mexico, Guadalajara and Monterrey from an Urban Political Ecology (UPE) approach. We identify the main triggers of such urban socio-ecological conflicts and the causal links between actors, resources and spaces which make up the uneven production of urban space. This focus includes unequal access to resources, uneven distribution of environmental impacts, and the rise of contestation. We outline UPE theoretically and conceptually, and delineate what is meant by urban socio-ecological conflict. UPE is then contextualized within Mexico's contemporary urbanization process as a prelude for characterizing case studies (including their metabolic profiles) and the analysis of prevailing socio-ecological conflicts. For the latter, we identify the main urban conflicts in the years 2012 and 2022, highlighting some of the main characteristics, similarities, and discontinuities across three metropolitan areas. In the face of an increasing metabolism of contemporary urbanization, we conclude with a brief consideration of the potential role of socio-ecological conflicts for enabling alternative forms of urban space production, particularly through the agency of social movements, including their capacity to propose and build "urban spaces of hope."

**Keywords:** Urban Political Ecology, urban socio-ecological conflicts, urban metabolism, urban spaces of hope, Metropolitan Area of the Valley of Mexico, Metropolitan Area of Guadalajara, Metropolitan Area of Monterrey

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## Résumé

Cet article analyse les conflits socio-écologiques urbains dans les zones métropolitaines mexicaines de la Vallée de Mexico, Guadalajara et Monterrey à partir d'une approche d'écologie politique urbaine (EPU). Nous identifions les principaux déclencheurs de ces conflits socio-écologiques urbains et les liens de causalité entre les acteurs, les ressources et les espaces qui constituent la production inégale de l'espace urbain. Nous décrivons UPE d'un point de vue théorique et conceptuel, et définissons ce que l'on entend par conflit socio-écologique urbain. L'EPU est ensuite replacée dans le contexte du processus d'urbanisation contemporain du Mexique et des trois études de cas (y compris leurs profils métaboliques et leurs conflits socio-écologiques dominants). Nous nous concentrons sur les principaux conflits urbains des années 2012 et 2022, ainsi que sur leurs principales caractéristiques, similitudes et discontinuités. Face au rythme du métabolisme de l'urbanisation contemporaine, nous concluons par une brève considération du rôle potentiel des conflits socio-écologiques pour permettre des formes alternatives de production d'espace urbain, en particulier à travers l'agence des mouvements sociaux, y compris leur capacité à proposer et à construire des "espaces urbains d'espoir."

**Mots-clés**: Écologie politique urbaine, conflits socio-écologiques urbains, métabolisme urbain, espaces urbains d'espoir, région métropolitaine de la vallée du Mexique, région métropolitaine de Guadalajara, région métropolitaine de Monterrey

## Resumen

Desde una aproximación de la Ecología Política Urbana (EPU) se analizan los conflictos socioambientales urbanos en las zonas metropolitanas del Valle de México, Guadalajara y Monterrey (México) con el fin de identificar los principales detonantes de los conflictos socioambientales urbanos y los vínculos causales entre actores, recursos y espacios en disputa que modelan la producción desigual del espacio urbano; incluyendo el acceso desigual a los recursos, la distribución desigual de afectaciones ambientales, y la emergencia de procesos contestatarios. Teórica y conceptualmente se bosqueja brevemente a la EPU para desde ahí delinear qué se entiende en este trabajo por conflicto socioambiental urbano. Posteriormente, se contextualiza a la EPU en el ámbito de la urbanización contemporánea en México como antesala a la caracterización de los casos de estudio (incluyendo su perfil metabólico) y el posterior análisis de la conflictividad socioambiental imperante. Para esto último, se identifican y mapean los principales conflictos socioambientales urbanos para el periodo 2012-2022, precisando las características, similitudes y discontinuidades principales de la EPU en las tres zonas metropolitanas seleccionadas. Se concluye con un esbozo del potencial papel de los conflictos socio-ecológicos de cara al esperado aumento de los patrones metabólicos, así como de la necesidad de habilitar formas alternativas de producción del espacio urbano, contexto desde el cual se revalora el papel y la agencia presente de los conflictos socioambientales urbanos.

**Palabras clave:** Ecología Política Urbana (EPU), conflictos socioambientales urbanos, metabolismo urbano, espacios urbanos de esperanza, Zona Metropolitana de Monterrey, Zona Metropolitana de Guadalajara, Zona Metropolitana del Valle de México.

## 1. Introduction

Most studies of socio-ecological conflicts have focused on rural environments, generally associated with the intensive use of natural resources, extractive practices, and their implications. Conflicts in urban environments have been relatively less visible (Aliste & Stamm, 2016). For example, of the 3,713 case studies reregistered in the Environmental Justice Atlas by the end of July 2022 (ejatlas.org), only 273 conflicts or 7.3% were specifically related to urban development. Other conflicts with an urban dimension make up an additional 24.9 per cent (for example those related to tourism [143], ports and airports [172], waste management [80], chemical industry [162], manufacturing [107], water treatment and access to sanitation [141], and construction

materials [121]). In addition, even though many conflicts in rural areas can indirectly be associated with the intense energy and materials consumption patterns of cities, urban conflicts – that is those that arise within urbanized spaces and spaces that are under direct control of cities – have been comparatively less studied from a socio-ecological viewpoint. Nonetheless, the conceptualization, identification, and characterization of urban socio-ecological conflicts is an ongoing effort to show how they – and the social actors involved – (re)shape our cities, or have the potential to do so.

Research on urban socio-ecological conflicts is also important for delineating how Urban Political Ecology (UPE) takes place on the ground and how its analytical methods and theory could evolve. UPE has made important contributions to understanding contestation in defense of the "right to the city" along with subdisciplines including urban geography, urban political sociology, and urban anthropology (see, for example: Logan & Molotch, 1987; Smith, 1990; Sassen, 2001; Harvey, 2012; Brenner, 2014). By drawing on such approaches but also from ecological economics, social ecology, or industrial ecology, UPE is concerned with understanding how different forms of social organization craft a diversity of metabolic processes whose socioecological impacts take placed unevenly (Desfor & Keil, 2004; Heynen, Kaika & Swyngedouw, 2006; Delgado, 2019a). In the analysis of these processes, which translate into different socio-ecological assemblages with multi-scalar and multi-temporal relations and implications, UPE seeks to reveal who benefits and who is affected. A major focus on UPE is thus on who wins and loses within certain social, political and economic arrangements that support specific socio-metabolic patterns which, in turn, enable explicit forms of urban space production and control that are functional to the logic of the prevailing production system (Smith, 1990; Heynen, Kaika & Swyngedouw, 2006; Delgado, 2019b; Napoletano *et al*., 2020).

Urban space production includes more than urbanized spaces themselves, but also territories for acquiring urban resource inflows and for expelling urban outflows. Understanding extractive activities and megaprojects in non-urbanized spaces (including, for example, the location of infrastructure for the extraction of resources or the generation of energy) is also important. There is a hybridization of research approaches that some have denominated a "political ecology of urbanization" (Glitz *et al*., 2021; Quimbayo & Vásquez, 2016). An interesting dialogue has been opened among scholars of this hybrid approach in Latin America and the Caribbean with decolonial studies that have been present in the region's political ecology literature for some time (Quijano, 2000; Restrepo & Rojas, 2010; Alimonda, 2011). A similar path is already being explored through a dialogue with the exploration of alternative territorial practices. This has led to support for cities for the "common good" or for "good living" (Delgado, 2015a; Lara, 2017).

The political ecology of urbanization and UPE are approaches that distance themselves from "modern naturalism", which is based on a human-nature divide (Sacher, 2019; Foster, 2020) and supports an anthropocentric viewpoint on the radical transformation of the conditions that allow life on planet Earth. UPE approaches, on the other hand, clearly and explicitly include the recognition of cities as ontological entities that are not separated from nature (Tzaninis *et al*., 2020). Cities are open systems with complex metabolic relationships of materials, energy, information flows, people and other living beings, which directly and indirectly impact nature at multiple spatial and temporal scales. Such impacts under the prevailing system of production have been recognized as the main drivers of an increasingly acute metabolic rift (Foster *et al*., 2011; Clark *et al*., 2019). An integral and holistic vision sees cities as a "second nature" that does not cease to be an intrinsic part of the "first nature" (Lefebvre, 1996). Particularly noteworthy in this regard are those readings that call for transcending anthropocentric visions of the urban to enable "multi-species cities" and thus a "more-than-human-right to the city" (Houston *et al*., 2017; Connolly, 2020; Shingne, 2020; Delgado *et al*., 2021).

Urban metabolic arrangements, our focus, are relations of power. Not only do they relate to demographic dynamics or the biophysical characteristics of each city, but also to the circulation of increasingly globalized capitals that affect both. Thus power relations that intersect the (re)production and management of urban space should be at the core of any UPE approach to production relationships – including the very production of urban space – and the access to "goods" as well as the distribution of "bads." This applies not only to power relations that emanate from economic circuits, international institutions, or national and subnational governments, but also to those that emerge from social resistance and contestation against socioecological injustices and in favor of alternative futures and concrete actions that, to one degree or another point towards the production of *urban spaces of hope* (paraphrasing Harvey, 2000). For this reason, socio-ecological conflicts expose the

characteristics, circumstances, complexity, tensions, and contradictions that originate in each city or urban space. They also allow us to identify urban transformations that are desired and possible, as well as the resistances to such change.

This article is based primarily on the analysis of a database of urban socio-ecological conflicts identified from 2012 and 2022 in the Metropolitan Area of the Valley of Mexico (MAVM), the Metropolitan Area of Guadalajara (MAG), and the Metropolitan Area of Monterrey (MAM); the three major metropolitan areas in Mexico. From the analysis of 125 cases (see dataset at https://doi.org/10.5281/zenodo.10330498), we identify the main circumstances and arrangements that have enabled the persistently uneven production of urban space and its socioecological impacts. We focus on two elements:

1) the political, social, economic, cultural, and environmental conditions that produce and reproduce certain urban socio-natures;
2) the structure and organization of prevailing power relations and their social and institutional manifestation. (Domene, 2006; Sywngedouw & Heynen, 2004)

From a comprehensive analysis of the socio-ecological conflicts in the database, the political-ecological characteristics and circumstances in the three selected metropolitan areas are distilled to expose the contradictions, challenges, and prospects for advancing urban transformation. In other words, we identify the urban 'spaces of hope' that advance a diversity of paths of action with a common goal of working for nature and people. Finally, some conclusions are offered about what we consider to be key contributions of this analysis to UPE's theory and analytical methods.

## 2. UPE and urban inequalities in Mexico

Cities are defined through socio-spatial practices, and therefore reflect the enclosures and interests that underlie these practices (Harvey, 2012). Prevailing social, economic, and political arrangements are shaped by ethical principles, norms, and rights. Power relationships shape the material form of space and, consequently, territorial planning, land uses, and architectural practices. In other words, social relations play a crucial role in how cities get built, how benefits and costs accumulate for individuals, and how they aggregate to create durable differences among places, including the ecological destruction associated with the production of urban space (Logan & Molotch, 1987). Land uses (including unwanted ones), infrastructure and urban utilities, and even territorial planning can produce and usually reproduce and intensify uneven conditions (Arias, 2009; Navarrete, 2019; Moreira, 2020).

From the 1950s to the 1970s Mexico saw a big increase in urban housing and infrastructure supply, following rural-to-urban migration, and a welfare state model that progressively developed manufacturing poles in Mexico City, Monterrey, Guadalajara and border cities like Tijuana and Ciudad Juárez (part of the 1965 Border Industrialization Program; Sobrino, 2011). The state model influenced housing conditions, but without fully addressing structural inequalities. From the late 1980s, neoliberalism meant a change in urban policy through the replacement of the existing, yet limited urban planning with national and foreign private investment (Neuman, 1998).

Cities and their metropolitan areas, besides concentrating the most people (currently about 83% of the national urban population), became vibrant "growth machines" (Logan & Molotch, 1987). This was made possible not just through the establishment of direct and indirect relations with global markets but by commodifying urban space to enable long-term cycles of capital accumulation (Harvey, 2012; Delgadillo, 2021). The metropolitanization of urban space in Mexico, particularly since the beginning of the 21st century, has deepened socio-spatial inequalities and territorial imbalances, while generating the conditions for novel forms of urban speculation, urban sprawl, gentrification, and segregation (Ruiz, 2009; Moreira, 2020; Gasca y Castro, 2021). As a result, cities and their metropolitan areas are not being designed or organized productively, operationally, or symbolically to offer optimal conditions for liveability or social inclusion (Arias, 2009). Some Mexican cities host powerful economies, with high quality buildings, infrastructure, and services, while most of the remaining ones continue to grow amid poverty and overcrowding, all within a context strongly permeated

by informality and structural violence (Lefebvre [2016 [1972]). All urban spaces incarnate inequalities, including environmental ones: from access to green areas, to the exposure to pollutants, various kinds of risks, and unwanted land uses. There are recurrent political consequences. These include: citizens have limited access to institutions (and there are limited institutional capacities); a deficiency of autonomous and deliberative spaces; the persistent exclusion of citizens and grassroot movements from decision-making; a lack of democratic attributes in the exercise of public office, resulting in public programs that are not well designed and implemented (Valverde and Gutiérrez, 2017). Politically-situated UPE research tackles the persistence of socio-ecological injustices due to the unequal production of urban space, neoliberal competition, urban branding and marketing (Rosi & Vanolo, 2012).The focus is within and between cities (Bartels, Bruns & Simon, 2020; Keil, 2020; Delgado, 2019a, 2021).

Branding and marketing in Mexico and across Latin America both hide inequalities, while promoting business opportunities in a "modern" and "globalized" urban environment. Homogenization of built environments and urban aesthetics is common, affecting the sense of place and community engagement (Grêt-Reegameey & Galleguillos-Torres, 2022; Nguyen, 2022). A fairer socio-natural relationship under growing urbanization must recognize today's environmental and climate change crises. UPE not only explores the causes of urban socio-ecological conflicts, but also the perspectives and practices that may help to rethink and reformulate how individual cities are planned, designed, built and managed (Delgado, 2015a; Delgado, van Staden & Villaseñor, 2018).

Next, we briefly delve into our understanding of urban socio-ecological conflicts that will allow us to build and analyze a socio-ecological conflict database for the selected metropolitan areas in Mexico.

## 3. Urban socioecological conflicts

We understand socio-ecological conflict to be the processes of public opposition between two or more actors arising from the non-consensual transformation of the environment that emerges from an unfair access to natural resources (including land) and the unjust burdens of pollution (Walter, 2009). This is also described as the ecological distribution of conflicts (Martínez-Alier & O'Connor, 1996; Folchi, 2001; Martínez-Alier, 2002, 2006 and 2014). The actors involved range from local communities to the State, which can be a regulator, as well as a creator or mediator of conflicts (Ferrer *et al*., 2014). Generally, there is an asymmetry to the power of actors. There are communities whose social existence and lives are threatened, and government administrations or the private sector. All are intertwined in accumulation dynamics at a subnational, national, and global scale, asserting particular land uses and the ultimate purpose of territorial transformation and control (Svampa, 2009).

Negotiations are difficult in these kinds of conflict. Interventions can threaten social existence, life systems, and cultural practices through control of a biogeophysical space or resource, and the risk of disturbance (Rungruangsakorn, 2020). But the languages of valuation used by different actors can be incommensurable (Martínez-Alier, 2002; Escobar, 2008; Paz, 2012; Tetreault, 2015). Ecological-distribution conflicts may overlap with other social conflicts based on class, ethnicity or indigenous identity, gender, caste, or territorial rights (Martínez-Alier, 2018). Socio-ecologies are manifested in life systems that express relational modes, including the production of space *vis-à-vis* world views and values, beliefs, perceptions, and habits. The parties in conflict use media, symbolic or even judicial resources of opposition and contestation (Aliste & Stamm, 2016).

Despite sharing characteristics with other types of socio-ecological conflicts, urban socio-ecological conflicts have certain features that can be associated with how urban space is produced through capitalism (Harvey, 2012). Worldwide, cities concentrate populations, material resources, means of production, wealth, and power and decision-making structures. They demand large quantities of land and resources and, consequently, generate entropy – degraded energy and materials – which has impacts on both urban and non-urban spaces (Delgado, 2019b; Delgado *et al*., 2021; PNUMA, 2021).

Socio-ecological conflicts within cities originate when the stability, habitat and main livelihood of an urban community are disturbed. Many such conflicts revolve around access and use of resources, particularly water, recoverable waste, and especially land, because of its importance for ecology, livelihoods and quality of

life (Vieyra & Larrazábal, 2014; Vieyra, *et al.*, 2018; Ruiz, Martínez-Alier & Mingorria, 2019). Urban socio-ecological conflicts often include struggles over water sources at the local and basin scale (Kaika, 2004; Peña, 2014; Delgado, 2015b; Vitz, 2018). They also involve the socio-ecological impacts of land speculation, fragmentation, segregation and urban expansion. There are impacts from construction, whether of buildings or transportation infrastructure, logistics, or waste processing (Heynen, Kaika, & Swyngedouw, 2006; Alfie, 2013; Delgado, 2019a). Other common causes of urban conflicts are those related to public and urban green spaces, due to their uneven spatial distribution, their appropriation for other purposes, privatization, or because of their degradation (PAOT, 2010; Delgadillo, 2018; Wertheimer, 2021).

Although urban socio-ecological conflicts can arise in various places and social groups, the most disadvantaged peri-urban locations usually concentrate these tensions and conflicts, including those that Azuela and Cosacov (2013) describe as "proximity conflicts." These may include mining of materials for construction (aggregates such as sand, gravel and crushed natural stone that due to their high weight are usually exploited in locations as close as possible to urban consumption sites) as well as those that derive from the unwanted disposal of building waste (Delgado, 2019c). Tourist destination cities see frequent land conflicts, particularly along the coast (Mostafanezhad *et al*., 2016). Land and water grabbing and the destruction of mangroves and other local ecosystems makes economic gain for exogenous agents possible at the expense of local communities (Valiente, 2015; Camacho, 2016).

To summarize, in low-income and highly marginalized urban spaces, conflicts are usually associated with three processes:

1) limited, or lack of, access to resources and basic public services such as water and sanitation;
2) issues with overcrowding, informal land occupation, urban sprawl and land tenure;
3) unwanted land uses and their socioecological impacts on air, soil, and water, such as the emission of toxic air pollutants, the discharge and treatment of wastewater, or the disposal of urban waste of various kinds, including highly toxic and radioactive ones (McCulligh & Fregoso, 2019; Delgado & Mac Gregor, 2020; Guevara *et al*., 2020).

These effects fall on landscapes, biodiversity, local food production and so-called 'environmental services.' In medium and high-income urban spaces, socio-ecological conflicts derive from the loss and degradation of urban green spaces, urban speculation and undesirable land uses that from the viewpoint of local populations are seen as negative. An example in the case of Mexico City is the civil association "La Voz de Polanco" ("The Voice of Polanco") which represents the position of mid- to high-income residents of the gentrified, high-income Polanco neighborhood (Delgado, 2019a). Socio-ecological conflicts thus acquire distinctive tones due to the profound uneven production of urban space (Zentella, 2020). This is a process in which socio-spatial segregation and differentiation are combined with disaster risk, leading to the social production of vulnerability (Aliste & Stamm, 2016; Castillo, 2019) which in turn translates into a differentiated exposure that unequally touches the urban rich and the poor (Revi *et al*., 2018; Novillo, 2018; CES, CDMX-PUEC, UNAM, 2018; Delgado *et al*., 2020; Pelling & Garschagen, 2019).

## 4. The metropolitan areas of the Valley of Mexico, Guadalajara and Monterrey

The Metropolitan Area of the Valley of Mexico (MAVM), and the metropolitan areas of Guadalajara (MAG) and Monterrey (MAM) are the largest by population size in Mexico (SEDATU-CONAPO-INEGI, 2018). The MAVM has a population of 21.8 million inhabitants occupying an administrative area of 7,889 km$^2$ and an estimated urbanized space of 1,493 km$^2$, with an average urban density of 146 inhabitants per built hectare (updated from Delgado, 2020).[2] It plays a global economic and sociopolitical role, and is a "metropolis"

[2] Data differs from traditional urban density area which usually shows the resulting division between total municipal population and municipal administrative area (or any other spatial analytical units such as the Basic Geostatistical Areas – AGEBs that are used in Mexico). In this case, for our estimations we use urban population and urbanized area only. Population data corresponds to the 2020 National Population and Housing Census. Estimations of built area were calculated

according to Hall (2005). This metropolis, even though its participation in the national economy has decreased since the 1990s, still generates the bulk of the national wealth, which is around a quarter of the national GDP. Within the urban area, municipalities that make up Mexico City (or the central city) generate 3.7 times more wealth than their counterparts in the State of Mexico and Hidalgo that are also part of the MAVM (OCDE, 2015). There is an uneven distribution of population with almost half living in just 10 out of the 76 municipalities that compose the MAVM.

The MAG, which serves as a political and economic growth pole in the west of the country with important international relationships, is – in accordance with Hall's (2005) categorization – a "capital city" with significant services and manufacturing activities, especially in electronics and cybernetics. It contributes about 5% of the national GDP. Its population of 5.2 million inhabitants occupies an administrative area of 3,432 $km^2$ with an urbanized space of 413 $km^2$ and an average urban density of 127 inhabitants per urbanized hectare (updated from Delgado, 2020).[3]

Similarly, the MAM is a "capital city" specializing in basic metallurgical activities and the production of food and beverages, with a less significant service economy. Like the MAG, it is a metropolitan area with many economic and political ties at the regional, national, and international levels, and wealth generation equivalent to 6.5% of the national GDP. With a population of 5.3 million people, it comprises an administrative area of 7,657 $km^2$ with an urbanized space of 559 $km^2$, and an average urban density of 95 inhabitants per urbanized hectare (updated from Delgado, 2020).[4]

In a nutshell, these three cities – analyzed below – are home to a quarter of the national population, a third of Mexico's total urban population, and more than a third of the national economy. They also have a considerable share of national resource consumption, a concentration of material stock, of waste generation and pollution, and therefore of urban socio-ecological unrest.

*National and metropolitan resource consumption patterns*

From a metabolic perspective, cities are spaces of intensive use of resources in relation to their rural counterparts (UNEP & UN-Habitat, 2021). This is true in absolute terms due to population concentration in cities and, at least in the Global South, also relatively, because of prevailing asymmetric consumption patterns. Depending on how urban space is produced and managed, there is inefficient resource use (IRP, 2018; PNUMA, 2021). With a lack of land use planning, there can be low densities, automobile dependence, inadequate design and construction practices, poor maintenance of buildings and infrastructure, and single land uses. Inefficient resource use also involves high resource consumption patterns.

The International Resource Panel has analyzed the weight of cities in terms of their current and potential resource demand in the future, using for Latin America and the Caribbean a metric of urban Domestic Material Consumption or DMC_u[5] (PNUMA, 2021). Using this methodology, estimations for Mexico's National Urban System[6] suggest that total resource use in 2015 reached 1.09 billion tons (Delgado, 2020). We have updated that estimate, suggesting a 27% increase by 2020, a period during which population only grew about 6.5

using the 2020 National Population and Housing Census and the average urbanized area of 2015 for the national urban system, and for 167 major Mexican cities. The latter is based on data of Florczyk *et al* (2019) as used in *The Weight of Cities in Latin America and the Caribbean* report (PNUMA, 2021). Average population density in 2010 was estimated at 160 habitants/hectare (SEDATU-CONAPO-INEGI, 2018). Urban sprawl accounted for a decrease to 2020.

[3] In 2010 average urban population density was estimated in 124 hab/hectare, similar to 2020 (SEDATU-CONAPO-INEGI, 2018).

[4] In 2010 average urban population density was estimated in 108 hab/hectare, with urban sprawl accounting for a decrease to 2020 (SEDATU-CONAPO-INEGI, 2018).

[5] Domestic material consumption or DMC, "…measures the total amount of materials directly used by an economy and is defined as the annual quantity of raw materials extracted from the domestic territory, plus all physical imports minus all physical exports" (Eurostat, not dated). Urban DMC or DMC_u measures the corresponding fraction of total DMD attributable to urban space or cities.

[6] The National Urban System is comprised of 401 cities which gather 99.8 million inhabitants within an urban footprint estimated in 2022 in the range of 10.3 to 10.8 thousand $km^2$ (Delgado, 2020).

percent.[7] Of the 2022 national DMC_u – about 1.38 billion tons per year – the proportion contributed by the MAVM was 21.8 %, the MAG 5.3 %, and the MAM 5.1% (updated from Delgado, 2020 and PNUMA, 2021). This intensity of total urban resource consumption, on average of about 13.6 tons per capita yearly, is above the recommendation for sustainable consumption, which should be in the range of 6 to 8 tons per capita yearly; and much higher than average rural consumption patterns of 7.2 tons per capita (IRP, 2018). Furthermore, these average consumption patterns hide differences between the urban poor and rich. As presented in Figure 1, the richest 10% of Mexico's urban population consume on average 6.2 times more than the poorest 10%, and almost twelve times more than the poorest 10% of rural inhabitants.

It is therefore no coincidence that socio-ecological conflicts accompany the metabolic dynamism of the three major metropolitan areas, due to access, management and use of energy and materials, but also of water (which is not included in the DMC accounting).[8]

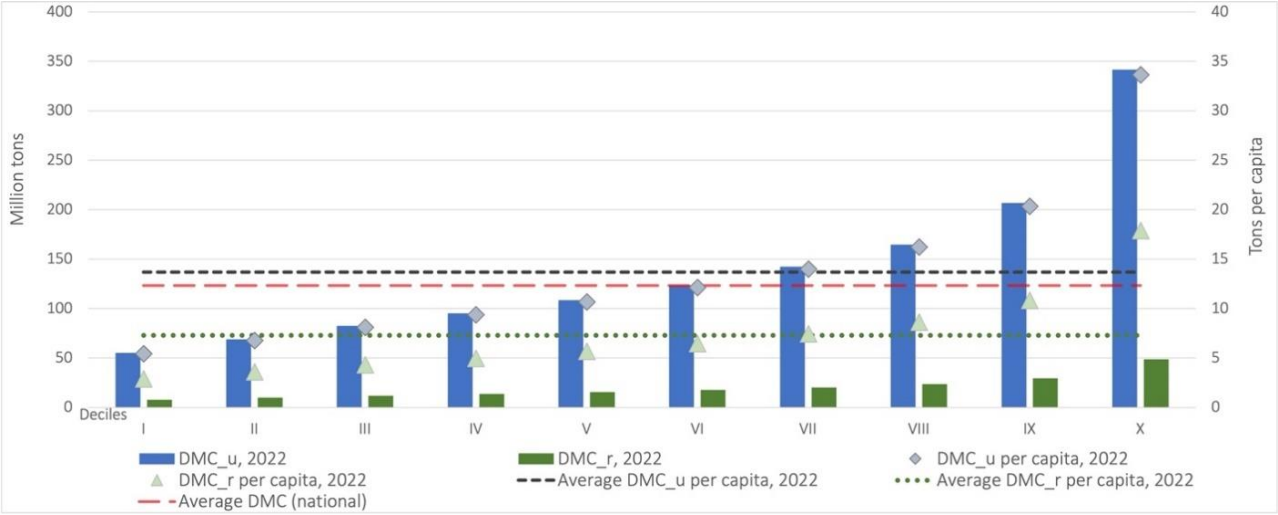


Figure 1: Total and per capita DMC_u and DMC_r in Mexico by decile – 2022. Source: Authors' own elaboration based on data updated from Delgado, 2020 and PNUMA, 2021.

*Metropolitan structure, international and global interactions, and metabolic patterns.*

When observing the metabolic profiles of Mexico's metropolitan areas, it is important to take account of their regional, national, international, and global interactions. The three metropolitan areas have been strongly influenced by the North American Free Trade Agreement (1994-2020), which led to an increase of more than 50% in value productivity chains (Aguilera & Castro, 2018). The three selected metropolitan areas are "integrating hubs of the North American market" due to their trade, financial, and migratory relationships (Arámbula & Santos, 2008). Likewise, NAFTA positioned the USA as Mexico's main trading partner (Aguilera & Castro, 2018), a role that was reinforced by the United States-Mexico-Canada Agreement – USMCA in July 2020 (SE, Government of Mexico-CAF, 2021). All three metropolitan areas have been central for the

[7] Increase in DMC_u responded to four main issues: 1) a growth in urban population; 2) persistent urban sprawl; 3) increase in consumption patterns; and 4) an adjustment to raw DMC national data which now includes waste, excavated earthen materials and manufactured materials (see: https://www.resourcepanel.org/global-material-flows-database).

[8] Urban water flows, measured in terms of urban water footprint (estimated for 2022), reached 225.3 billion $m^3$/year at the national level (estimates based on per capita urban water footprint for Mexico as calculated in PNUMA, 2021). Water demand intensity has been pressured for some time, at the scale of water supply basins (Delgado & Blanco, 2018; Aguilar & Ramírez, 2015; Peña, 2014; González *et al*., 2011).

integration of the North American market. The MAVM, for example, is the leader in all major financial services and I&D activities while the MAG and MAM are frontrunners in manufacturing and trade.

The centralized pattern of Mexico's economy and power structures, along with a macrocephalic spatial urbanization pattern, has translated into higher economic growth and social welfare levels in all three metropolitan areas, and especially in the MAVM. The greatest population density, lower social gap levels[9], and the most favorable living conditions are found in Mexico City, while its peri-urban municipalities suffer from greater poverty and marginalization (OECD, 2015; Delgado & Mac Gregor, 2020). Approximately 25% of the national population actively working in knowledge-intensive sectors reside in the MVMA, mainly in Mexico City. The same applies for workers in the manufacturing sector and in information services with 20% and 45% of the total workforce in such niches respectively. Also, approximately 60% of national workforce employed in financial, insurance and real estate services, and 41.5% of the workforce in professional, technical, scientific, and business support services, are concentrated in the MAVM (SEDESOL-CONAPO-INEGI, 2012). The MAVM is strongly globalized and prominent in the national urban system as part of what has been called Mexico's megalopolis (comprised of 10 metropolitan areas with 35 million inhabitants residing in some of the 225 municipalities of Mexico City, the State of Mexico, Hidalgo, Puebla, Morelos, and Tlaxcala).[10]

The MAG, during the period analyzed, had one of the lowest social gap levels in the country (CONEVAL, 2010, 2016 and 2021a). It attracted a quarter of the national economically active population in the metalworking, electronics, chemical and manufacturing industries (SEDESOL-CONAPO-INEGI, 2012), connecting its production and trade to the metabolic needs of other nearby metropolitan areas as well as to national and international dynamics. Manufacturing and trade activities were 48.3% and 19.6% of its gross production in 2018, respectively (INEGI, 2019), while information, financial, and scientific services barely came to 5.3% of total MAG gross production that same year (IIEG, 2020). This metropolitan area is an "integrating hub" committed to industrial production and trade with important international links, yet not globalized and still with restricted innovation and development (I&D) of its own.

Two municipalities of the MAM, San Pedro Garza García and San Nicolás de los Garza, had the lowest percentage of population living in poverty in the period analyzed (CONEVAL, 2020, 2021b). Likewise, MAM municipalities such as Apodaca, San Nicolás de los Garza and Guadalupe, showed a low social gap level accordingly to CONEVAL's index (2010, 2016 and 2021a). The MAM has 5.9% of Mexico's employed population, the vast majority in manufacturing. In 2018 these generated 53.8% of gross production in the MAM, followed by non-financial services with just 16.3 percent (INEGI, 2019). Like the MAG, the MAM integrates with the North American market, mostly committed to industrial production with important international links. Despite not being fully globalized, the MAM is developing an important manufacturing hub for electric vehicles, propelled by Tesla (USA), Sungwoo Hitech (Korea) and Hyundai (Korea). An increasing demand for mineral resources and water is expected, to support production.

As indicated in Table 1, beyond the increase in resource consumption between 2010 and 2020, the characteristics described above shed light on differentiated resource use in the three selected metropolitan areas *vis-à-vis* their economic structure and their weight and function at the local, regional, national and international scale. The data shows the volume of waste flows too, as well as the type of waste generated and its related socioecological impacts. Industrial waste is certainly of particular concern in the MAG and the MAM, while demolition and construction waste is a problem in all three metropolitan areas, as is all the waste and emissions associated with high automobility.

Considering that the three selected metropolitan areas demand the largest volume of resources and generate, directly and indirectly, a great part of air, land and water pollution in the country, the socio-ecological conflicts identified between 2012 to 2022 constitute a non-exhaustive yet fair representation of UPE dynamics in Mexico. The analysis offered in the following section seeks to account for the links between metabolic profiles and the nature of ongoing urban socio-ecological conflicts.

[9] The social gap level is a composite index comprised of income, education level, household access to health and basic services (water, sanitation, energy), and building quality (type of materials and dwelling size).

[10] Recently the metropolitan area of Queretaro has also been unofficially considered as part of the megalopolis due to existing functional relationships.

| *Item* | | *MAVM* | | *MAG* | | *MAM* | |
|---|---|---|---|---|---|---|---|
| | | 2012 | 2022 | 2012 | 2022 | 2012 | 2022 |
| DMC_u (million tons/year) | Biomass | 90.3 | 98.9 | 20.3 | 24.3 | 19.0 | 23.4 |
| | related products | 0.86 | 0.83 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Fossil fuels | 30.3 | 20.3 | 6.8 | 5.0 | 6.4 | 4.8 |
| | related products | 7.2 | 13.9 | 1.6 | 3.4 | 1.5 | 3.3 |
| | Metal ores$^{\nabla}$ | 59.3 | 91.3 | 13.3 | 22.4 | 12.4 | 21.6 |
| | related products$^{\nabla}$ | -0.8 | -2.5 | -0.2 | -0.6 | -0.2 | -0.6 |
| | Non-metallic materials$^{\blacktriangledown}$ | 76.9 | 78.7 | 17.3 | 19.3 | 16.1 | 18.6 |
| | related products$^{\blacktriangledown}$ | 0.071 | 0.8$^{*}$ | 0.016 | 0.196 | 0.015 | 0.189 |
| | Other | 2.9 | 0.2 | 0.6 | 0.05 | 0.6 | 0.05 |
| | Total | 267.1 | 302.4 | 60.1 | 74.2 | 56.1 | 70.5 |
| Water (billion $m^3$/year) | Inflows$^{\spadesuit}$ | 3.94 | 4.24 | 0.88 | 1.04 | 0.82 | 1.00 |
| | Footprint | 45.3 | 49.1 | 10.2 | 12.0 | 9.5 | 11.6 |
| Urban stock (accumulated by 2020; million tons) | | 1,401.3 | 1,516.9 | 361.4 | 426.8 | 449.9 | 548.5 |
| Pollution | Municipal solid waste (million tons/year) | 10.4$^{\rho}$ | 10.8$^{\rho}$ | 1.7$^{\nabla}$ | 2.0$^{\nabla}$ | 2.0$^{\alpha}$ | 2.1$^{\alpha}$ |
| | GHG emissions (gigagrams of $CO_2e$) | 57.2* | 76.6$^{\blacklozenge}$ | 15.6* | 17.9$^{\blacktriangledown}$ | 17.6* | 24.8$^{\sigma}$ |
| | Water outflows$^{\clubsuit}$ (billion $m^3$/year) | 1.49 | 1.72 | 0.33 | 0.42 | 0.31 | 0.40 |

ρ Estimation based on Mexico City's per capita generation for 2012 and 2021 (and population of 2022), respectively.

∇ Estimation based on MAG's per capita generation for 2017 (latest data available).

α Estimation based on MAM's per capita generation for 2021 (latest data available).

* Estimation for 2012 based on per capita GHG emissions reported in 2013 (to ICLEI).

♦ Estimation for 2022 based on per capita GHG emissions reported in 2018 (latest inventory).

♥ Estimation for 2022 based on per capita GHG emissions reported in 2016 (latest inventory).

σ Estimation for 2022 based on per capita GHG emissions reported in 2013 (to ICLEI).

♠ Includes the extraction of water for industrial and municipal uses. Estimation for 2012 and 2022 metropolitan population based on average national values according to Aquastat for 2012 and 2020 (the most recent value).

♣ Includes only produced municipal wastewater. Estimation for 2012 and 2022 metropolitan population based on average national values according to Aquastat for 2012 and 2020 (the most recent value).

Table 1: Estimation of DMC_u by resource type, urban stock, and generated pollution in the MAVM, MAG and MAM (2012-2022). Source: authors' elaboration based on data from Delgado, 2020; PNUMA, 2021; Aquastat database (www.fao.org/aquastat/en/databases); and waste and GHG city/metropolitan inventories (SEDEMA, 2021; IMEPLAN-WRI, 2021). The variety of base years is due to limited availability, so the closest available year was used. DMC_u for 2022 was estimated with the latest DMC available data, which corresponds to 2019. Average DMC_u growth rate for 2012-2019 (for each type of resource category) was then used for estimating DMC_u for 2020-2022 (we did not model the COVID-19 pandemic, but by using pre COVID-19 average data, a certain degree of consumption slowdown has been considered). Built-up area was estimated from average growth for the period 2000-2015, the only years of available data from the same satellite method (Florczyk *et al*., 2019). Per capita built-up area in 2015 is then used for the period 2016-2022. Urban consumption intensity was calculated based on national household consumption of 2016 and 2020, the closest data available. Estimated degree of uncertainty associated with the use of synchronic data for urban consumption intensity is about ± 0.65%.

## 5. Urban socio-ecological conflicts in the MAVM, the MAG and the MAM: 2012-2022

*The urban socio-ecological conflicts database*

Socio-ecological conflicts in the MAVM, MAG and MAM were identified for the period of 2012–2022 through an extensive review of national and local newspapers, scientific journals, and dissertations. We also considered blogs or other social media channels used by grassroots movements as a means to "recover the voices" of communities whose social existence and livelihoods have been threatened or have been perceived to be threatened. Journalistic material that is no longer available online was also consulted.

Following the discussion in Section 3, we distilled ten urban socio-ecological conflict types. They are not mutually exclusive as one may find multiple aspects or a concatenation of issues that play a central role in each conflict. The types are:

1) urban infrastructure,
2) energy-related,
3) water-related,
4) mining-related,
5) biodiversity and landscape,
6) industry-related,
7) territorial disputes,
8) urban waste,
9) real estate-related, and
10) land use and urbanization

For describing and assessing the different urban socio-ecological conflicts, eleven indicators were used to systematize and provide information on the following aspects:

a) current status of the project that triggered the conflict;
b) agents involved;
c) repertoire of actions;
d) environmental impacts;
e) socioeconomic impacts;
f) health impacts;
g) current status of the conflict;
h) governing political party or party coalition at the state level;
i) governing political party or party coalition at the local level;
j) relevant policy instrument or governmental program identified by one or more actors in conflict; and
k) the main identified narrative actor(s).

Urban socio-ecological conflicts with clearly identifiable "parties" were analyzed rather than environmental problems themselves. Environmental problems may eventually become conflicts if they persist, and could be tracked in future assessments. For similar reasons, legal environmental complaints – a mechanism for reporting potential environmental offences – are not considered although again, some may indeed be part of the action repertoire of the parties or actors in conflict.

The database analyzed in this section is comprised of 125 cases, of which 51% correspond to the MAVM, 28% to the MAG, and 21% to the MAM. The prevalence of conflicts reflects the intensity of metropolitan resource consumption (or the *metabolic profile*; as illustrated most clearly by the MAVM) and the existence of the conditions and a culture for social contestation (as in the MAM with constrained conditions, and also weaker visibility). The types of conflicts that occur are nevertheless mixed, as presented in Figure 2. They are related to current urban development, aggravated environmental conditions, and conjunctural issues. Conflicts related

to infrastructure deployment and loss or erosion of biodiversity and urban and natural landscapes have the most weight. The former was found in the MAVM and the MAM, and the latter in the MAG and the MAM. Conflicts about property and land are relevant and have a consistent weight in all three metropolitan areas, confirming the role of real estate as the major form of wealth storage in Mexico and globally (Savills, 2021).[11]

It is important to point out that for the same socio-ecological conflict one or more "elements" or "tags" may be reported, either regarding typology, actors, repertoire of action, or impacts. For statistical analyses all tags allocated have been considered, yet for conflict mapping only the "leading" conflict type or the one that predominantly structures the conflict has been contemplated.

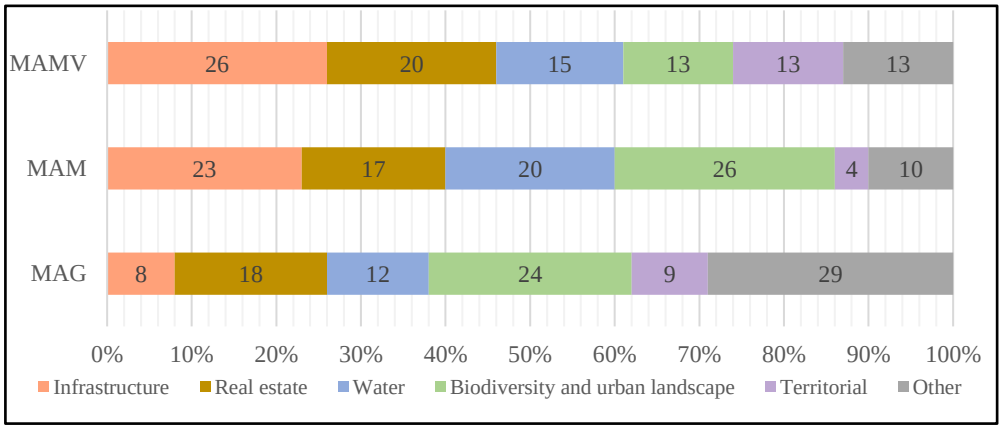


Figure 2: Typology of urban socio-ecological conflicts for the selected metropolitan areas.
Source: authors' own elaboration

The database is not exhaustive but offers a sample of those cases that have achieved greater visibility, some with a history that can be traced back to 2006. While some cases are closed, others are still active or latent. The latter situation was particularly noticeable during the COVID-19 pandemic because it disrupted the mobilization capacities and visibility of grassroot movements (for further details see the supplementary material at https://doi.org/10.5281/zenodo.10330498).

*Comprehensive assessment of urban socio-ecological conflicts*: MAVM *case*

The socio-ecological conflicts registered in the MAVM show some similarities related to the spatial and metabolic dynamics of territories. The more noticeable types of conflicts were those linked to urban infrastructure development and real estate projects, followed by water-related conflicts, threats to biodiversity and urban and natural landscapes, and territorial disputes and other matters regarding land use. This reflects a double trend: on one hand there has been a speculative densification of central areas (sometimes along with gentrification and segregation) and, on the other, urban sprawl has been continuous on the MAVM's periphery, with speculation and segregation. The implications are important for infrastructure demand and the provision of public services, given the intense material and energy flows needed to demolish, build or rebuild, and operate a more extensive built environment (Delgado, 2019a).[12]

[11] In 2020 the global real estate value reached US$326.5 trillion, of which 79% corresponded to residential properties. Such a concentration of wealth was greater than all equities, mined gold and debt securities (Savills, 2021).

[12] Among the circumstantial factors that were present during data collection is the influence of the earthquake of September 19, 2017. With a magnitude of 7.1 on the Richter scale, the earthquake provoked significant damage to buildings and critical infrastructure, affecting housing, mobility, water security and energy supply. The conflicts derived contain an important focus on the uneven distribution of damage, the displacement of local populations, the gentrification of areas with significant

Another observation of significance related to this double trend derives from the dichotomous spatial distribution of conflicts between central areas and the periphery. A trend towards displacement, dispossession and gentrification is usually visible in the centrally located conflicts, while those in the periphery are mostly due to the shortage of infrastructure and public services, inadequate waste disposal, and a lack of local institutional capacities (Figure 3). All of these characteristics are evidence of a relationship in which center and periphery have differentiated roles within urban metabolic stages and flows (Figure 3). Most of real estate conflicts take place in central areas of the MAVM.

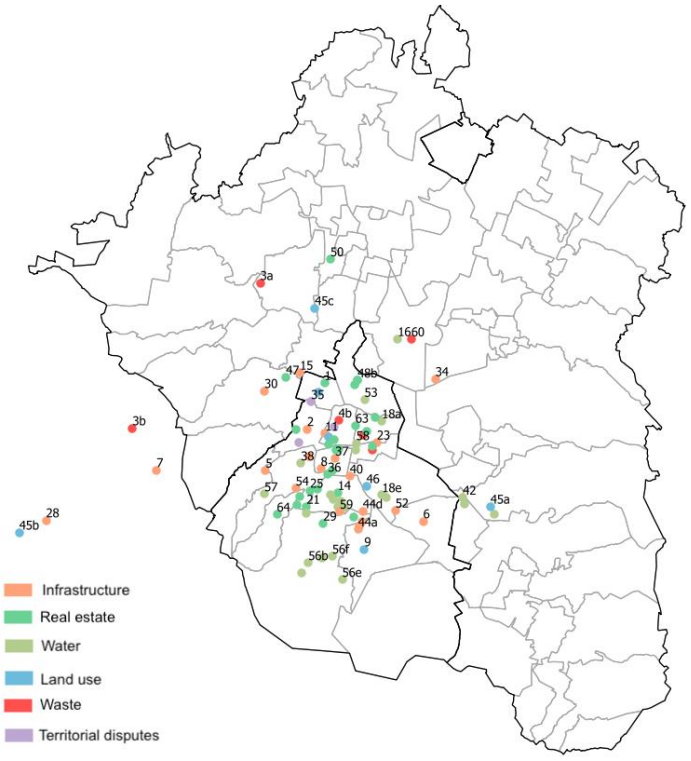


Figure 3: Spatial distribution of socio-ecological conflicts by type in the MAVM, 2012–2020. For details of each case, see supplementary material (https://doi.org/10.5281/zenodo.10330498). Source: authors' own elaboration.

The detonation of conflicts about infrastructure or real estate occurs when construction is close to completion or in operation (39% of the cases), followed by projects in the planning stage (8%). This may suggest a low effectiveness of resources or action within neighborhood or community organizations, as well as a weak intervention of judicial authorities in the event of non-compliance with land and construction regulations, including the incentives and terms of governmental programs. Only 7 projects were stopped and 6 were cancelled, despite substantial evidence of their illegality or deficiencies in planning, development, or operation. Neighborhood organizations or grassroot movements are present in 100% of the cases, while civil society organizations only figure as counterparts of other actors in just over a quarter (26%). Also present as major actors are state level governments (76%); municipal governments (68%); national companies (40%); transnational companies (21%); the federal government (14%); and political parties (10%). There is a marked

damage, and public neglect of generated or exacerbated socio-territorial vulnerabilities (for further details see: CES, CDMX–PUEC, UNAM, 2018).

preference for non-institutional protest in the repertoire of actions used. Of 163 actions recorded (see supplementary material https://doi.org/10.5281/zenodo.10330498), 75% did not involve institutional or governmental support, with demonstrations and public statements being the most prevalent actions. The remaining 25% of actions recorded were of an institutional nature such as lawsuits, *amparos* ("appeal for protection"), litigation, and legal opinions or advice.

The conflicts registered for the MAVM showed a diversity of circumstantial concurrences in respect to environmental, socioeconomic and health impacts. Of the 173 environmental impacts recorded, 16% were about water damage, 14% about the loss of biodiversity and landscapes, and 12% concerned air and noise pollution. All had implications for urban public health. Observed socioeconomic impacts corroborate an ongoing pattern of urbanization and gentrification that translates into gentrification and increased socio-economic status (27% of total impacts), the violation of human rights (25%), the ritual discontinuity or cultural dislocation of communities (20%), going hand in hand with displacement (14%) and dispossession (6%). For further details see the supplementary material (https://doi.org/10.5281/zenodo.10330498).

Finally, narratives around conflicts. The information we assembled indicates that neighborhood organizations or grassroot movements have the greatest presence and dominance of the conflict narratives (86% of total conflicts analyzed), while government or institutional incidence is weak (27%) and business sector incidence even weaker (18%). This means that in the face of social unrest, governments and businesses are less likely to establish a dialogue with the involved counterparts, and less willing to issue positional statements. As most of the burden is carried unevenly, is no surprise that the main actors mobilized and dominant narratives are neighborhood organizations or grassroot movements. But a strong narrative does not translate into the resolution of conflicts. There is no direct correlation between the programmatic content and the management of public opposition by prevailing ruling parties, despite their role as symbolic vehicles for renewing the political narratives of potential incoming political administrations.

Socio-ecological conflicts in the MAVM during the period express a dissonance between, on one hand, the recent normative and programmatic arrangements of Mexico City[13] and its local governments, and on the other, the socio-ecological, political, and economic circumstances that take place in their administrative territory and beyond (the conurbation area). A consistent exclusion of the population from urban planning and management was the norm until very recently, when the Democratic and Prospective Planning Institute was launched to promote more democratic and long-term urban planning. It has only been operating for a short time (since 2021), so it is too early to judge how far public involvement will go, and whether it will be passive (though representative democratic means) or active (through participatory democracy, with an inclusive coproduction of knowledge and solutions).

The Institute is currently working on a long-term *General Development Plan* for Mexico City and a *General Program for Territorial Planning* which will provide guidelines for policies and programs on building codes, housing and public services provision, as well as other issues such as compliance with human rights mandates (to water, to a healthy environment, mobility, access to information, etc.). These guidelines could enable – yet do not guarantee – the instrumentalization of environmental justice, democratic planning, and climate governance in Mexico City, particularly by reverting the rampant uneven production of urban space that usually minimizes the importance of biological and cultural diversity and underestimates the urgency of transforming current and trending metabolic dynamics (see Section 6). There will be resistance from real estate developers as well as contradictions and tensions among decision makers who see in the new Institute a potential loss of their power. Furthermore, scaling up the process of democratic planning at a metropolitan level is still far from politically possible, despite the unavoidable need to solve socioecological challenges at that scale, from better air quality to water provision and biodiversity conservation.

[13] Within the period the *Political Constitution of Mexico City* was developed and approved in 2018. This new arrangement provides this subnational entity with its own Congress. It also delineates a set of legal compromises and regulations on key issues such as urban ecology, sustainability, housing, mobility, democratic planning, energy, water, waste management and circular economy, with protection of local traditional communities and urban villages.

*Urban socio-ecological conflicts*: *the* MAG *case*

Socio-ecological conflicts in the MAG have arisen in the context of permanent urban expansion, mostly in the municipalities of Zapopan, Guadalajara, Tlajomulco de Zúñiga and Tonalá. This urban growth has compromised provision of public services, and particularly waste management. Growth has threatened green spaces including urban and peri-urban protected areas, forests, parks, hills, and even in zones where environmental restoration was mandated by public decrees. The impacts of infrastructure and real estate projects on biodiversity, green space, and waste generation has been contested. Of the 35 conflicts identified (see Figure 4), 14 relate to waste management, 18 involve biodiversity and landscapes, and 13 are associated with real estate developments. The synergies among those categories are evident.

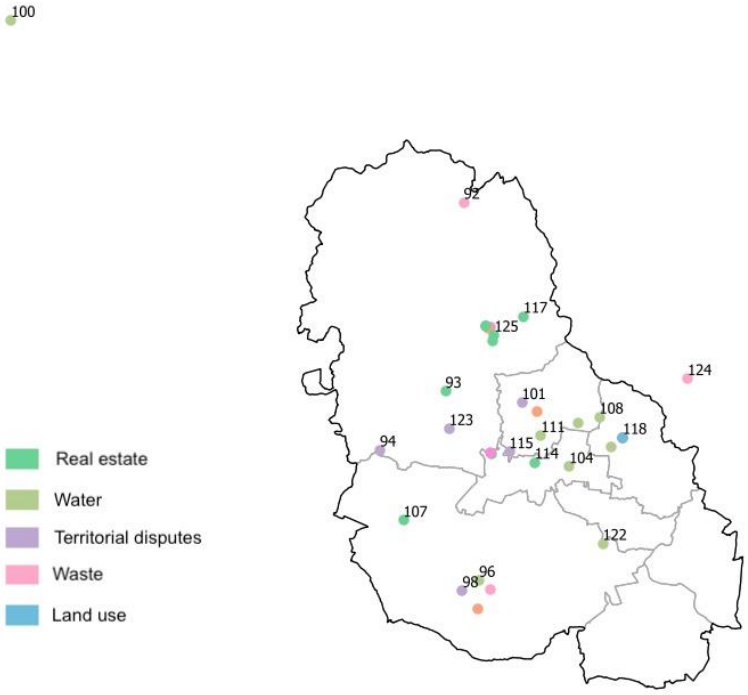


Figure 4: Spatial distribution of socio-ecological conflicts by type in the MAG, 2012–2020. For details of each case, see supplementary material (https://doi.org/10.5281/zenodo.10330498). Source: authors' own elaboration

Most conflicts, except for those in the real estate category, took shape in areas with moderately or severely socially marginalized populations. Waste management problems or infrastructure development were usually at the metropolitan periphery. Conversely, most real estate conflicts tend to be concentrated in central areas with greater social status and income. These two geographically divergent processes are common in contemporary Mexico. In most of the cases (91%), neighborhood and community organizations were leading actors. They confronted a diversity of actors but most important were national construction and real estate companies. The participation of governmental actors was contradictory because on the one hand they acted as protesters, particularly against national companies involved in municipal solid waste management. On the other hand, they were the object of protests due to their responsibility for granting construction licenses and land use change permits, including those in areas of strategic environmental value such as Bosque la Primavera and Bosque el Nixticuil.

The involvement of judicial institutions and autonomous organizations as mediators of conflicts was noticeable. Even though social mobilization (demonstrations and public statements) dominated the repertoire

of actions, in 43% of the cases legal appeals for protection (*amparos*) were used to temporarily or permanently suspend projects that threatened biodiversity and urban and natural landscapes.[14] Similarly, the use of civil rights complaints was reported in more than a third of the conflicts. Recommendations to government authorities made by the Human Rights Commission of Jalisco State have been decisive in the development of conflicts, as exemplified in the struggle over the pollution of the Santiago River and a still-valid Recommendation 1/2009 (CEDHJ, 2009).

Despite ongoing institutional and non-institutional actions in the MAG, only 31% of socio-ecological conflicts in our database have been concluded. In some of these cases, such as the conflict over the *Local Ecological Planning Program* in the neighborhood of Tonalá, the contested projects were canceled or permanently suspended. In others, struggles diluted after initial works were completed and, moreover, once certain modifications to the original projects were made. For example, due to social protests and mobilization, Guadalajara's Macrolibramiento project had to include 101 wildlife crossings. In 23% of the conflicts analyzed, actions to oppose them are ongoing: the Hasar's and Picachos landfill conflicts in Zapopan, for example, have been active since 2009. In most cases, conflicts extend beyond governmental administrative cycles at both state and municipal levels. Where they were at an impasse as a result, contestation was reactivated. In the Río Azul (Tonalá) conflict, for example, the Colectivo Defendamos el Cerro de la Reina revitalized its mobilization as soon as the new municipal president was elected in 2021.

*Comprehensive assessment of urban socio-ecological conflicts*: *the* MAM *case*

The MAM is home to a diverse array of disputes. The main causes of the urban socio-ecological conflicts that took place there between 2012 and 2022 were: the threat to biodiversity and landscape (13 cases), changes in land use (12 cases), infrastructure deployment (12 cases), water (10 cases), and real estate projects (9 cases). These were followed by others related to industry (5 cases), energy (4 cases), mining (3 cases), territorial disputes (2 cases) and waste management (1 case) (Figure 5). These varied disputes responded to the prevailing expansion of housing, commerce and tourism, as well as infrastructure for public services (including roads), at the cost of biodiversity, green areas, and landscapes. Spatially, most of the conflicts were close to or within areas of medium to high social and economic marginalization, which again confirms the uneven contemporary production of urban space.

Varied projects were responsible for the conflicts we analyzed: six were being planned, four under construction, three in operation, three on hold, two cancelled, and three postponed. Contestation involved community organizations and grassroot movements (92% of the cases), and civil society organizations (81% of the cases). A smaller proportion involved institutional or governmental institutions at the state (58% of the cases) and municipal levels (54%), followed by the private sector (46%), the federal government (19%), national judicial institutions (7%), financial institutions (4%), and autonomous organizations (4% of the cases).

Of the 52 repertoire actions identified, 65% took place outside official channels (44% were mobilizations and 21% were public statements). The remaining 35% involved class action lawsuits, *amparos* or appeals for protection, other lawsuits, rulings, and plebiscites of which two percent corresponded to human rights complaints.

Of the 82 environmental impacts acknowledged, the majority were due to loss of biodiversity (18%), followed by loss of landscape (16%), deforestation (15%), harm to biological connectivity (13%), water damage (10%), noise pollution (6%), and air pollution (5%). The least frequent impacts reported were desertification or drought, floods, food insecurity and soil pollution (4% each), and soil erosion (2%).

[14] For example, in the case of Guadalajara's *Macrolibramiento* project, an urban highway of 111 km, more than 50 appeals were filed from 2012 to 2017 to suspend and modify the project so that biological corridors of La Primavera Forest and the associated cultural heritage could be preserved (Alcocer, 2015; Martínez & Castañón, 2016). The resolution involved an additional investment of 200 million pesos (US$11.5m) according to the Ministry of Communications and Transportation (El Informador, 2016).

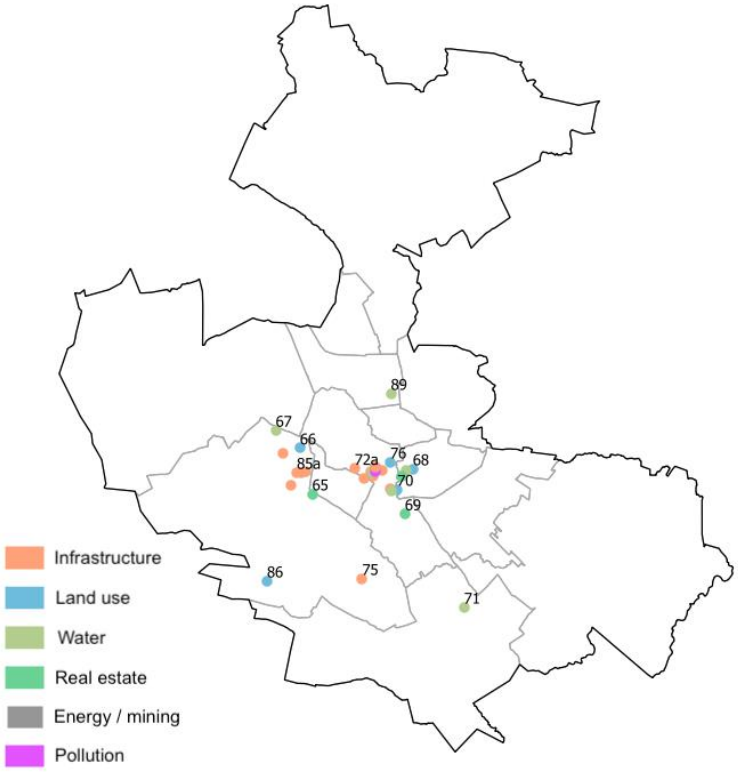


Figure 5: Spatial distribution of socio-ecological conflicts by type in the MAM, 2012–2020. For details of each case, see supplementary material (https://doi.org/10.5281/zenodo.10330498). Source: Authors' own elaboration.

Regarding socioeconomic impacts, 36% of a total of 45 impacts identified were connected to human rights violations, 13% to corruption or cooptation of different actors, 11% to deaths due to environmental damage, and 9% each to displacement, creating elite neighborhoods, gentrification, and dispossession. The least frequent were associated to loss of livelihood with 3 percent of the total impacts. In the case of health impacts, of a total of 31 identified, 35% were due to psychological effects, 25% due to exposure to unknown agents, followed by respiratory diseases, serious diseases, and deaths with 10% each, and the least frequent were oncological and occupational diseases with 5% each.

Evidence shows that the dominant narratives involved in the conflicts came from community groups or grassroot movements in 65% of the cases, followed by organized civil society (31%), and governmental or institutional actors (4%). By mid-2022, 38% of the socio-ecological conflicts were concluded, 34% were unspecified, and 19% were latent. Some 8% were still active, as a result of continuing damage.

Returning to the impacts of urban sprawl, particularly the loss of green space and related "ecological services", the MAM has several examples. There are informal settlements in quarries and on slopes which, in addition to the loss of green space, increase their vulnerability to landslides. The reason is the cost of land in central areas which for most of the MAM inhabitants is unaffordable. Soaring land values also means that affordable new real estate developments are built in peripheral regions far from employment. This urbanization model has increased motorized travel patterns and led to a deficient and expensive public transport service, a situation that has generated urban conflicts (Castro & Delgado, 2022). It has also encouraged the extraction and

processing of construction materials and the overexploitation of the Santa Catarina riverbed, which has deteriorated MAM's land, water, and air quality.

There are two aspects of water conflict in the MAM. Firstly, water management has become a challenge due to urban sprawl, poor land use and construction. To cope with hydrometeorological disturbances, the government has proposed infrastructure aimed at reducing risks in urbanized areas close to rivers and water sources. Secondly, because of the MAM's steppe and desert climate (according to the Köppen Climate Classification) water scarcity is an established and growing concern (Esparza *et al*., 2014). This has reinvigorated conflicts around the allocation of flows, particularly in the face of huge water concessions granted to industry while water scarcity and the impacts of climate change deepen (Sisto *et al*., 2016).

Although collective actions around urban socio-ecological conflicts have been strengthened as a result of increased participation as well as the emergence and support of new organizations such as the Ecological Movement in Defense of Mother Earth and Life, synergies attained through collective actions have been insufficient in most of the cases. They have not accomplished favorable outcomes, or at least in the majority of cases, have had limited effectiveness. Political cycles and changes in ruling parties and their political and policy approaches are in part responsible. The unsuccessful reactivation of the conflict around the Monterrey VI aqueduct megaproject is an example. After being cancelled, this proposal was relaunched at the beginning of 2022 by an incoming state-level government as a possible response to the current water crisis in the MAM. Later, in August 2022, it was replaced by a presidential decree to build the El Cuchillo II aqueduct, a second connection to the El Cuchillo reservoir, begun in July 2023 and opened rapidly in September. Dissent with these projects is in part due to the state-level ruling party opposing the federal leadership, and there are fiscal and political reasons for rushing though the opening of El Cuchillo II.[15] Despite the existence of regulations at the federal level to prevent and resolve socio-ecological conflicts, these often lack compliance at the local scale. An analogous situation is observed with state-level policy (e.g., in the last reform to the *Environmental Law of the State of Nuevo León* of June 2022 as well as in the *Political Constitution of the State of Nuevo León*) that recognizes the need to address environmental and natural resources degradation, but has not yet had an evident effect on conflict prevention and resolution.

*Implications for UPE of urban socio-ecological conflicts in the three largest metropolitan areas in Mexico*

Urban socio-ecological conflicts in the three metropolitan areas largely respond to the expansion of infrastructure and building stock. The latter accompanies population growth and urban speculation, and infrastructure serves urban expansion and the "needs" generated by the three metropolitan areas at the regional, national, international and/or global scales. These include securing the continuity of metabolic functions in terms of inflows and outflows, as well as of other type of urban spatial "teleconnections" (Seto *et al*., 2012). All of this supports neoliberal urbanization and capital accumulation, in Mexico and beyond.

As neoliberal urbanization and its effects continue to expand, urban socio-ecological conflicts are likely to increase and become more visible. Tendencies in the three metropolitan areas suggest that under a business-as-usual (BAU) scenario for 2050, DMC_u for the MAVM will increase slightly while in the MAG and the MAM a considerable growth will be experienced due to the expected expansion of their urban footprints. Accordingly, under the BAU scenario, total DMC_u could reach 303 million tons/year in the MAVM, 81.5 million tons/year in the MAG, and 91.2 million tons/year in the MAM (*Ibid*).[16] Similarly, the water footprint could expand to a volume of 54.7 billion $m^3$/year in the MAVM, 14.3 billion $m^3$/year in the MAG, and 15

[15] https://www.courthousenews.com/mexico-president-refutes-reports-that-aqueduct-launch-was-simulation/

[16] National per capita DMC_u for 2050 estimated by PNUMA (2021) for Latin America and the Caribbean, has been used to calculate total DMC_u for the three metropolitan areas by 2050 using population growth projections of 23.2, 6.1 and 6.4 million inhabitants, for the MAMV, the MAG, and the MAM, respectively. Urban growth projections are conservative and are based on the average estimated growth officially estimated for the period 2010–2030 (CONAPO, 2010), assuming continuation for 10 years until an inflexion point, after which growth would slow by half for the remaining 10 years. If current trends persist, the greatest increase might take place in the MMA at a very similar rate to the one expected for the national population in 2050 (CONAPO, 2019). These projections may be refined as the national DMC database is improved and more and better resource accounting is incorporated (as already happened in 2021).

billion $m^3$/year in the MAM (*Ibid*).[17] Urban outflows such as wastewater, waste and air pollutants will also increase, yet it all will depend on the actions taken.[18]

With urban metabolic intensification such as this, the types of conflicts experienced will reflect, on one hand, the stage, nature and the specific characteristics of urbanization processes in terms of changes to urban function, form and structure, and on the other, the impacts experienced in each city *vis-à-vis* the relationships and existing synergies with other urban and non-urban spaces that serve as resource suppliers or receivers of waste. Governments, due to their role in policy design and implementation, will be the most recurrent actor in conflict, usually facing neighborhood organizations or grassroot movements, as shown by the set of conflicts analyzed (Figure 6).

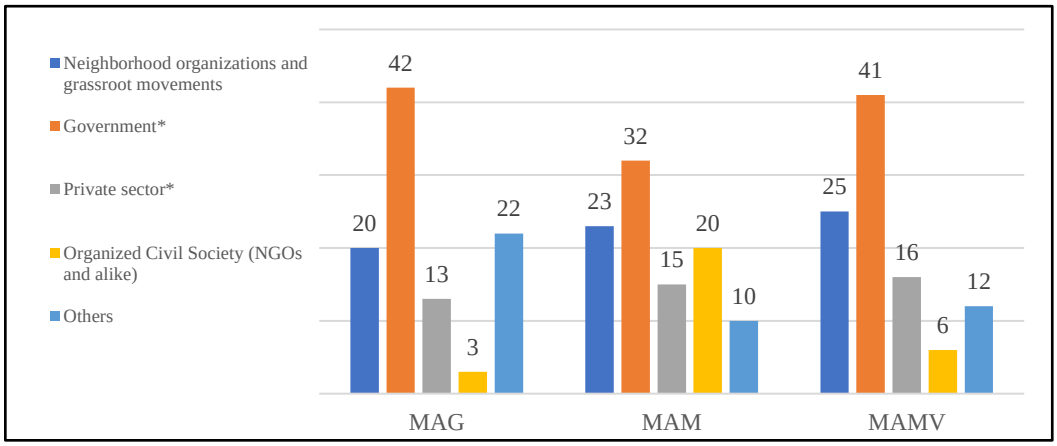


Figure 6: Actors' prevalence in socio-ecological conflicts by metropolitan area (percentages). Source: authors' own elaboration

In such a scenario, grassroots as well as general social mobilizations will persist as a main feature of the UPE dynamic in Mexico's largest urban areas (as Figure 7 demonstrates for the set of conflicts in all three metropolitan areas). Yet, as some experiences already suggest, social mobilization might become more coordinated as impacts and "late lessons of early warnings" in urban and non-urban settings keep mounting.

Despite the usefulness of social mobilizations by formal institutional means, they might only play a complementary role in the future. Non-institutional means might continue to be robust as contestation narratives empower localized mobilization and capacity building, regardless of the scientific certainty of the narratives that direct them. However, the contribution of radical science and local knowledge (or citizens' science), could definitely strengthen different forms of social contestation and also increase the social creativity needed to cogenerate solutions and eventually propel a sustainable, just and inclusive urban transformation in which cities are designed for people and nature, not profit.

[17] Urban water footprint projections for 2050 have been updated from Delgado (2020) and PNUMA (2021) based on population growth projections in the three selected metropolitan areas. Urban water footprint estimations for 2050 assume changes in consumption patterns that would allow those experiencing poverty and extreme poverty to increase their consumption by 25% and 50% respectively as a mean to improve compliance with the human right to water.

[18] Waste generation for the three metropolitan areas may reach a volume of between 11 and 11.4 million tons/year in the MAMV, 2.8 and 2.9 million tons/year in the MAG, and 3 and 3.1 million tons/year in the MAM in 2050. By 2050 GHG emissions for the three metropolitan areas could be approximately: 95–120 million tons of $CO_2e$ in the MAVM; 25–31.5 million tons of $CO_2e$ in the MAG; and 26–33 million tons of $CO_2e$ in the MAM.

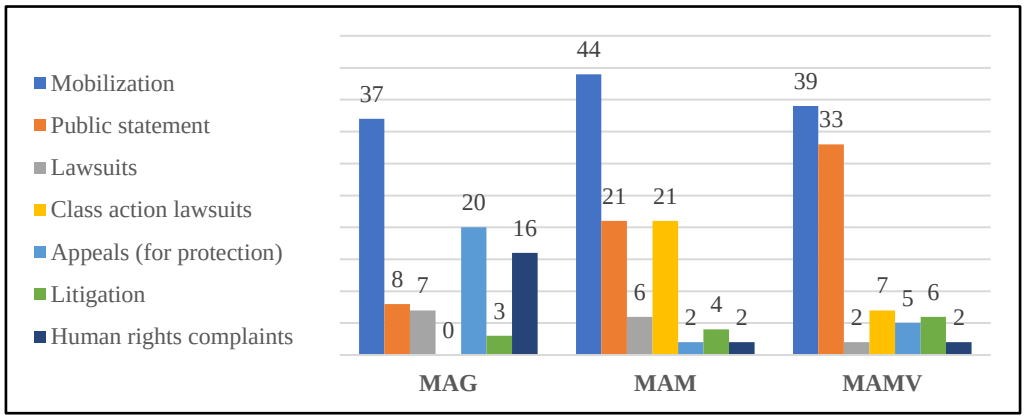


Figure 7: Type of action used in socio-ecological conflicts by metropolitan area (percentages). Source: authors' own elaboration

## 6. Conclusions

The redefinition of the logic that determines how and at what costs urban resource flows are obtained, allocated and excreted (the basis of *urban metabolism*), is a key issue for advancing socially desirable urban transformations. This requires rethinking in a broad sense the way in which cities are produced, from the spatial and temporal relationships and synergies involved, to their urban function, structure, form, and density. "Strategic intensification" or the intensification of the number of jobs, people, and services located within a network of high-density, but desirable, primary and secondary nodes that are well connected by efficient and affordable public transport systems is one goal (IRP, 2018; PNUMA, 2021). This goal could play an important role in using land and resources more efficiently if it results from comprehensive long-term urban planning. However, strategic intensification will only be meaningful if prevailing urban injustices and inequalities are radically reversed. Poverty, informality and the processes of urban fragmentation and segregation demand special attention in paving the way towards urban "spaces of hope" (Harvey, 2000) and thus a more-than-human-right to the city (Shingne, 2020). The challenge is especially important in the Global South, where the uneven production of urban space tends to be bolder and where most of future urban population growth is expected to take place.

Limited human, material and budgetary capacities that distinguish the local scale in Mexico will undoubtedly handicap any urban transformation efforts. This is true even in the case of the MAVM, because despite its comparative advantages in relation to other smaller metropolitan regions, it faces profound inequalities in local institutional capacities between the central and peripheral municipalities (Delgado & Mac Gregor, 2020; Delgado, 2021). This is a reality that constrains the coordination of actions around several issues, including water, wastewater, waste and transport planning and management. With that in mind, both leadership and the processes of co-production of knowledge and co-generation of solutions with and by the people, are not only relevant but necessary for a more successful, inclusive, and just urban transformation.

Since urban transformation refers to a dynamic state of operation within desirable parameters, its realization is ultimately an outcome of a reflexive political process that is relevant in its own right for advancing an intentional UPE approach. Analyzing urban socio-ecological conflicts is central to UPE but as challenges continue to pile up it will be increasingly relevant to track and understand the aspects that enable such a transformative process. This endorses the need for UPE studies to embrace complexity and diversity and advance systemic, multi-scalar transdisciplinary approaches. To understand and contribute to desirable paradigm shifts at the local scale, biophysical, economic, political, social and cultural characteristics of each locale need acknowledgement. This includes understanding the nature of urban socio-ecological conflicts themselves, for which a comprehensive and territorialized reading of contestation processes is necessary. But

specific cases is not enough for fully revealing the uneven nature of contemporary urban space production. It is also a wider transformative process, with complexity and multiscale interconnected dynamics.

UPE can support urban transformation processes on the ground. It can address not only the spatial logic by which urban space is being transformed by capital, but also how, by who, and under what circumstances such processes are contested. It can also interrogate the articulation of urban social resistance and transformative agency, where strengthened in a context of contemporary urban life that favors social atomization. Even more, by studying cases, UPE needs to interrogate current transformative experiences and the capacities that reside in them. This is particularly valuable since a socially desirable urban transformation differs in each case. Empowering social agents through the cogeneration and appropriation of locally based solutions can benefit from national, regional and international cross-fertilization through sharing experiences.

A comprehensive understanding of the urban built environment and its multiscale and multitemporal connections is required to adequately identify opportunities and resistances to change, as well as the contradictions and tradeoffs at the local level that might be connected to interests at other scales (for example, the uneven creation of value in global real estate assets). Multi-scalar research helps to reveal similarities and differences in urban socio-ecological conflicts, as well as transformative experiences and existing capacities according to a set of city features such as location, size, urban structure and form, and biophysical attributes. The three metropolitan areas analyzed in this paper shed some light on large urbanization settings in Mexico. Further studies should not only offer an approach based on specific features, but also help identify distinct UPE schools of thought in regions with diverse urban features and dynamics, which exist regardless of the strong tendency of capital to homogenize the uneven process of urban space production.

With or without such diversity in UPE, urban socio-ecological conflicts will not disappear in the short term even under a transformative process, although their characteristics may change: from the triggers that foster them, to the demands at stake, to the repertoire of individual and collective actions in a context of both resistance to change and ecological rift. As a reflection of an active and participatory society, urban socio-ecological conflicts should be seen as something desirable if they are the prelude to social agency co-producing imaginaries of the good urban life, with the inclusive co-generation of knowledge and solutions. In the face of a continuous planetary urbanization process, this is a focus for future UPE studies.

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