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ELEMENTS OF INFRASTRUCTURE UNDER-INVESTMENT IN MEXICAN SLUMS

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Declaration

I hereby declare that this Master Thesis entitled "Elements of Infrastructure Under-Investment in Mexican Slums" was composed by myself, under the supervision of PhD Pascale Combes Motel, and submitted to Palacký University Olomouc, in fulfilment of the Erasmus Mundus Joint Master Degree in International Development Studies (GLODEP) requirements. Furthermore, I declare that the work contained herein is my own, except where explicitly stated otherwise, and confirm that this work has not been submitted for any other degree or professional qualification except as the specified above.

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Zásady pro vypracování

According to the United Nations, the extensive expansion of the cities from the 20^{th} century to the present days has led to more than half of the world’s population to live in urban settlements. Furthermore, the urban sprawl is expected to continue, aggravating the issues related to massive agglomerations, such as air pollution and overburdened infrastructure. Although these issues have not gone unnoticed, a proper analysis of each urban context is subjected to its particularities. In this regard, I will focus my research on Mexico, particularly on Mexico City which is considered to be one of the main Megacities of the developing world.

In addition, to have an adequate housing with access to public spaces for recreation and leisure supposed to be an inalienable right in Mexico. However, the reality is that only a reduced share of the population fully exerts that right, whilst the number of Mexico’s urban poor is in the millions. Although in Mexico City the poor can be found scattered all around, it is also true the presence of densely populated slum areas located at the east side of the city, characterized by precarious habitability, partially caused by the poor provision of urban infrastructure which is considered an ever-present feature of urban slums. Notwithstanding the existence of a growing research framework highlighting the benefits derived from infrastructure upgrading investments, the research projects that explain and analyze the subtleties rooting such under-investment are scarce.

In this regard, this study strives to address the elements that lead to an infrastructure under-investment in the slums of Mexico, particularly Mexico City during the 21^{st} century. Analyzing and comparing, through secondary sources of data, the levels of infrastructure investment in the slums and other areas, making use of national gross fixed capital formation calculated with data from the IMF, infrastructure characteristics captured in diverse surveys, and governmental expenditure data as well as other aspects recorded in censuses compiled by public agencies.

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"*No one lives in the slums because they want to.*
It's like this train. It can only go where the tracks take it."
(Cloud Strife in Final Fantasy VII)

Abstract: This research is circumscribed to the growing analysis framework that explores the visualisation of the spatial dimension of poverty. It uses the most recent disaggregated census and public finance data to produce maps that allow observing the characteristics and spatial patterns of poor and vulnerable groups in the Metropolitan Zone of the Valley of Mexico. Concretely, it seeks to answer whether local governments, to which the main slums adhere, are responsible for being negligent in effectuate insufficient levels of infrastructure investments or not. In this sense, the agglomerations of poor and vulnerable groups have been mapped and identified in municipalities at the eastern edge of Mexico City, where the investment levels in infrastructure are the highest in absolute terms but the lowest measured per capita. However, a divergent spatial pattern of those lacking piped water, drainage, and electricity indicates that different social deficiencies suppose more significant challenges in the slums than the basic services' provision, thus, illustrating the nonexistence of such negligence. Nonetheless, this research recognises that an integral characterisation and depiction of the slums requires further studies that break down the information at a neighbourhood level and include the spatial allocation of the infrastructure investment from the state level.

Keywords: Infrastructure, poverty maps, slums, Mexico, deprivations.

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List of Abbreviations

Abbreviation	*Definition*
AGEM	Municipal Geostatistical Areas
CONAPO	Mexican National Population Council
CONEVAL	National Institute of Statistics and Geography of Mexico
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
EFIPEM	State and Municipal Public Finance Statistics
GFCF	Gross Fixed Capital Formation
INEGI	National Institute of Statistics and Geography of Mexico
INPC	National Consumer Price Index
IPL	Income Poverty Line
IRS	Social Backwardness Index
NBI	Unsatisfied Basic Needs
SCNM	System of National Accounts of Mexico
SEDATU	Mexican Ministry of Agrarian, Territorial and Urban Development
SNA	System of National Accounts
UN-HABITAT	United Nations Human Settlements Programme
UNSC	United Nations Statistical Commission
ZMVM	Metropolitan Zone of the Valley of Mexico

1 Introduction

From the 20th century to the present, urban sprawl has reached the point where over half of the world's population resides in urban settlements. According to the United Nations (2019, 7), it is expected that almost all future population growth worldwide will be absorbed by urban areas. As a result, the problems associated with overcrowding within massive cities like Tokyo, Delhi, Shanghai, São Paulo, Mexico City and Cairo will add important challenges to the ones already existing (e.g., sufficiency and quality of infrastructure, and air pollution). Moreover, deficient planning and bad governance, coupled with high urbanisation rates, have led to a whole new side of ignominious poverty concentrated in the slums of the developing world, as a clear expression of poverty and inequality within cities (UN-Habitat, 2018, 3).

Equally important, the interaction and population dynamics do not always restrain to established political-juridical spaces; a sole urban agglomeration might comprise several cities or towns, including their suburban fringes (United Nations, 2008, 123). Nonetheless, while some urban agglomerations are not well-defined geographical units, some others are officially delimitated. Such is the case of the Metropolitan Zone of the Valley of Mexico (hereafter ZMVM by its Spanish acronym), which comprehends the sixteen municipalities (*alcaldías*) from Mexico City, fifty-nine municipalities from the surrounding state named México (also known as the State of Mexico) and one municipality from Hidalgo state (SEDESOL, 2012, 13). Additionally, to consider the ZMVM as a unit of analysis instead of solely Mexico City allows one to take into consideration those adjacent territories to the city where high proportions of the poor population are concentrated and that, altogether, enclose the largest megaslum[1] of the world, according to Davis (2017, 28).

Although adequate and decent housing, with access to public spaces for recreation and leisure, is an inalienable right in Mexico, the urban poor with such deficiencies can be found scattered all around by the millions. In this regard, the territorial distribution of the poor from the ZMVM mainly locates them in the north and east areas of Mexico City (Aguilar & López, 2016, 10). Potential explanations of said patterns and their origin can take various standpoints. For instance, in the model of rural migration described by Todaro (1969, 141), the rural-urban expected income differentials drive the migration; in this regard, some may argue that a city with an inadequate capacity for the integration of those newcomers will naturally place them in the least developed areas. Alternatively, a gentrification process, where people relocate towards the periphery due to punitive policies and rising rents, as explored by McDermott (2019, 3532), can complement the analysis of why poor groups have agglomerated on cheap land with difficult access and significant deficiencies, such as poor access to basic services.

Furthermore, several months of personal accumulated experience in the financing search unit for implementing basic infrastructure projects in Africa, through the non-governmental organisation *Travaux Publics Sans Frontières*, have raised the concern on the potential role of private actors in the promotion of basic infrastructure projects. However, said participation turns out to be considerably narrow compared to the scope of government investment, which is indispensable for addressing the disparity in the levels of life quality of the slum's dwellers. Moreover, in Mexico, it is the obligation of the state to guarantee sufficient,

[1] Defined by Davis (2017, 26) as the outcome when shantytowns and squatter communities merge in continuous belts of informal housing and poverty, usually on the urban periphery.

acceptable and affordable access to basic services such as water, in compliance with the fourth article of the Political Constitution of the United Mexican States. Therefore, this work addresses the specific deprivations of the ZMVM's inhabitants and the jurisdictional differential levels in the public infrastructure expenditure by the local governments.

Accordingly, the main interest of this research is to provide insights on the elements related to the infrastructure under-investment that characterise slums. Therefore, this research explores and better characterises the ZMVM's slums through its population deficiencies and territorial patterns in an analysis that aims to answer the following: What is the spatial distribution of poor groups in the ZMVM in relation to their specific social deficiencies? What elements are connected with the infrastructure provision in said territories? What has been the municipal infrastructure investment during the 21st century in those territories? And finally, are the slums' dwellers from the ZMVM suffering negligence from their local governments in the provision of basic infrastructure services?

This research elicits primary data from the measurements and statistics created by the National Institute of Statistics and Geography of Mexico (INEGI by its Spanish acronym) and the National Council for the Evaluation of Social Development Policy (CONEVAL by its Spanish acronym). Moreover, this research aims to contribute to the formulation of urban poverty alleviation policies, providing helpful information on the elements of infrastructure under-investment in the slums of the ZMVM through the construction of maps that illustrate the main findings.

For that purpose, this work is organised by first exploring the essential characteristics of the slums, their role, challenges, and general infrastructure conditions; while the importance and possible effects of the infrastructure investment in the slums are also highlighted. Furthermore, the context particularities of the Metropolitan Zone of the Valley of Mexico are approached from the same angle. Subsequently, the research goes into the outline of the studied area and clarifies the methods and categories used. The successive part of this thesis presents and discusses the generated maps that incorporate infrastructure investment elements in the slums into their spatial analysis. Finally, the conclusions summarise the main findings and attempt to shed some light on the possibility of governmental negligence in infrastructure investment at the local level.

2 Literature review

This chapter explores the different discussions and standpoints revolving around the constitutive elements of a slum, its role and challenges, and its infrastructure conditions to delve into ZMVM's case afterwards. More precisely, we ask whether the urban poor from the ZMVM exhibits distinct features that allow us to categorise them as slum dwellers according to their territorial distribution.

2.1 The ambiguity of a slum definition

The category "slum" can only get its meaning in relation to its inhabitants' characteristics and living conditions. Therefore, our research must begin with the analysis of the fundamental slums' characteristics. At first sight, it could seem that a relative agglomeration of the population regarded as urban poor could undeniably constitute a slum; nevertheless, the definitions of what is considered a slum changes depending on the consulted source. For instance, Seabrook (1996, 174) claims that the word "slum" is a misleading term borrowed from the British urbanisation conditions in the nineteenth century, alluding to courts, tenements

and carelessly built streets for profit. On the other hand, the Oxford English Dictionary (2021) defines a slum as "*A street, alley, court, etc., situated in a crowded district of a town or city and inhabited by people of a low class or by the very poor; a number of these streets or courts forming a thickly populated neighbourhood or district where the houses and the conditions of life are of a squalid and wretched character*". For the Real Academia Española (2014), the definition of "*suburbio*" refers to a "*Neighbourhood or population centre located on the outskirts of a city and which, generally, constitutes a depressed area*", while the definition of "*bidonville*" provided by l'Académie française (2019) describes it as "*A heterogeneous agglomeration of precarious housing devoid of equipment, built near a large city with disparate materials, most often from salvage, and where a population is crowded which has been unable to find accommodation elsewhere".*

The above definitions provide us with a general conceptualisation of slums. However, they do little to help us understand the processes by which they originate and the limits of their constitution. For this reason, it is necessary to expand these definitions with practical elements that allow the characterisation of the emergence mechanisms and the particularity of the inhabitants. In this regard, a logical starting point is the analysis of the metropolis. In short, metropolitan areas combine urban agglomerations where most of the secondary and tertiary activities of an economy are concentrated. Such activities require a spatially concentrated workforce, which progressively grows while their necessities demand the creation of more activities. Thus, the population constantly attracts businesses into the area to meet the current needs of the population, leading to a concentration of many activities and enhancing the economy's expansion. Along this process, the wealthier areas obtain better coverage of public services than the poor ones. According to Mohan (1994, 94), more affluent residents are more effective in voicing their demand for urban public services. Consequently, the poor residents sharing the area with the rich benefit from better services (e.g., sanitation, schools, more reliable water supply, safer roads, schools) than their agglomerated counterparts. Moreover, she states that dissatisfaction with municipal and public services increases with distance from the centre (Mohan, 1994, 133).

Meanwhile, Stokes (1962, 191), using a general approach, considered slums as temporary areas that housed the classes that do not participate directly in the economic and social life of the city. Furthermore, he described the formation of said slums through the rates of in-migration and of migrants' absorption, combined with ability barriers that prevent its dwellers from ameliorating their social condition. Alternatively, the United Nations Human Settlements Programme (UN-HABITAT) does not resort to an area-based definition of slums since the sole regard of the geographically contiguous units excludes the isolated ones. Instead, they use "slum household" as the basic unit of analysis, which is defined in the following way:

> A group of individuals living under the same roof in an urban area who lack one or more of the following: durable housing of a permanent nature that protects against extreme climate conditions, sufficient living space which means not more than three people sharing the same room, easy access to safe water in sufficient amounts at an affordable price, access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people, and security of tenure that prevents forced evictions. (UN-Habitat, 2006, 21)

Similarly, the conceptualisation of Cities Alliance (2006, 1) is based on the dwellers' deprivations and regard the slums as impoverished areas in the cities where housing and living conditions are deficient, often lacking water, sanitation, waste collection, storm drainage and street lighting. Likewise, the CONEVAL studies and identifies the urban poor population in Mexico based on multidimensional deprivations.

Although CONEVAL does not use a slum area classification, the lack of access to essential household services and the lack of quality and housing spaces, both part of the urban poor deprivations, fit the slum definitions mentioned above.

Moreover, although he does not speak specifically of slums, Fassin (1996, 44) presents the idea of a territorial configuration in cities where the social space is discontinuous, with an "interior" that locates the adequately social integrated individuals, and an "exterior" where excluded people live. He argues that the excluded population are those struggling inhabitants of the suburbs, the children in school failure, the long-term unemployed, and the population which no longer has access to social assistance and medical care. In other words, he believes that the exclusion relies on the distribution of people regarding the city borders, the school standards, the professional contracts, and the Social Assistance.

In short, the classification and perspectives regarding slums present ambiguities depending on the source. However, some of the recurrent deprivations of their dwellers, such as education, health, social security, quality housing spaces and basic services, allow us to identify the areas through their agglomeration patterns as slums.

2.2 Role and challenges of a slum

Stepping out from the basic features of a slum and to promote a greater understand of its dynamics, it is necessary to ask if said slums fulfil a purpose or are just, as regarded by some, these "*filthy barracks of despair that constitute a piece of hell on earth*" (Granotier, 1980, 8). Some studies elaborate on the idea that slums are transitory and a perforce part of the economic growth process of any developing economy. Such is the case with Frankenhoff's analysis (1967, 29), which suggests that migration of the poor to the cities will ultimately create communities and associations under the pressure of common needs. He argues that it is possible to enhance the integration of the slums into the urban centre by improving their labour force skills via the creation of more adequate community infrastructure (e.g., water, lightning, sewers), coupled with better nutrition and access to educational opportunities.

In turn, Stokes (1962, 194) theorises the distinction of two types of slums that commonly offer to house the poor and the strangers. Those attracted to the city by the potential opportunities there are differentiated by their languages, education, and other social and economic resources. The slums mentioned above differ from each other because the "hope" ones will be temporary as they contain those migrants with sufficient skills to be more easily absorbed into the working population. On the other hand, the "despair" slums will be those that concentrate the population hindered in improving their social status, either because of their skin colour or religion and/or because of their abilities. The latter type of slum does not disappear over time and is permanently inhabited by the poor.

Taking a similar standpoint on the deciduous nature of the slums, Ruggeri (2005, 43) argues that the coverage of services tends to improve over time as settlements become formalised or merely more organised. Moreover, she provides evidence that the main determinants of access to household services are the age of the house and the maturity of the settlement, clarifying that this happens due to the way the poor population acquire their housing. In this regard, Siembieda et al. (1997, 7) distinguish occupation, transition and consolidation as phases for said housing acquiring processes. First, occupation occurs when some people take physical possession of a plot of land. Then, the transition stage occurs if there is no opposition from the

authorities or landowners; it consists of the arrival of more families that start to construct their houses and demand basic services. Lastly, the consolidation stage consists of obtaining all essential infrastructure and land titles. In the same spirit, the World Bank (2009, 24) also exemplifies that slums have been cleaned up in the past by tackling dysfunctional land markets, building infrastructure and intervening to improve housing.

On the other hand, Jalan & Ravallion (1997, 2) consider the existence of spatial poverty traps that can lead the households living in better-endowed areas to raise their living standards over time, while others do not. Along the same lines, Marx et al. (2013, 190) consider slums to be part of such poverty traps and therefore regard them as neither temporary nor a provisional interruption towards more significant economic opportunities. For instance, they argue that the lack of adequate living space, lousy quality of the basic amenities, and the insufficient provision of public goods are ever-present problems in the slums. Moreover, they argue that marginal investments in housing, health, or infrastructure, *per se*, are not enough to improve the slum dwellers' standard of living. Thus, in several cases, households from the slums find themselves trapped for generations instead of managing to seize the opportunities offered by proximity to the city and pass the benefits of their migration on to their children. Along the same lines, Aguilar & López (2013, 360) argue that the urban poor in Mexico suffer from an accumulation of disadvantages that prevents them from emerging from misery. They identify the main accumulative disadvantages to be related to the lack of basic services, poor-quality housing, overcrowding, unhealthy and hazardous living conditions, insecurity of land tenure, and poverty and social exclusion.

Nonetheless, some consider slum dwellers to be equally responsible for the impossibility of alleviating themselves of poverty. For instance, Lewis (1966, 21) considers the existence of a self-perpetuating culture of poverty, created through the habitus of the poor in coping with the despair of their conditions. Said culture is supposedly composed of certain attitudes and values that prevent slum dwellers from taking full advantage of the opportunities that might improve their living conditions. Alternatively, some others take an equally extreme standpoint and regard slum dwellers as possessors of community values, camaraderie, and support. For example, Granotier (1980, 9) mentions that some people praise the hard work and organisational skills of the slum dwellers based on how they choose their representatives to negotiate with the authorities for a minimum of social protection and effective mutual aid, as well as how they secure income through the informal market. On the flip side, Seabrook (1996, 174) claims that "slums can be places of cruelty and violence, but equally of solidarity, tenderness and hope" and remark that it is necessary to distinguish between people's living conditions and their response to said conditions.

Concerning the above-mentioned organisational skills, some studies suggest that low wages and precarious employment have undermined the possibilities of the urban poor in Mexico to appeal to those social structures that can curtail the deterioration of living conditions (e.g., support and mutual aid networks). Consequently, the problems of the urban poor in Mexico are considered to have gotten worse rather than improving. For instance, Enríquez (2008, 536) argues on the fact that there is not real-time for associating and social managing the habitat in an environment where basic needs are unmet. Moreover, he claims that obtaining aid through the extended family has become complicated because of the disappearance of linked families that are internally displaced, thus leading the isolated ones with a nuclear structure towards irregular settlements in the peripheral areas of large cities. As for Bayón (2008, 123), spatial poverty concentration has

been aggravated by the unequal access to health and education services, coupled with the deterioration of employment opportunities.

In contrast, when the dwellers' capacity for action is so diminished, it is natural to turn our gaze towards government interventions. However, this makes it imperative to consider that the management of the ZMVM involves the concurrence of different state and municipal governments with their respective authorities. Thus, the obstacles posed for an adequate provision of public services (e.g., differences in urban regulations, lack of agreements, absence of intersectoral coordination mechanisms) contribute to the segregation and social division in the ZMVM (CONEVAL, 2014, 82).

Another relevant aspect of the ZMVM is that its large size and population growth rates have influenced a territorial social division that reproduces the workforce at a meagre cost through the formation and expansion of slums. According to Schteingart (2010, 349), this process of territorial social division began around the 1950s with the arrival of poor migrants from the most underdeveloped rural areas of the country. She argues that wealthy groups settled in the best areas of the metropolitan area to maintain the value of their properties and enjoyed excellent physical conditions and protection. At the same time, the most impoverished families were forced to settle in remote areas. Consequently, and due to the significant weight of said poor population in the urban social structure, massive *cumuli* of settlements were agglomerated in areas not suitable for being populated, located progressively at greater distance from the metropolitan centre. Meanwhile, UN-Habitat (2003, 216) states that "*historically, urban segregation in Mexico City was caused by topography and colonial land use, with the flood-prone areas to the east of the city being occupied by the lower classes*".

Another interpretation is that the utility maximisation pursued by families and economic units follows the differences in resources and opportunities; thus, it drives the distribution of economic activities in the territory. Consequently, the impoverished population in the ZMVM is the reflection of different structures and policies of the country; for example, public programmes that aim to reduce poverty can have direct effects on income and indirect ones on the behaviour of beneficiaries (Sawhill, 1988, 1101). In this regard, the labour market holds particular importance as slum dwellers cannot cover their necessities due to their insufficient income. Along the same lines, economic growth, unemployment rates, productivity rates, education and skills are influential factors for integrating into the job market (Johnson & Mason, 2012, as cited in CONEVAL, 2014, 120).

Lastly, as a pivotal source for deepening the identification of the slums in the ZMVM, it is essential to mention the findings made by Aguilar & López (2016, 9), in which they pointed out various locations, mainly in the periphery of Mexico City, exhibiting significant disadvantages for the population. In this regard, they observed that by the year 2010, large socially deprived groups were predominantly located in the periphery of Mexico City, whilst the poverty levels of the city population reached around fifty per cent. For instance, the main areas hosting said populations were slums and poor neighbourhoods with rugged topography at the north and east of the city. Additionally, poverty strips developed along communication axes, in which urban patches in the farthest periphery and small poverty enclaves in central urban locations were identified.

2.3 A slum infrastructure

A substantial body of research addressing the analysis of infrastructure investment has made clear its beneficial effects. For instance, Aschauer (1990, 23) traced a series of links between infrastructure investments and various aspects affecting the quality of life, such as health, safety, recreation, economic opportunities, and leisure. Calderon & Servén (2004, 26) provided evidence supporting the linkages between the volume of infrastructure stocks on the long-run economic growth and the infrastructure quantity and quality on income inequality. Allcott et al. (2014, 5) estimated the effects of electricity shortages in India by building on an estimation of the economic effects of investments in electricity, transportation, and other infrastructure. Additionally, the International Monetary Fund (2014, 81) elaborated on the fact that increases in public infrastructure investments enhance the aggregate demand in the short term and expand the productive capacity of the economy in the long term.

Notwithstanding the above-mentioned benefits, approaching the infrastructure investment analysis from the slums' perspective requires a different set of research interests, not only focusing on the benefits, but also exploring the reasons behind their absence. In this regard, it is essential to point out the standard features of the infrastructure in slums to then describe its conditions on the ZMVM and explore the underlying causes that drive and deter investments. In the first place, different studies regard a pitiful infrastructure to be a standard feature of the slums. For instance, UN-Habitat (2003, 9) states that the quality of dwelling in slums "*varies from the simplest shack to permanent structures, while access to water, electricity, sanitation and other basic services and infrastructure is usually limited*". Additionally, Gulyani et al. (2010, 1), build on the argument that not all slum dwellers are poor; *ergo*, their living conditions can be highly variable depending on their poverty levels. They argue that impoverished slums often lie behind their non-poor counterparts regarding access to basic infrastructure, thus forcing their dwellers to endure worse living conditions.

Likewise, Aguilar & López (2016, 6) consider slums to be characterised by a general inadequate provision of urban infrastructure and a low presence of urban services. Furthermore, they argue that the peripheral locations of poverty and informality in large cities occur precisely in places that lack proper infrastructure, making them cheaper to inhabit (Aguilar & López, 2013, 360). In this regard, Davis (2017, 40) argues that such cheap lots usually do not offer more than few streets and water posts. According to Mohan (1994, 150), most infrastructure investments typically follow the formation of settlements. Nonetheless, Schteingart (2010, 372) argues that irregular settlements take many years to be regularised and obtain the necessary infrastructure and basic services.

Davis (2004, 7) argues that the provision of infrastructure lags notably behind the urbanisation pace, adding that peri-urban slum areas frequently do not possess formal services or sanitation provision of any kind. Meanwhile, he also makes the case that the absence of infrastructure in the slums could be perceived by some as a producer of niches for informal workers, for example, "*selling water, carting nightsoil, recycling trash, delivering propane and so on*" (Davis, 2004, 18). Nonetheless, such a standpoint entails the reproduction of jobs carried out by those with no choices other than to subsist or perish. In this regard, Rogerson (1997, 349) argues that those "survivalist enterprises" require the merest capital investment and no skills whatsoever; therefore, they regularly render insufficient income for securing minimum living standards. Additionally,

according to Fay & Wellenstein (2005, 97), "*It is much more difficult for the informal sector to properly undertake the collective action role of the public sector, ensuring the provision of public goods such as well-defined rights of way, properly titled properties, and basic services*". Lastly, it is essential to keep in mind that almost all informal workers are deprived of working standards and the protection of labour laws.

On the other hand, for Imparato & Ruster (2003, 279), the lack of adequate infrastructure in the slums is a consequence of the negligence of the public sector interventions provoked by the absence of accountability, resistance, and lack of technical capacity of the executing agencies. Correspondingly, UN-Habitat (2003, 6) has mentioned that "*the direction of both national and international interventions during the last 20 years has actually increased urban poverty and slums, increased exclusion and inequality, and weakened urban elites in their efforts to use cities as engines of growth*". Additionally, they make the case that urban poverty has increased its share in most countries due to structural adjustment programs "*which are deliberately anti-urban in nature*" (UN-Habitat, 2003, 30). Nonetheless, they clarify that government institutions are not the only ones to be blamed; they attribute responsibility also to the private and commercial systems.

Granting the fact that the descriptions above could correspond to numerous contexts, the slums of the ZMVM also carry some particularities. First of all, not every irregular settlement in the ZMVM should be regarded as slums; as per Connolly (2009, 32), those settlements have provided shelter to a wide range of social strata. Secondly, the geographical position of the ZMVM exerts influence on the location of slums and urban segregation. For instance, the ZMVM sits in a closed basin, which once was a series of lakes, and thus it does not have a natural drainage outlet and suffers from constant flooding, while fresh water is brought in via aqueducts. Therefore, the areas more prone to flooding, with difficult access to fresh water and located by the abrupt hills encircling the extinct lakes, are unacceptable for most general constructions; nonetheless, they provide a low-cost alternative for irregular settlement (Connolly, 2003, 2). For instance, according to Fay & Wellenstein (2005, 99) "*in urban Mexico's poor neighborhoods, three-quarters of households have water service on their property (indoor or outdoor), but just 56 percent of them actually get water all day every day*".

On top of that, according to the UN-Habitat (2003, 217), the irregular settlements in the ZMVM keep developing in a more scattered and distinctive way while numerous public housing projects are shifting into slums due to inadequate self-administration. Furthermore, Connolly (2003, 34) emphasises that the provision of basic infrastructure improvements, such as water and drainage, might take longer than obtaining electricity, which in initial phases could be obtained by illegal hook-ups to the distribution lines. Finally, she elaborates on the notion that community property rights and inadequate regulations hinder the formal development of large plots of land located on the urban periphery of the ZMVM. An additional obstacle for such development could be attributed to the limited private sector involvement. In the opinion of Imparato & Ruster (2003, 280), the non-existence of private funding through the banking sector, caused by the requirements of physical collateral, obliges the poor communities to finance their shelter needs via personal savings and informal credit sources. Moreover, they add that financing community-wide infrastructure through collecting shares from the households is particularly problematic due to free-rider issues.

Other causes hindering the investment in infrastructure and public goods in the slums have been explored by Marx et al. (2013, 195). In the first place, they argue that formal land titling can encourage

investment in poor urban areas since the dwellers without them lack incentives to improve their houses and neighbourhoods. Secondly, they add that numerous sorts of upgrades demand fairly significant private investments; therefore, negligible marginal returns from small upgrading investments are considered an important investment deterrent. In this regard, Dufflo et al. (2012, 20) have documented that people might not be willing to pay for improving services with technologies when they do not fully understand their worth. Thirdly, living nearby the city demands expensive rent premiums; thus, the saving capacity of the dwellers is particularly affected. Additionally, governance gaps and lack of coordination in the slums provoke mafias and some influential individuals to fill such gaps, for example, in the housing market. Finally, the last deterrent for investment in the slums considered by Marx et al. (2013, 197) is Todaro's paradox[2] which could discourage both public and private investment in the slums in order to avoid increasing migration influxes. Nonetheless, they remark that there is a lack of clear evidence linking those effects to slums growth.

Foremost, the deprivation of adequate infrastructure in the slums takes profound importance if neighbourhood effects are considered. According to Ruggeri (2005, 37), "*the type of infrastructure available, regular lighting in the streets etc., seems to influence social interactions, for example, by influencing perceptions of security, participation in communal activities etc*". Moreover, Goetz (2003, 3) argues that neighbourhood environments are crucial in determining individuals' opportunities and experiences. He states that rates of school delinquency, school dropout, teenage pregnancy, out-of-wedlock childbirth, violent crime, and drug abuse are higher in communities with extreme concentrations of poverty. As per Bird (2019, 4), *bad neighbourhood effects* hinder the opportunities of slum dwellers even if they possess entrepreneurial skills, enough capital, and the will to invest it. This is because investment returns, even those in human capital, will be lower than in areas with more significant geographic capital and *good neighbourhood effects*.

Along the same lines, Durlauf (2000, 3) describes the influence of neighbourhood composition on individual families by listing the diverse types of effects. For instance, the *peer group* effects occur when a person is more prone to adopt specific behaviours if friends or acquaintances also have them. The *role model* effects happen when the characteristics of an older group's member influence the preferences of younger ones. Additionally, *social learning* effects appear if the results experienced by some members of the community influence others' perceived benefits regarding particular choices (e.g., attending college). Lastly, *social complementarities* refer to the fact that some members' choices can alter others' benefits by complementing their choices.

Nonetheless, the neighbour effects can suppose a potential tool in the improvement of the slum as well. In this regard, research on the neighbourhood impacts of local infrastructure investment carried out in 60 municipalities of Mexico by McIntosh et al. (2018, 283) address the social and economic benefits of investment in underserved neighbourhoods. According to them, "*urban slums may prove a particularly attractive place to make new infrastructure investments precisely because they have been historically underserved*" McIntosh et al. (2018, 264). Furthermore, their research has revealed that the increases in the access to well-functioning public

[2] Todaro (1976, 212) documented how an autonomous increase in the rate of urban job creation could lead to a cumulative induced migration, which would negatively affect urban employment.

lighting, paved roads, and sidewalks produce a drop in the crime rates and reductions in the neighbourhood churn in real estate. Although when the value of the properties rises, so do the properties' prices and the rents. Additionally, Turley et al. (2013, 50) also contribute to the slum's upgrading effects body of research and declare that slum dwellers value the essential infrastructure upgrading above health, education, or financial interventions; thus, the improvement in the physical environment precedes the upgrading in health and education facilities.

In short, the condition of the slums' infrastructure can influence dwellers' lives either positively or negatively. Notwithstanding that an insufficient provision of essential infrastructures, such as electricity, water, drainage, and paved roads, seems to be common characteristics in most slums, the underlying factors propelling the deficiencies of said infrastructure draw heavily on the particularities of each case. The spatial patterns of social segregation in the ZMVM have been majorly driven by the orography in which the city rests and the macroeconomic environment that reproduces cheap labour. Nonetheless, additional deterrents such as lack of land titles, low marginal returns from upgrade investments, high rent premiums, and governance gaps have contributed to such concentrations of misery. Lastly, many significant neighbourhood effects emanating from the infrastructure's condition have been documented to impact the dwellers living conditions and future opportunities. Ergo, a more detailed analysis on the spatial distribution of the urban poor, according to their specific deprivations, and its relationship with the public infrastructure investment are vital elements that strive to contribute to the formulation of policies that can efficaciously alleviate the misery in the slums of the ZMVM.

3 Methodology

This section regards the methodological approach of this investigation. Its purpose is to explain this research's design, delimitate the territory of study, provide the rationale for the categories used, and detail the measurements and statistical instruments utilised.

3.1 Delimitation of the Metropolitan Area of the Valley of Mexico

Around the 1930s, the ZMVM's population increased at relatively high rates, higher than in the rest of the country. In the 1940s, new restrictions imposed by the government of Mexico City on the construction of settlements produced a progressive spatial expansion of the metropolis, practically within the limits of Mexico City, which at that time encompassed 99 per cent of the region's population. Within a couple of decades, at least 11 municipalities in the neighbouring state were vastly integrated with the city's activities (SEMARNAT, 2002, 2-7). Moreover, as additional municipalities were integrated, the definitions regarding the metropolitan area changed in a constant process. Nevertheless, the formal definition of what constitutes the Metropolitan Zone of the Valley of Mexico emanates from a series of documents entitled *Delimitación de las zonas metropolitanas de México* (Delimitation of the metropolitan zones of Mexico). This series of documents were produced in a joint effort by the Mexican Ministry of Agrarian, Territorial and Urban Development (SEDATU for its Spanish acronym), the Mexican National Population Council (CONAPO), and the National Institute of Statistics and Geography of Mexico (INEGI); the most up-to-date version is from 2015.

In this regard, the introduction of the said zone must begin by presenting a metropolitan area's constitutive criteria. The essential criteria for a metropolitan area are reaching a certain number of inhabitants

and having functions and activities that go beyond the limits of the municipalities it contains. In this regard, two or more municipalities enclosing a city with more than one hundred thousand inhabitants can be regarded as a metropolitan area, as long as the contained municipalities maintain a high degree of socioeconomic integration. Moreover, those municipalities with relevant characteristics for the urban planning of the metropolitan zone are also included (SEDATU et al., 2015, 35).

The Valley of Mexico locates on approximately 19° 20' of North Latitude and 99° 05' of West Longitude; it is considered part of a basin with an average elevation of 2,240 meters above sea level and a total surface area of 9560 square kilometres (SEMARNAT, 2002, 2-3). The ZMVM is contained within this valley, with a total surface area of 7866.1 square kilometres and an urban average density of 160.1 inhabitants per hectare (SEDATU et al., 2015, 106). Moreover, the ZMVM comprises significant parts of the State of Mexico, a small portion of the south of the Hidalgo State, and the entirety of Mexico City. Additionally, it rests on the extinct lakes of Texcoco, Xochimilco, and Chalco, encompassing a series of intermountain valleys, plateaus, glens and semi-flat terrains (SEMARNAT, 2002, 2-3).

Finally, based on the results obtained by the first series of documents above-mentioned, the government of Mexico City jointly with the government of the State of Mexico, saw fit to issue the Declaration of the Metropolitan Zone of the Valley of Mexico in their Official Gazette on the 23rd of February 2006. A translation of said declaration presents as follows:

> "THE STATE OF MEXICO "and" THE FEDERAL DISTRICT ", with absolute respect for the sovereignty and territory of each federative entity, and with the character of instrument for the unification, conceptualisation, integration of plans, programs, actions and joint or coordinated attention of matters of common benefit in the metropolitan ambit of their respective jurisdiction, declare that the Metropolitan Zone of the Valley of Mexico is comprised of the territory made up of the 16 Delegations of the Federal District and the following 59 municipalities of the State of Mexico: Acolman, Amecameca, Apaxco , Atenco, Atizapán de Zaragoza, Atlautla, Axapusco, Ayapango, Coacalco de Berriozabal, Cocotitlán, Coyotepec, Cuautitlán, Cuautitlán Izcalli, Chalco, Chiautla, Chicoloapan, Chiconcuac, Chimalhuacán, Ecatepec de Morelos, Ecatzingo, Huehuetoca, Hueypoxtla, Huixquilucan, Isidro Fabela, Ixtapaluca, Jaltenco, Jilotzingo, Juchitepec, La Paz, Melchor Ocampo, Naucalpan de Juárez, Nezahualcóyotl, Nextlalpan, Nicolás Romero, Nopaltepec, Otumba, Ozumba, Papalotla, San Martín de las Pirámides, Tecámac, Temamatla, Temascalapa, Tenango del Aire, Teoloyucan, Teotihuacán, Tepetlaoxtoc, Tepetlixpa, Tepotzotlán, Tequixquiac, Texcoco, Tezoyuca, Tlalmanalco, Tlalnepantla de Baz, Tonatitla, Tultepec, Tultitlán, Valle de Chalco Solidaridad, Villa del Carbón and Zumpango (Gaceta Oficial del Distrito Federal, 2006, 20).

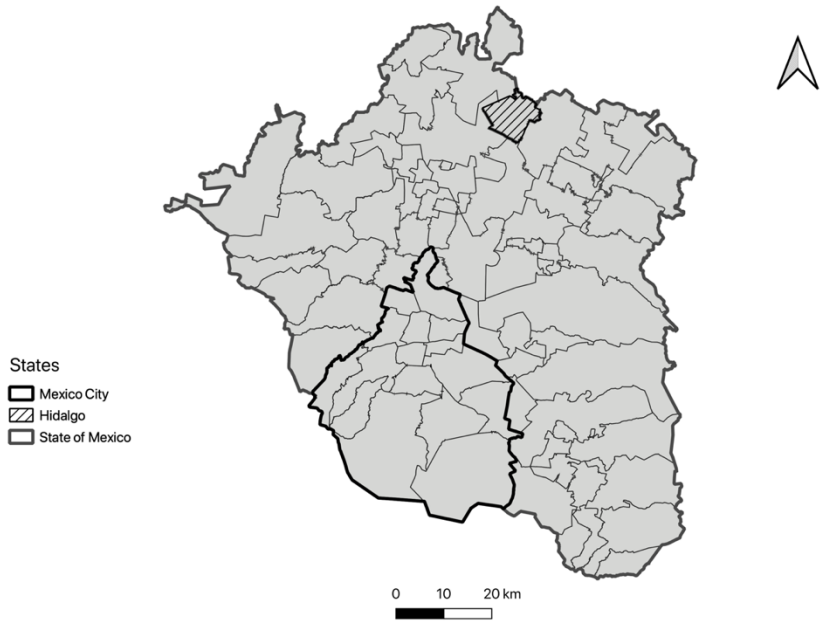
Since the definition mentioned above dates from 2006, some precisions must be considered due to time affectations. First, the Federal District mentioned in the definition refers to Mexico City; second, the included 16 *Delegations* from Mexico City are legal demarcations very similar to municipalities, but with some administrative differences; nowadays, said demarcations are referred to as *Alcaldías* by law[3]. Lastly, the 2015 version of the document *Delimitación de las zonas metropolitanas de México* incorporates in the ZMVM one municipality of Hidalgo State named Tizayuca.

With that in mind, the Municipal Geostatistical Areas (AGEM by its Spanish acronym) composing the ZMVM referred in this work are the following: Azcapotzalco, Coyoacán, Cuajimalpa de Morelos, Gustavo A. Madero, Iztacalco, Iztapalapa, La Magdalena Contreras, Milpa Alta, Álvaro Obregón, Tláhuac, Tlalpan,

[3] To keep a certain level of clarity in this work, these *Alcaldías* are referred to as the municipalities of Mexico City.

Xochimilco, Benito Juárez, Cuauhtémoc, Miguel Hidalgo, Venustiano Carranza, Tizayuca, and the 59 municipalities from the State of Mexico mentioned in the declaration (See Figure 1.).

Figure 1: Map of the Metropolitan Zone of the Valley of Mexico.



Source: Own elaboration using data from AGEM-INEGI. Note: Categories refer to the State to which the enclosed municipalities belong to.

3.2 Poverty and deprivation-based maps

In the context of a growing analysis framework that debates for the most adequate approach to measure poverty, clarifications on the perspective adopted to address the concept of poverty must be stated. Those categorisations of poverty that rely solely on an income-consumption approach, like those explored by Ravallion & Chen (1997, 359), are destined to exhibit general drawbacks related to the consubstantial variegations of people's spending habits. Additionally, other issues such as inadequate registration of the consumers' expenses, the transformations of the utility concept, or the allusion to theoretical assumptions not present in reality, hinders the assessment of the public goods' impacts on welfare (Klasen, 2000, 33). Contrastingly, poverty approaches that consider the valid opportunities of the people to achieve well-being, as explored by Sen (1992, 40), necessarily include other relevant dimensions to achieve those minimal levels of capabilities to function in society.

Therefore, this research resorts to the multidimensional poverty measurement used by CONEVAL, which draws on the theoretical foundation of the Unsatisfied Basic Needs (NBI for its Spanish acronym) method, introduced by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) in the 1980s. Said approach chooses a series of census indicators that allow verifying whether a household satisfies its main needs or not. Once the satisfaction condition has been established, poverty maps

can be built, geographically locating the deficiencies noted (Feres & Mancero, 2001, 8). Likewise, CONEVAL's measurement regards poverty as a series of defined shortages in multiple domains, such as opportunities for participating in collective decisions, the resource appropriation mechanisms or rights' entitlements that allow access to physical, human or social capital. However, its multidimensional nature does not require to account for all the possible areas involved in the development of an individual's life (CONEVAL, 2018, 4). The number and type of dimensions considered by CONEVAL are directly associated with minimum or acceptable living standards for every member of society.

Consequently, in accordance with the provisions of the Mexican General Law of Social Development (2004, 9), the identification and measurement of poverty in Mexico include the following indicators:

I. Current income per capita.
II. Average educational backwardness in the household.
III. Access to health services.
IV. Access to social security.
V. Quality and spaces of dignified and decent housing.
VI. Access to basic services in dignified and decent housing.
VII. Access to nutritious and quality food.
VIII. Degree of social cohesion.
IX. Degree of accessibility to a paved road.

In this regard, CONEVAL considers that a person is poor when they have at least one social deprivation and their income is insufficient[4] to purchase the necessary goods and services to satisfy their food and non-food needs; the extreme poor are those with at least three social deprivations and their income is insufficient to satisfy their food needs. Moreover, due to the availability constraints of the sources for calculating people's income at the municipal level, the latest integral poverty measures at said level date from 2015. Nonetheless, CONEVAL also generates a Social Backwardness Index (IRS by its Spanish acronym) based on the statistical technique of Principal Component Analysis[5]. This index integrates into a single measurement the variables related to education, access to health services, quality and living spaces, basic services in the house and home assets. However, variables such as income, social security and food, which are not explicitly found in the Population and Housing Censuses, are not included in the index. Therefore, the IRS cannot be regarded as a poverty measure *per se* since it would contravene the provisions set by law. Nonetheless, although the IRS is helpful to compare the relative order of entities, municipalities and localities over time, its primary function is ordering territories at a concise point in time according to their degree of social backwardness.

For this reason, given the main objective of this research, the IRS is disaggregated in its constitutive variables to focus on the components of the *access to basic services in dignified and decent housing*. Said components are utilised in this work in the elaboration of deprivation maps that spatially disaggregate the underlying

[4] Said necessary income is set by the Extreme Poverty Income Line (EPIL), which is the monetary value of a food basket, and the Income Poverty Line (IPL), which is the sum of the food basket and a non-food one values. In December 2015, the poverty lines were the following: Urban IPL: 2923.29; Rural IPL: 2032.80; Urban EPIL: 1341.26; Rural EPIL: 1017.03. (CONEVAL, 2021). Note: These income poverty lines are measured in monthly MXN pesos and sometimes are referred to as welfare lines.

[5] According to Esbensen, K., & Geladi, P. (1987, 37), PCA forms the basis for multivariate analysis. "*PCA provides and approximation of a data table, a data matrix, X, in terms of the product of two small matrices T and P'. These matrices, T and P', capture the essential data patterns of X*".

infrastructure deprivations of the poor in the ZMVM. The elaboration of said maps draws on Erenstein et al. (2010, 112) and Feres & Mancero (2001, 8) works, which highlights the usefulness of visualising the spatial dimensions of poverty through poverty maps to guide priority-setting and target poverty-alleviation intervention. Note that the maps presented in this work are generally referred to as *poverty maps*; however, some of them illustrate single social deprivations excluding the income, which is not a sufficient element to regard someone as poor accordingly to the classifications established in the aforementioned legal provisions. Withal, they aim to contribute to a better characterisation, at a municipal level, of the slums and infrastructure deficiencies of the ZMVM through its inhabitants' territorial patterns.

The variable *access to basic services in dignified and decent household* is composed by indicators that reflect percentages based on the inhabited households at a municipal level. Drawing on CONEVAL (2007, 7) methodology, the indicators are calculated based on the results of the 2020 Population and Housing Census[6] and are listed as follows:

I. Municipal percentage of inhabited private households that do not have lavatory or toilet.

$$I_{notoi} = \left(1 - \frac{iph\_toile}{inhprihou}\right) \times 100 \quad (1)$$

Where:

iph_toile: Inhabited private households in the municipality that have lavatory or toilet.
inhprihou: Total number of inhabited private households in the municipality.

II. Municipal percentage of inhabited private households that do not have piped water from the public network.

$$I_{nowat} = \frac{iph\_nowat}{inhprihou} \times 100 \quad (2)$$

Where:

iph_nowat: Inhabited private households in the municipality that do not have piped water from the public network.
inhprihou: Total number of inhabited private households in the municipality.

III. Municipal percentage of inhabited private households that do not have drainage.

$$I_{nodrain} = \frac{iph\_nodrain}{inhprihou} \times 100 \quad (3)$$

Where:

iph_nodrain: Inhabited private households in the municipality that do not have drainage.
inhprihou: Total number of inhabited private households in the municipality.

IV. Municipal percentage of inhabited private households that do not have electricity.

$$I_{noelec} = \left(1 - \frac{iph\_electr}{inhprihou}\right) \times 100 \quad (4)$$

Where:

iph_electr: Inhabited private households in the municipality that have electricity.

[6] The National Institute of Statistics and Geography (INEGI), responsible for producing and disseminating information of national interest for the entire society, conducted the 2020 Population and Housing Census from March 2nd to 27th. The purpose of the Census is to produce information on the size, structure and spatial distribution of the population, its main sociodemographic and cultural characteristics, and the housing count and its characteristics (INEGI, 2021).

inhprihou: Total number of inhabited private households in the municipality.

Moreover, this work excludes the indicator referring to *households that do not have lavatory or toilet* for not relating directly with the basic public infrastructure and uses the remaining three to calculate new indicators that reflect the municipal proportions in population terms instead of households. Said new indicators are listed as follows:

I. Municipal percentage of population that do not have piped water from the public network.

$$I_{2nowat} = \left(\frac{iph\_nowat \times \left(\frac{totpop}{inhprivhou} \right)}{totpop} \right) \times 100 \quad (5)$$

Where:

iph_nowat: Inhabited private households in the municipality that do not have piped water from the public network.

inhprihou: Total number of inhabited private households in the municipality.

totpop: Total municipal population.

II. Municipal percentage of population that do not have drainage.

$$I_{2nodrain} = \left(\frac{iph\_nodrain \times \left(\frac{totpop}{inhprivhou} \right)}{totpop} \right) \times 100 \quad (6)$$

Where:

iph_nodrain: Percentage of inhabited private households in the municipality that do not have drainage.

inhprihou: Total number of inhabited private households in the municipality.

totpop: Total municipal population.

III. Municipal percentage of population that do not have electricity.

$$I_{2noelec} = \left(1 - \frac{iph\_electr \times \left(\frac{totpop}{inhprivhou} \right)}{totpop} \right) \times 100 \quad (7)$$

Where:

iph_electr: Inhabited private households in the municipality that have electricity.

inhprihou: Total number of inhabited private households in the municipality.

totpop: Total municipal population.

Additionally, a new set of indicators that reflect the distribution of the deprived population across the entire ZMVM are created. This last set of indicators is listed as follows:

I. Percentage share of municipal population that do not have piped water from the public network to ZMVM total water deprived population.

$$I_{3nowat} = \left(\frac{iph\_nowat \times \left(\frac{totpop}{inhprivhou} \right)}{zmwttpop} \right) \times 100 \quad (8)$$

Where:

iph_nowat: Inhabited private households in the municipality that do not have piped water from the public network.

inhprihou: Total number of inhabited private households in the municipality.

totpop: Total municipal population.

zmwttpop: Total population that do not have piped water from the public network from the ZMVM.

II. Percentage share of municipal population that do not have drainage to ZMVM total drainage deprived population.

$$I_{3nodrain} = \left(\frac{iph\_nodrain \times \left(\frac{totpop}{inhprivhou} \right)}{zmdrtpop} \right) \times 100 \quad (9)$$

Where:

iph_nodrain: Inhabited private households in the municipality that do not have drainage.

inhprihou: Total number of inhabited private households in the municipality.

totpop: Total municipal population.

zmdrtpop: Total population that do not have drainage from the ZMVM.

III. Percentage share of municipal population that do not have electricity to ZMVM total electricity deprived population.

$$I_{3noelec} = \left(1 - \frac{iph\_electr \times \left(\frac{totpop}{inhprivhou} \right)}{zmeltpop} \right) \times 100 \quad (10)$$

Where:

iph_electr: Inhabited private households in the municipality that have piped water from the public network.

inhprihou: Total number of inhabited private households in the municipality.

totpop: Total municipal population.

zmeltpop: Total population that do not have drainage from the ZMVM.

The total sum of these indicators contributes to the elaboration of maps to identify the spatial distributions of dwellers with certain deprivations from the ZMVM. Moreover, the analysis of said agglomerations allows a further characterisation of the slums.

3.3 Public expenditure in infrastructure investment

In the context that the poverty measurement in this work is based on Sen's (1998,17) vision regarding the dependency of a person's well-being on their capacities and functioning, the analysis of infrastructure investments in the slums acquires a fundamental role. In this sense, drawing on Jean Piaget's notions regarding the house as a central reference from which humans construct their spatial perception and habits, Tello i Robira (2003) argues that social and cultural habits depend largely on the housing conditions and its surroundings. In addition, she emphasises that physical characteristic, such as dimensions, infrastructural and material equipment, and immaterial characteristics of the family, culture, and environment, can delimit the individual's personal development in the socio-cultural and technical-economic aspects of the community. Furthermore, although living in a properly built house that protects its inhabitants is a fundamental element, providing basic services such as water in the house and electricity has a strong impact on sanitary conditions and the activities carried out by the household members (CONEVAL, 2014, 59). Therefore, the scrutiny of infrastructure in the slums is an obligatory step.

The analysis of the public infrastructure investment in this work draws on some elements studied by Han et al. (2020, 6) regarding a new consensual method on how to approach the analysis of public investment in infrastructure. In this regard, although they imply the non-existence of a standardised approach to measure infrastructure investment, they argue that the best approximation would be through the analysis of the general government Gross Fixed Capital Formation (GFCF), alongside some private sector investment data. Moreover, according to the Asian Development Bank (2017, 19), "*An ideal measure of infrastructure investment could be constructed based on gross fixed capital formation (GFCF) in national accounts data*". Additionally, they elaborate on the fact that such measurement requires disaggregated information in order to distinguish investments in fixed assets by type of institution, e.g., general government, State Owned Enterprises, and private corporations.

By the agreements undersigned, Mexico has adopted and adapted the theoretical-accounting framework offered by the 2008 edition of the System of National Accounts (SNA), approved by the United Nations Statistical Commission (UNSC). The said system provides a far-reaching conceptual and accounting framework built using a sequence of flow accounts linked to each other and related to the different types of economic activities. Therefore, the accounts offer information on the economic units' behaviour and their activities, whether they be production, consumption, or accumulation of assets, allowing the analysis and evaluation of the economy's performance. Moreover, among the generated information, the capital account which records the values of non-financial assets that institutional units acquire or dispose of by transactions, encloses the information regarding GFCF.

According to INEGI (2018, IV-72), the GFCF is measured by the total value of acquisitions minus disposals of fixed assets and additions to non-produced assets' value. Fixed assets, which can be tangible and intangible, are obtained from production processes and are used repeatedly or continuously in other production processes for more than one year. This GFCF investment by asset is broadly classified in *Construction and facilities* and in *Machinery and equipment*, which then are reported in different groups[7]. The *Construction and facilities* classification is the one of our interest since it contains information regarding residential buildings, non-residential buildings, and infrastructure works such as: highways, roads, bridges, dikes, ports, airports, drinking water, drainage systems, dams, infrastructure for the generation and distribution of electricity, infrastructure for telecommunications, transportation and urbanisation works, oil and gas pipelines, and drilling of oil wells. At the same time, the *Construction and facilities* classification is subdivided in *dwellings* and *other buildings and structures*.

The *other buildings and structures* group works as a measurement for infrastructure GFCF, and according to Han et al. (2020, 7), said group includes "*public non-residential properties such as warehouses, industrial and commercial buildings, hospitals, schools, etc., while other structures include flood protection, highways and roads, harbours, pipelines, communication, and power lines*". Moreover, the information regarding infrastructure investment is reported for the

[7] The OECD (2021), for instance, reports the GFCF data compiled by the member countries in the following six different groups: "*dwellings (excluding land); other buildings and structures (roads, bridges, airfields, dams, etc.); transport equipment (ships, trains, aircraft, etc.); cultivated biological resources (managed forests, livestock raised for milk production, etc.); intellectual property products (such as R&D, mineral exploration, software and databases, and literary and artistic originals, etc.); and ICT equipment (computer software and databases, telecommunications equipment and computer hardware)*".

national economy as a whole, along with its constituent institutional sectors and subsectors that are listed below:

- Internal economy.
  - Non-financial corporations.
    - Public non-financial corporations.
    - National and foreign-controlled private non-financial corporations.
  - Financial corporations.
    - Central Bank.
    - Depository companies, except the Central Bank.
    - Money market funds.
    - Investment funds outside the money market.
    - Other financial intermediaries, except insurance companies and pension funds.
    - Financial auxiliaries.
    - Captive financial institutions and money lenders.
    - Insurance companies.
    - Pension funds.
  - General government.
    - Central government.
      - Federal government and government bodies.
      - Decentralised agencies.
    - State governments.
      - Government of Mexico City.
      - State governments.
    - Local governments.
    - Social Security.
  - Households.
  - Non-profit institutions serving households.
- Rest of the world.
- Goods and services.

Nevertheless, the general government disaggregation agglomerates within a single value the sum of all the local governments' infrastructure GFCF. In other words, the value reported for local governments encompasses the totality of the 2466 municipalities of the country[8] without distinction; thus, preventing the spatial analysis of said investments. Therefore, to carry out said analysis, it was necessary to resort to the input source used to generate the local governments' statistics regarding infrastructure GFCF. For that reason, this work utilises the State and Municipal Public Finance Statistics integrated through INEGI's EFIPEM[9] project.

The EFIPEM integrates information on the origin and application of the financial resources at both governmental levels. Additionally, it shows their performance in the economic and social sphere and assists in the System of National Accounts of Mexico (SCNM) calculations (INEGI, 2016, VII). Furthermore, the

[8] This number includes the 16 municipalities of Mexico City (see footnote number 3 for further clarification).
[9] State and Municipal Public Finance Statistics by its Spanish acronym.

collection of financial information regarding the public expenditure at different levels of government is classified in the following chapters: Personal Services; Materials and Supplies; General Services, Transfers, Assignments, Subsidies and Other Aids; Movable, Immovable and Intangible Assets; Public Investment; Financial Investments and Other Provisions; Resources Reallocated to Municipalities; Other Expenditures; Public Debt; and Final Availability.

Withal, the Public Investment chapter[10] contains a subdivision named *Public Works in Public Domain Property*, which contains the information of the public expenditure regarding the following: schools; hospitals; construction of works for the supply of water, oil, gas, electricity and telecommunications; division of land and construction of urbanisation works; construction of communication routes; and various public works in public domain property. Moreover, this *Public Works in Public Domain Property* is the main component for the reported figure in the SCNM regarding infrastructure GFCF. Therefore, it is utilised in this work as the major proxy for the municipal public infrastructure investment. Concomitantly with Han et al. (2020, 7), any potential upward bias in the measurement of infrastructure investment is considered to be mitigated by the omissions in merit goods infrastructure such as investment in Information and Computer Technology equipment.

The data obtained from the EFIPEM was then organised in matrices and subjected to simple homologation processes for the following main reasons: the data regarding the ZMVM' municipalities were scattered in files treating the municipalities of Hidalgo, the state of Mexico and Mexico City separately, and the expenditures for each year were expressed in current pesos, hampering their temporal comparison. Additionally, it is essential to emphasise that the data on infrastructure investment used in this work refer only to expenditures at the municipal level and do not include infrastructure expenditures made by state government levels, even if these were made in municipalities belonging to the ZMVM (e.g., Mexico City government expenditures on the metro collective transportation system).

The matrices regarding the total expenditure and the infrastructure investment from 1999 to 2019 were created to organise the data and facilitate its analysis. Said matrices have the same structure and can be illustrated as follows:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} \\ \vdots & \ddots & \vdots \\ a_{i1} & \cdots & a_{ij} \end{bmatrix}$$

Where:

A: Is a matrix with size $(y \times m)$, that contains the expenditure values (either total expenditure or infrastructure expenditure) of the municipalities from the ZMVM.

i: Represents the year from which the values come from (1999 to 2019).

j: Represents the municipality from which the values come from.

[10] The Public Investment chapter captures the allocations destined to works by contract, productive projects, and promotion actions, including the expenses in pre-investment studies and project preparation. It is subdivided into *Public Works in Public Domain Property*, *Public Works in Own Property*, and *Productive Projects and Promotion Actions*.

For instance, the total expenditure of the municipality named Iztapalapa for the year 2005 would be the element located in the intersection where the i represents the year 2005 and j the Iztapalapa municipality.

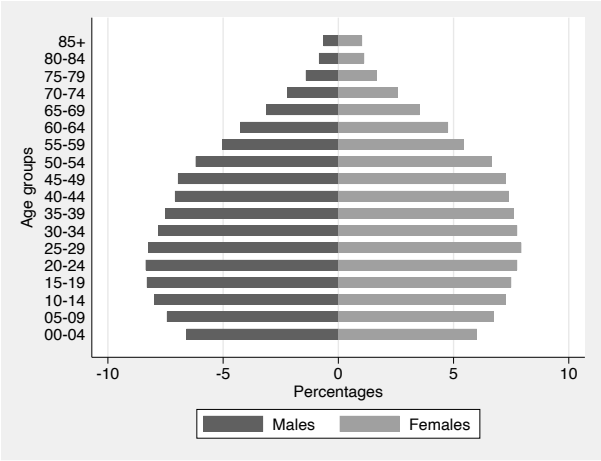
Lastly, in order to obtain standardised data suitable for comparisons, the values in current pesos were converted into constant 2013 values[11]. This was carried out by creating a deflator for each year, based on the National Consumer Price Index (INPC)[12] reported by INEGI (2021), and then transforming the current values into constant accordingly. Lastly, the figures on the population size of each municipality were taken from the Population and Housing Censuses reported by INEGI.

The data above-mentioned provides advantages for the analysis of infrastructure investment at a municipal level across time and for the generation of maps that illustrate the levels of investment in relation to other municipalities and their dwellers.

4 Discussion of findings

This chapter presents and discusses some maps and figures resulting from this research, organizing them to first show the distribution patterns of poor people in the ZMVM to then delve into those with deprivations concerning the provision of basic public infrastructure and the municipal investment in it. Moreover, the appreciation of the phenomena presented below is enhanced through some population age structure portrayals, commencing with the ZMVM's overview (see figure 2).

Figure 2: ZMVM's population structure.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the ZMVM's total population structure by the year 2020, classified in 18 age groups by sex. Additionally, note that negative numbers in the "x" axis refer to positive percentages of male population.

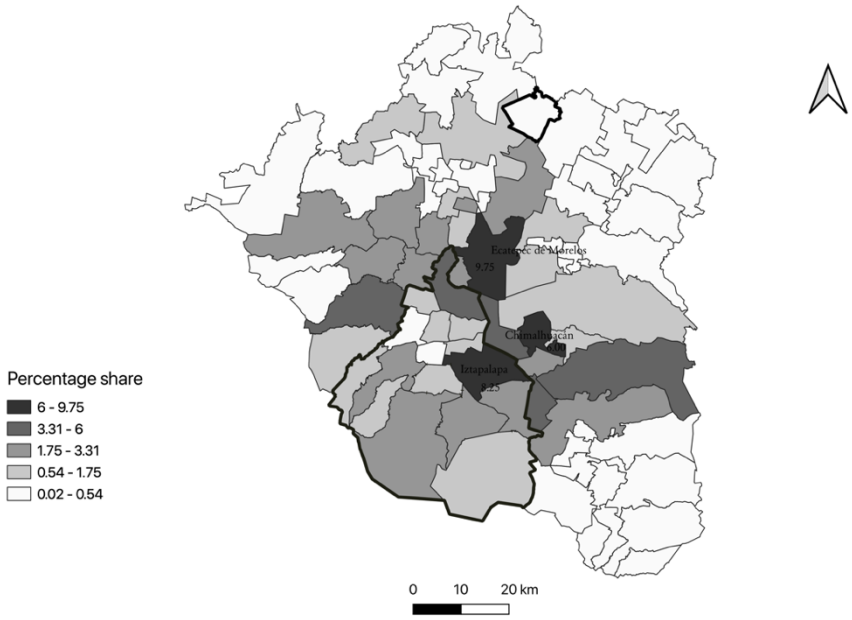
It can overall be noticed that the amount of young population in the ZMVM has been reducing in recent years.

[11] The constant pesos with base 2013 were selected to be consistent with the SCNM that is reported in the same base.
[12] The base of the INPC had to be changed to 2013 since INEGI reports it with base 2018.

4.1 Poverty in the ZMVM

Below are presented the maps which reflect the spatial distribution of the *poor* in the ZMVM. These poor are those with at least one social deficiency (educational backwardness, access to health services, access to social security, quality and spaces of housing, basic services, and access to food) and whose income locates below the income poverty line[13]. Note that the category *poor* comprises the moderate poor and the extreme poor together.

Figure 3: Map of distribution shares of ZMVM's poor population.

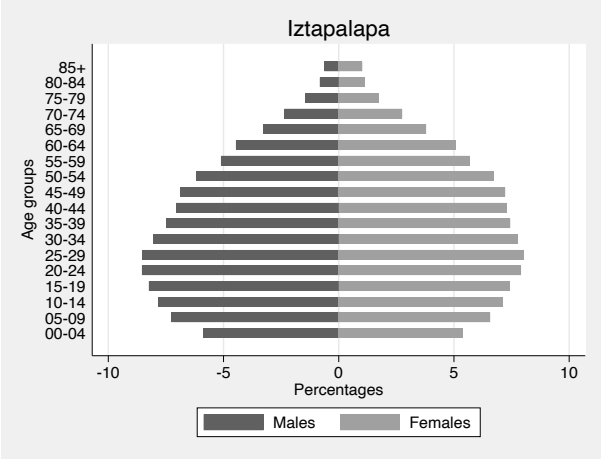


Source: Own elaboration, using data from AGEM-INEGI and CONEVAL. **Note**: Categories refer to the percentages from the total ZMVM's poor concentrated in the municipality during 2015.

The Figure 3 shows that the places concentrating the most significant numbers of poor population from the ZMVM are municipalities located on Mexico City's eastern edge. Such is the case of Ecatepec de Morelos, Iztapalapa, Chimalhuacán, Nezahualcóyotl and Gustavo A. Madero; however, some complementing facts must be noted. First, Ecatepec de Morelos and Iztapalapa are also the most populated municipalities of the ZMVM; thus, it is understandable that they also agglomerate the most significant numbers of poor dwellers. Yet, this is not the case for Nezahualcóyotl and Chimalhuacán, considering that other municipalities are more populated and have fewer poor inhabitants. Secondly, in the last two decades, the population from Chimalhuacán, Ecatepec de Morelos and Gustavo A. Madero has decreased, especially on the latter. On the other hand, Iztapalapa's population has slightly increased by approximately four per cent while Nezahualcóyotl's has done so in about ten per cent during these last two decades. Additionally, this process can be observed by comparing the bases of the population age structures, from which Gustavo A. Madero has the smallest (see figure 8), suggesting a relative population decrease.

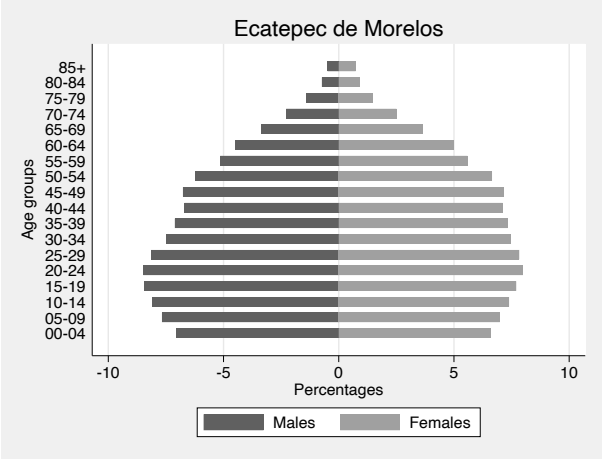
[13] See footnote number 4 for further clarification on the poverty lines.

Figure 4: Population structure, Iztapalapa.



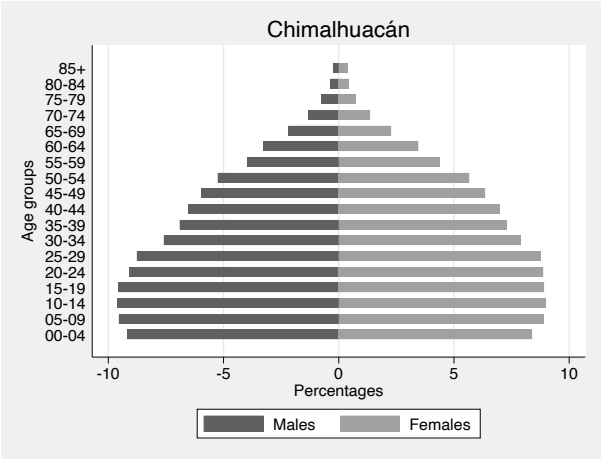
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Iztapalapa for the year 2020.

Figure 5: Population structure, Ecatepec de M.



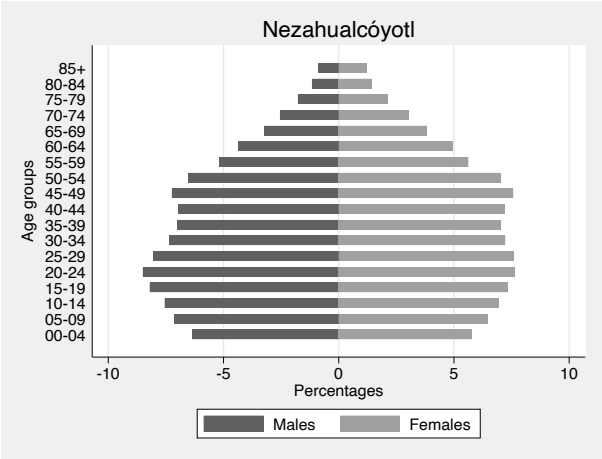
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Ecatepec de Morelos for the year 2020.

Figure 6: Population structure, Chimalhuacán.



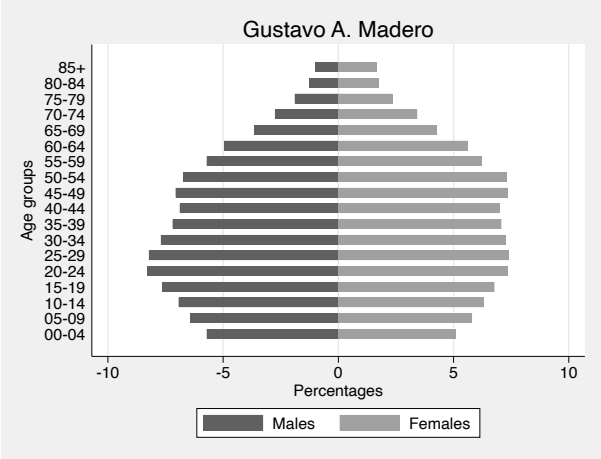
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Chimalhuacán for the year 2020.

Figure 7: Population structure, Nezahualcóyotl.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Nezahualcóyotl for the year 2020.

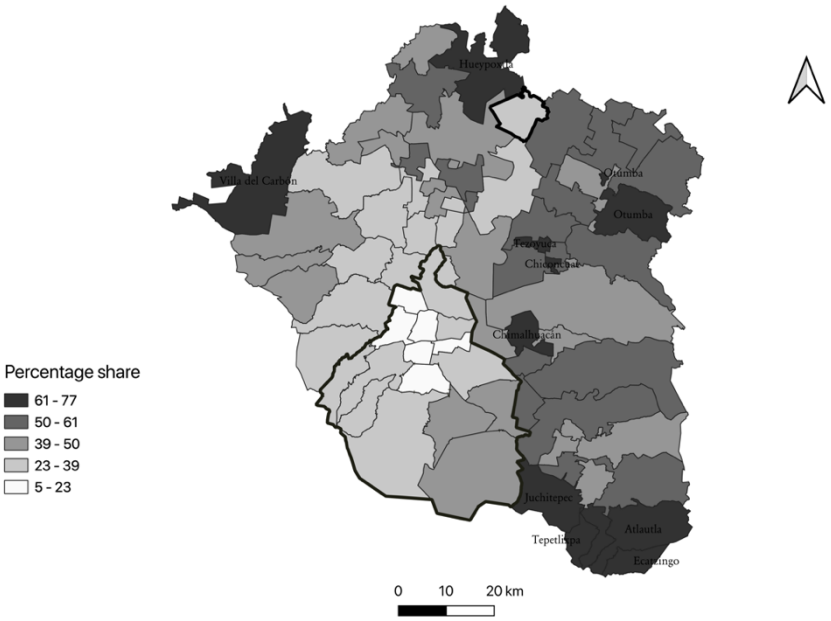
Figure 8: Population structure, Gustavo A. Madero.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Gustavo A. Madero for the year 2020.

Conversely, places with higher municipal shares of poor dwellers locate more towards the borders of the ZMVM, in municipalities experiencing more prominent rates of population growth (see figure 9).

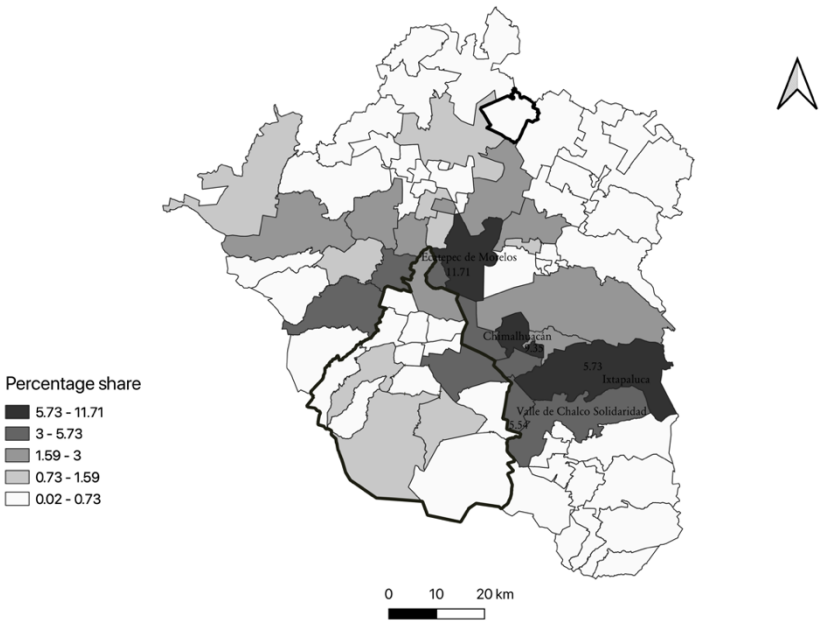
Figure 9: Map of municipal poor population share.



Source: Own elaboration, using data from AGEM-INEGI and CONEVAL. **Note**: Categories refer to the percentage share of poor inhabitants from the total municipal population, i.d., the proportion of how many inhabitants of the municipality were poor during 2015.

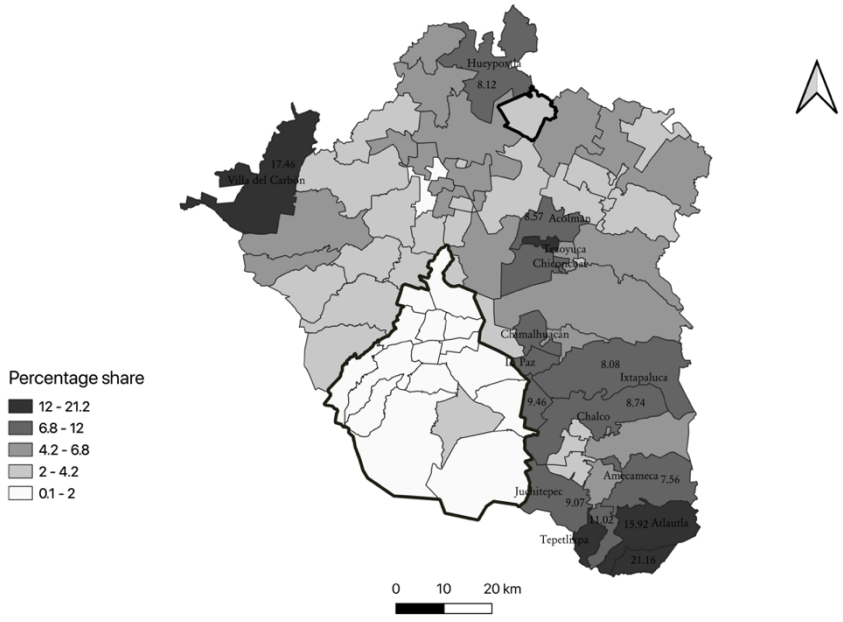
Based on the fact that the extremely poor population in Mexico is categorised through the accumulation of at least three social deficiencies coupled with an income below the minimum poverty line, the following maps examine the distributions of said extreme poor population in the ZMVM.

Figure 10: Map of distribution shares of ZMVM's extreme poor population.



Source: Own elaboration, using data from AGEM-INEGI and CONEVAL. **Note**: Categories refer to the percentages from the total ZMVM's extreme poor concentrated in the municipality during 2015.

Figure 11: Map of municipal extreme poor population share.



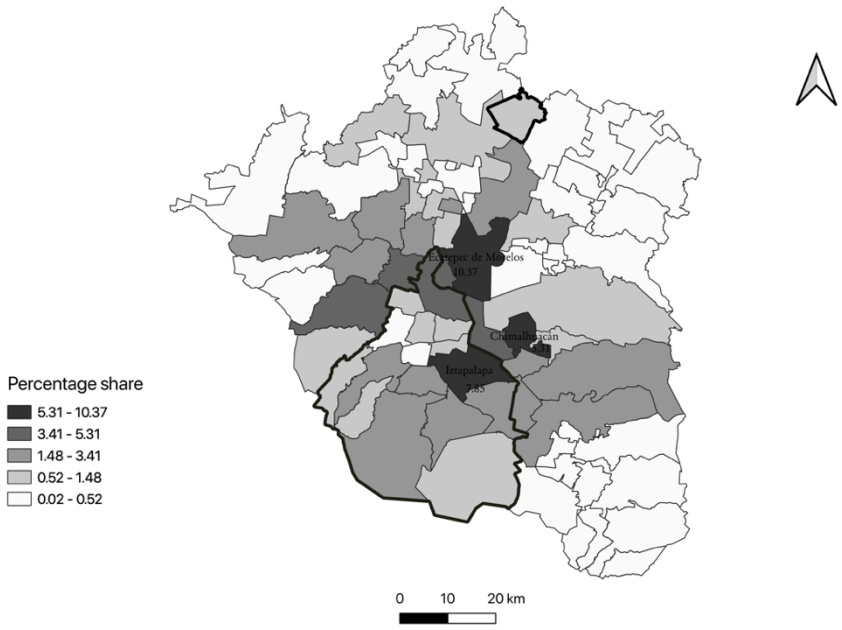
Source: Own elaboration, using data from AGEM-INEGI and CONEVAL. **Note**: Categories refer to the percentage share of extreme poor inhabitants from the total municipal population, i.d., the proportion of how many inhabitants of the municipality were extremely poor during 2015.

The spatial distribution of the ZMVM's extreme poor population show that they agglomerate significantly in Ecatepec de Morelos and Chimalhuacán, both belonging to the State of Mexico (see figure 10). However, when the shares of extreme poor inhabitants in the municipalities' population are analysed, the southeast side of the ZMVM stands out. In contrast, the municipalities in Mexico City present the lower shares of extreme poor within their population (see figure 11).

4.2 Insufficient income and social deficiencies in the ZMVM

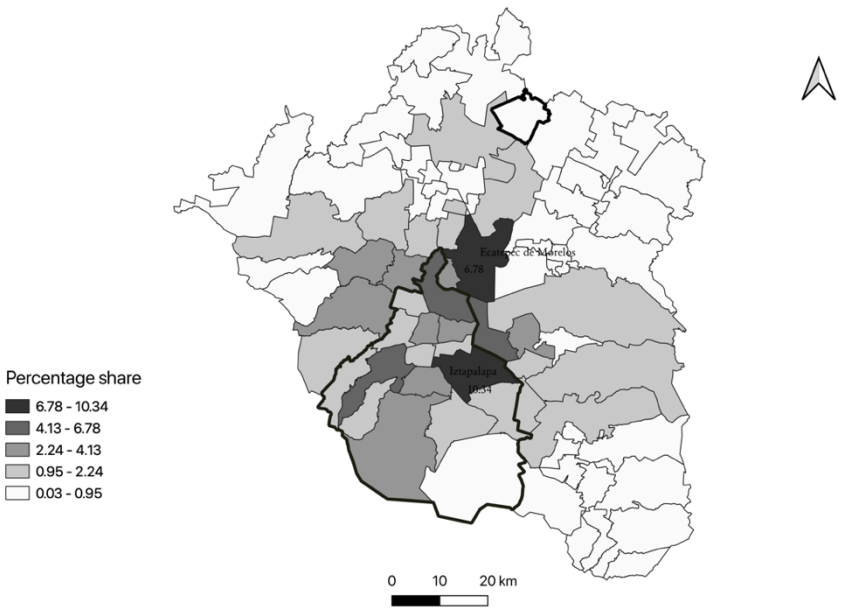
Given that the poverty measurement of this work is multidimensionally composed of social deprivations and an income component, the following maps present separately said components to identify at a more specific level the shortages and income of the ZMVM's inhabitants. This exposition order intends to later delve into the differentiation of the elements related to infrastructure, constituting the social deficiency of *access to basic services in dignified and decent housing*. Thus, the maps below expose the population with income below the income poverty line (see figure 12), and the population with sufficient income and at least one social deficiency also known as vulnerable due to social deficiencies (see figure 13).

Figure 12: Map of distribution shares of ZMVM's population with income below the IPL.



Source: Own elaboration, using data from AGEM-INEGI and CONEVAL. **Note**: Categories refer to the percentages from the total ZMVM's population with income below the Urban Income Poverty Line (2923.29 MXN monthly) concentrated in the municipality during 2015.

Figure 13: Map of distribution shares of ZMVM's vulnerable population due to social deficiencies.



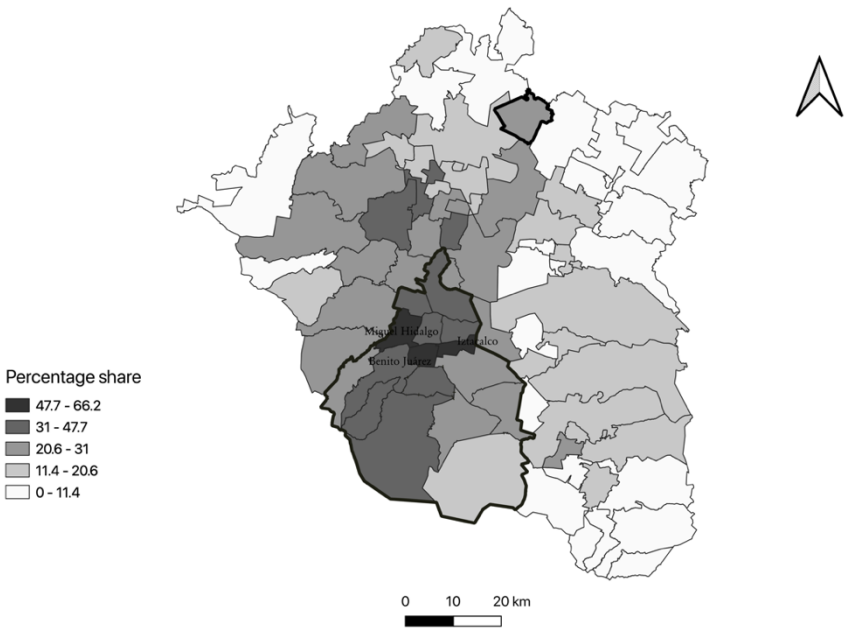
Source: Own elaboration, using data from AGEM-INEGI and CONEVAL. **Note**: Categories refer to the percentages from the total ZMVM's population with at least one social deficiency, but sufficient income, during 2015.

The spatial distribution of the ZMVM's vulnerable population naturally follows the same patterns as the one shown by the poor population; this is not surprising since the poor population is composed of those experiencing social deficiencies and have insufficient incomes. The main municipalities where they concentrate are Ecatepec de Morelos and Iztapalapa (see figure 13).

The significant spatial concentrations of the poor population, characterised by insufficient income and social deficiencies, push towards labelling those municipalities as vessels of the most prominent slums in the ZMVM. Moreover, the location and characteristics of these zones is concomitant with the literature (see figure 12 & figure 13).

Another critical component for comprehending the spatial patterns of the ZMVM's population demands to identify which municipalities have the lowest concentrations of poor and vulnerable people.

Figure 14: Map of municipal non-poor and non-vulnerable share.

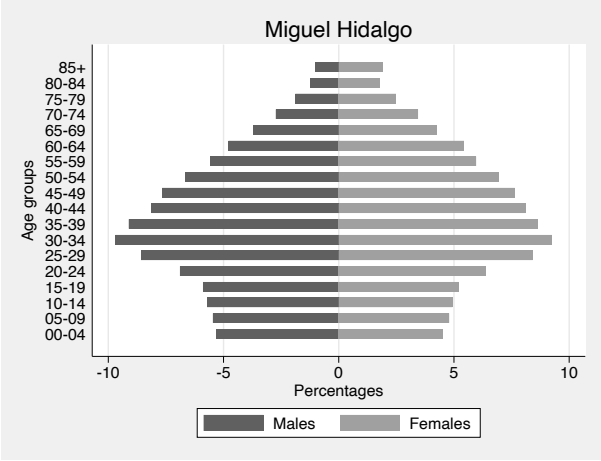


Source: Own elaboration, using data from AGEM-INEGI and CONEVAL. **Note**: Categories refer to the percentage share of non-poor and non-vulnerable inhabitants from the total municipal population during 2015.

The Figure 14 allows us to identify that the municipalities with less poor and vulnerable people are located on the centre and northeast side of Mexico City, without spreading outside its borders. The areas occupied by these municipalities have historically been in the centre of the capital life. The municipalities that stand out for their minimum shares of the poor and vulnerable population are Miguel Hidalgo and Benito Juárez.

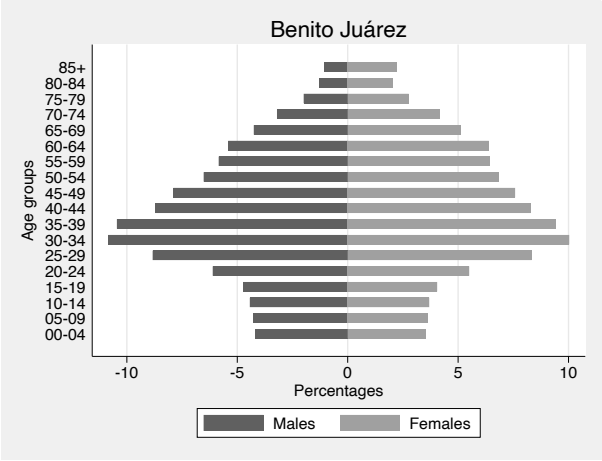
Additionally, the population structure of these two municipalities shows certain particularities, as illustrated below.

Figure 15: Population structure, Miguel Hidalgo.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** The information of this graph corresponds to the year 2020.

Figure 16: Population Structure, Benito Juárez.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** The information of this graph corresponds to the year 2020.

These municipalities exhibit a pronounced demographic transition in which their number of young inhabitants has been progressively decreasing for approximately the last 25 years (see figure 15 & figure 16).

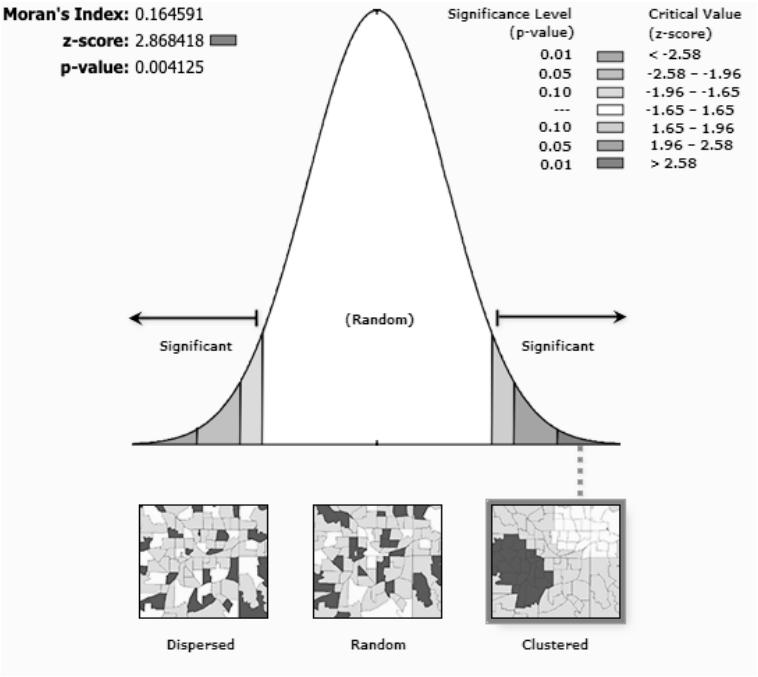
4.3 Infrastructure deprivation in the ZMVM.

Bearing in mind that the deprivation of basic services is a component of poverty, as detailed above, this section analyses and illustrates with maps the spatial patterns of the ZMVM's inhabitants that lack access to water[14], drainage[15], and electricity.

In this regard, a simple assessment of spatial autocorrelation through the Global Moran's I[16] test allows us to evaluate whether or not the municipal values of people lacking access to water, drainage, and electricity, are clustered, random, or dispersed. The null hypothesis is that the patterns are random or that no spatial autocorrelation is present. In the case that a clustered pattern is suggested, it means that closer features tend to have more similar values; if dispersion is suggested, this means that near spatial features tend to have more dissimilar values.

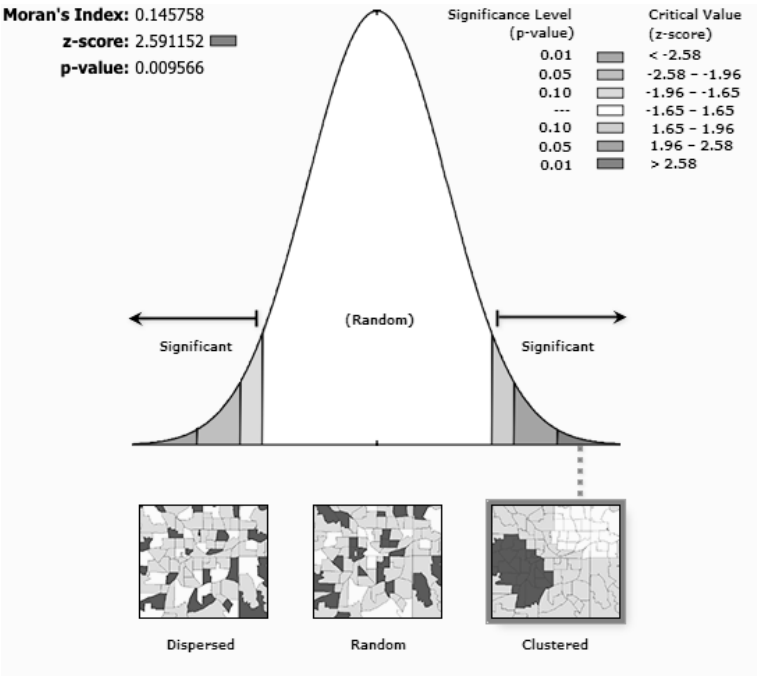
[14] Water is obtained from a well, river, lake, stream, tank truck, or by hauling it from another home, public tap, or hydrant.
[15] They do not have drainage service or drainage connects to a pipe that empties into a river, lake, sea, ravine, or crevasse.
[16] Further information on Moran's I can be consulted on Moran (1950).

Figure 17: Spatial Autocorrelation Report: No access to water.



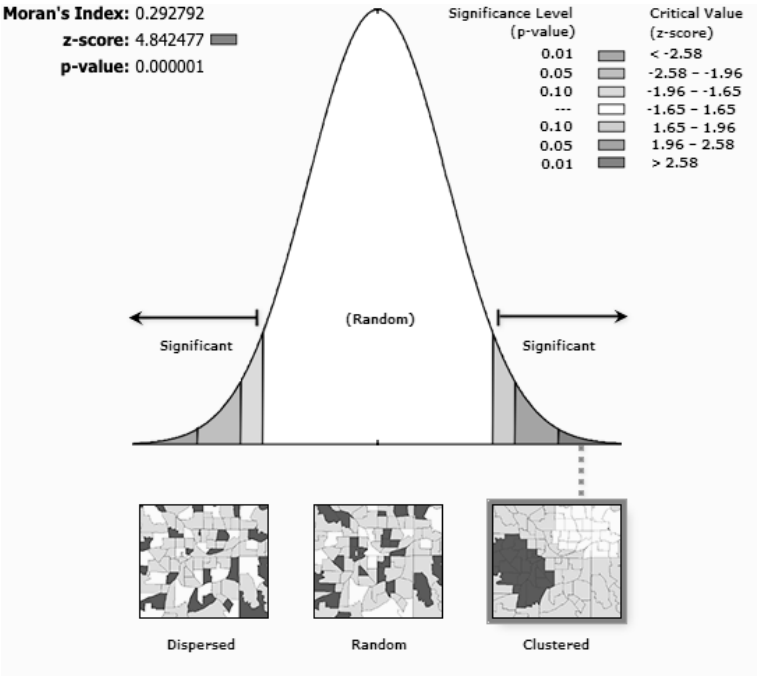
Source: Own elaboration, using data from INEGI (2021). **Note:** Given the z-score of 2.868418, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 18: Spatial Autocorrelation Report: No access to drainage.



Source: Own elaboration, using data from INEGI (2021). **Note:** Given the z-score of 2.591152, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 19: Spatial Autocorrelation Report: No access to electricity.



Source: Own elaboration, using data from INEGI (2021). **Note:** Given the z-score of 4.842477, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

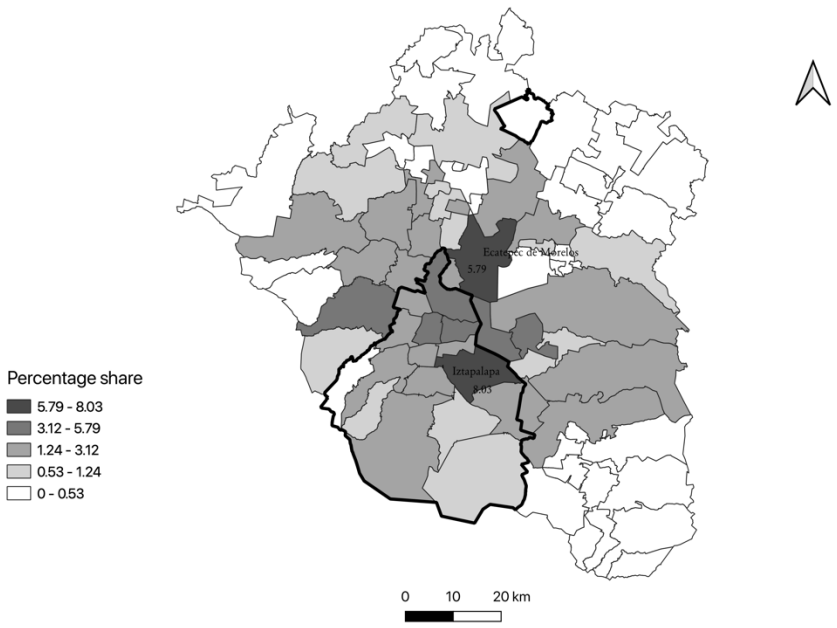
The positive values of the Moran's Index and the significant p-values indicate clustering patterns for each basic service (see figure 17, figure 18, & figure 19). In other words, there is strong evidence against the null that the patterns are random.

Consequently, the maps presented below illustrate the deficiencies in the provision of basic public infrastructure in the municipalities of the ZMVM. Note that the data used in the following maps come from 2020, unlike the other maps presented above, which correspond to 2015[17].

First of all, Figure 20 and Figure 21 reflect the population in premises not built for habitation, mobile home, or shelter. This consideration is done because the people in such situation are considered to be deprived of all basic services.

[17] CONEVAL's measurements of poverty in the municipalities of Mexico 2010-2020 will not be published until December 2021.

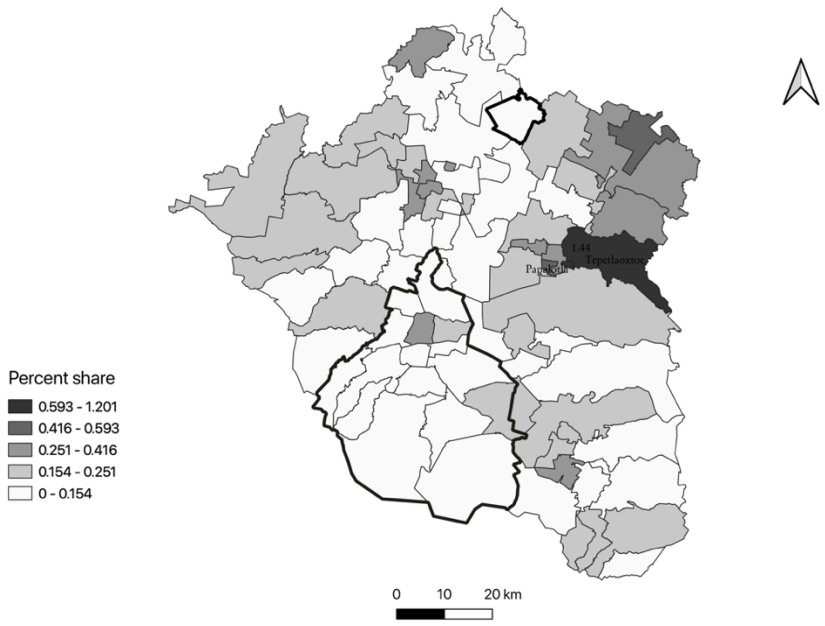
Figure 20: Map of distribution shares of ZMVM's population in premises not built for habitation, mobile home, or shelter.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021) and AGEM-INEGI. **Note**: Categories refer to the percentage shares from the total ZMVM's population in premises not built for habitation, mobile home, or shelter in the municipality during 2020.

Figure 20 illustrates that those inhabitants who live in premises not built for habitation, mobile home, or shelter (i.e., those without access to basic infrastructure) are concentrated mainly in Iztapalapa (Mexico City) and Ecatepec de Morelos (State of Mexico).

Figure 21: Map of municipal share of population in premises not built for habitation, mobile home, or shelter.

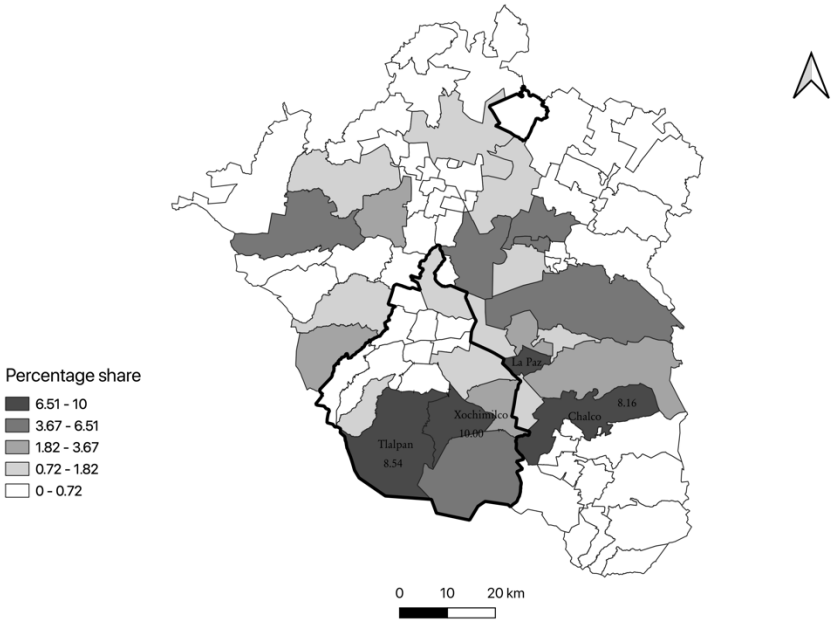


Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021) and AGEM-INEGI. **Note**: Categories refer to the percentage share of population in premises not built for habitation, mobile home, or shelter from the total municipal population, i.d., the proportion of how many municipality inhabitants were living in premises not built for habitation, mobile home, or shelter during 2020.

Nonetheless, the analysis by municipal shares shows that, with the exception for Tepextlaoxtoc, the inhabitants from the ZMVM living in such conditions are below one per cent of each municipal population (see figure 21).

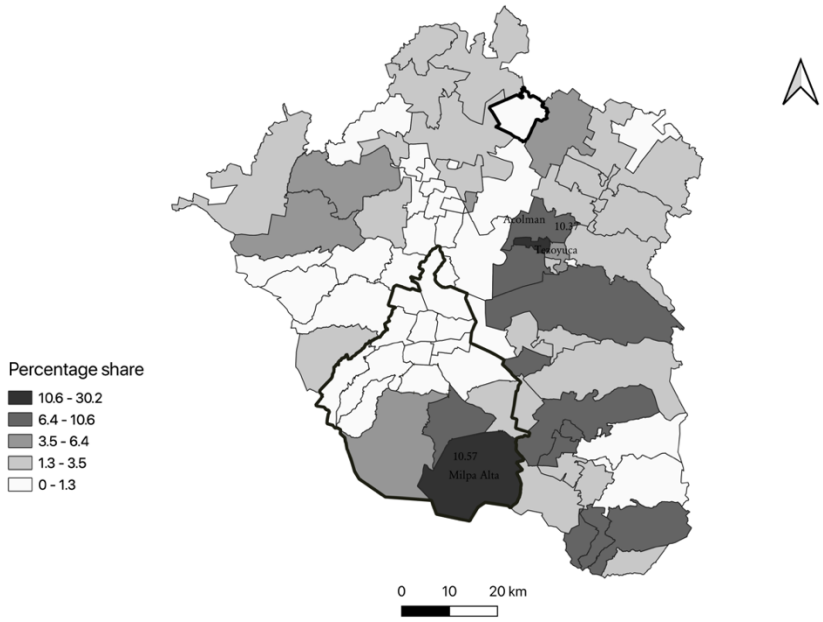
The subsequent analysis of the infrastructure-related deprivations of the population demands to clarify that an individual is considered to be deprived of the access to water when they obtain their water from a well, river, lake, stream, tank truck; or by hauling it from another house or a public hydrant.

Figure 22: Map of distribution shares of ZMVM's population with no piped water from the public network.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021) and AGEM-INEGI. **Note**: Categories refer to the percentage shares from the total ZMVM's population with no access to piped water from the public network in their households concentrated in the municipality during 2020.

Figure 23: Map of municipal share of population with no piped water from the public network.



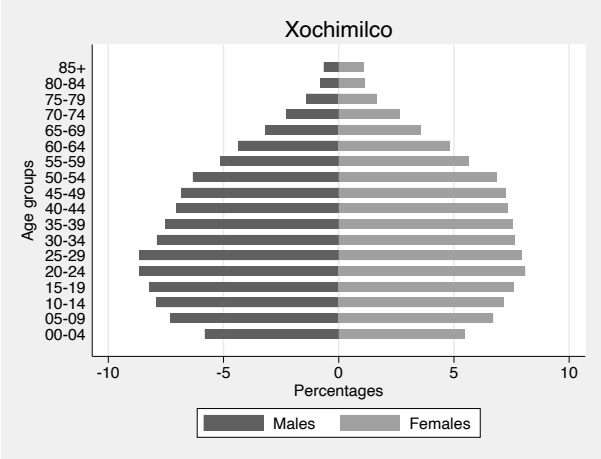
Source: Own elaboration, suing data from National Population and Housing Census 2020 – INEGI (2021). **Note**: Categories refer to the percentage share of population with no access to piped water from the public network in their households from the

total municipal population, i.d., the proportion of how many municipality inhabitants had no access to piped water from the public network in their households during 2020.

Interestingly, the municipalities that agglomerate the most significant numbers of people with no access to piped water from the public network do not coincide with those concentrating most of the poor and vulnerable. Instead, the municipalities that stand out for such deprivation are Xochimilco, Tlalpan, La Paz, and Chalco (see figure 22). This distribution may be a consequence of the geographic settings since those zones used to be important lake basins. Additionally, some municipalities present considerable altitude differences in their terrains, adding extra difficulties in constructing water supply lines; such is the case of Chalco with terrain elevations arising from the proximity to the Sierra Nevada. Regarding the share of municipal population deprived of piped water, Milpa Alta, Acolman, and Tezoyuca stand out (see figure 23).

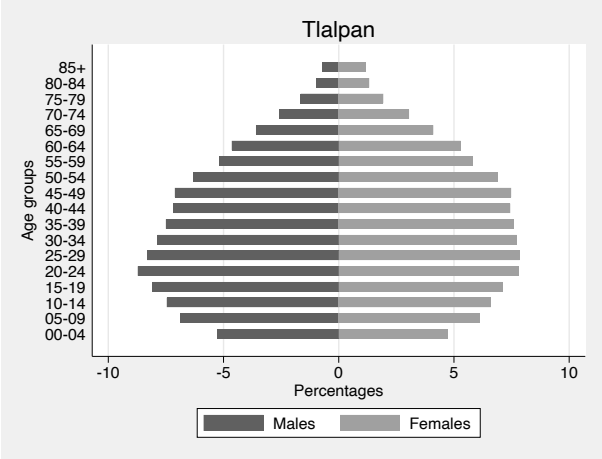
Additionally, the population structure of the municipalities that agglomerate most of the deprived of access to water shows a slightly different tendency depending on the state to which the municipality belongs.

Figure 24: Population structure, Xochimilco.



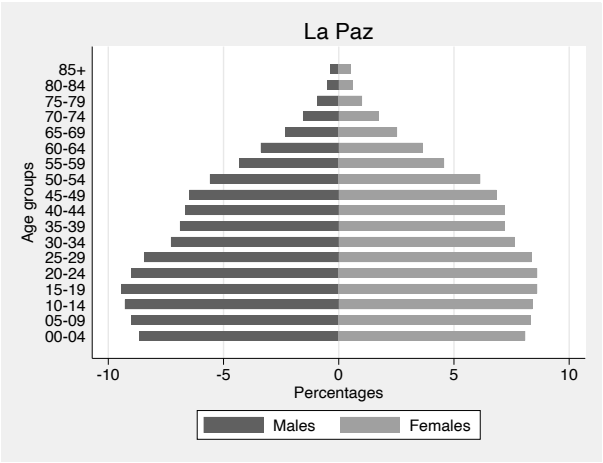
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Xochimilco for the year 2020.

Figure 25: Population structure, Tlalpan.



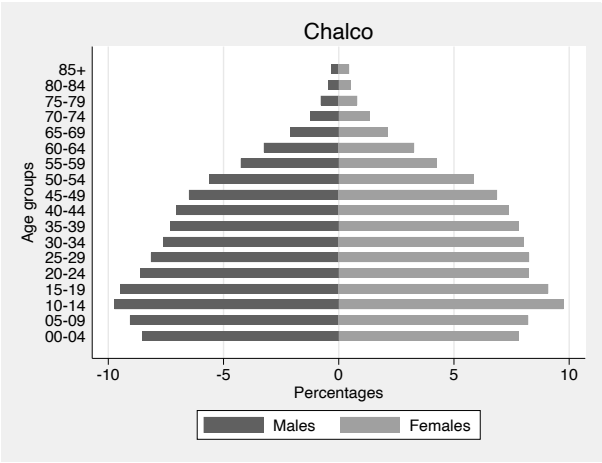
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Tlalpan for the year 2020.

Figure 26: Population structure, La Paz.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of La Paz for the year 2020.

Figure 27: Population structure, Chalco.

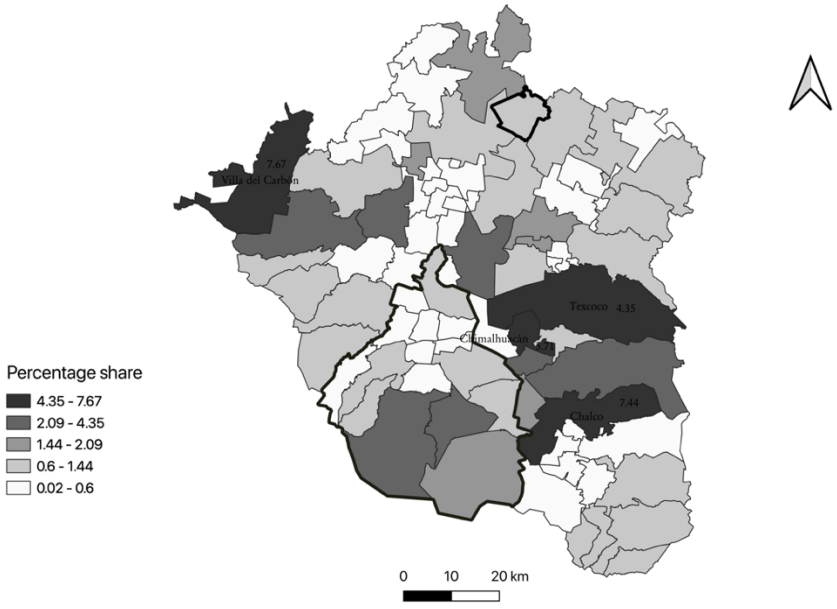


Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Chalco for the year 2020.

Figures 24, 25, 26 & 27 allow noticing a transition in the population structure towards a decrease in the young people taking place in the municipalities from Mexico City; whilst in those belonging to the State of Mexico, the youth decline is not as marked.

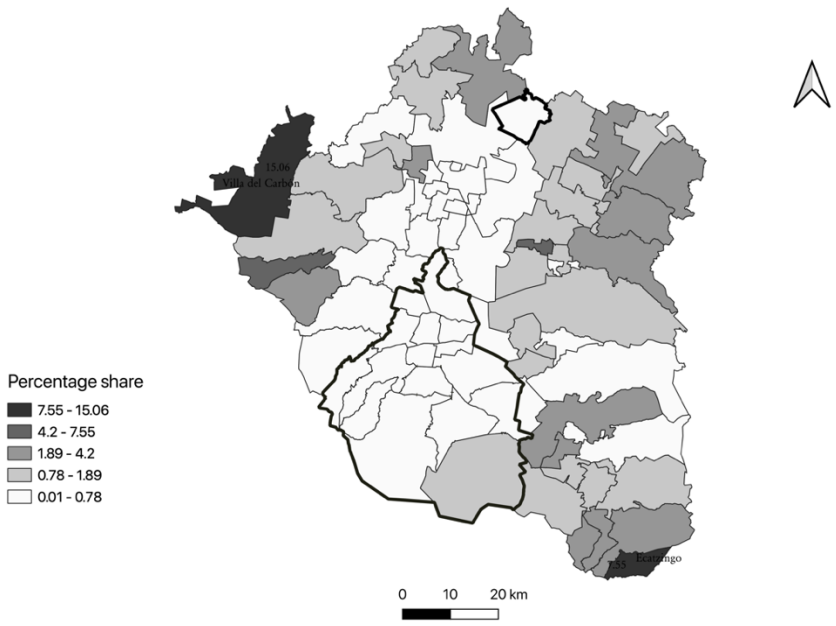
Following, it is analysed the drainage provision; note that a person is consider without drainage service also in the case where drainage connects to a pipe that empties into a river, lake, sea, ravine, or crevasse.

Figure 28: Map of distribution shares of ZMVM's population with no drainage.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021) and AGEM-INEGI. **Note**: Categories refer to the percentage shares from the total ZMVM's population with no drainage in their households concentrated in the municipality during 2020.

Figure 29: Map of municipal share of population with no drainage.

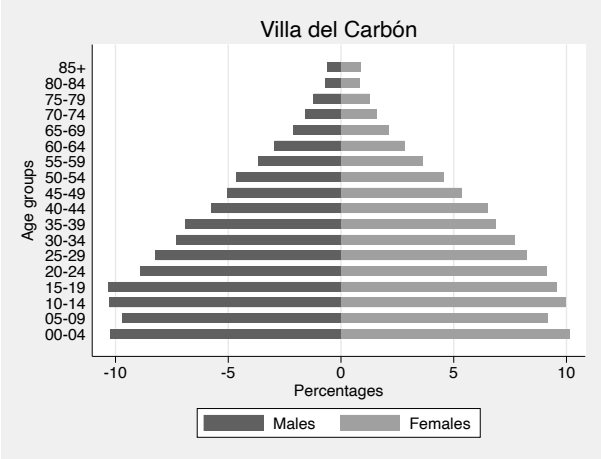


Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021) and AGEM-INEGI. **Note**: Categories refer to the percentage share of population with no drainage from the total municipal population, i.d., the proportion of how many municipality inhabitants had no drainage during 2020.

Once more, the distribution of those with no drainage does not follow the distribution of the poor and vulnerable; instead, they concentrate in Villa del Carbón, Chalco, Chimalhuacán and Texcoco, all municipalities from the State of Mexico (see figure 28). Furthermore, the terrain characteristics may explain the significant shares of the population with no drainage. For instance, there are many rugged areas irregularly distributed throughout Villa del Carbón and formed due to the mountain ranges of Monte Bajo and Tepotzotlán and the Cerro Gordo. Moreover, the municipal share of deprived from drainage stands out Villa del Carbón again, along with Ecatzingo (see figure 29). Additionally, Villa del Carbón and Texcoco exhibit different population structures patterns, in which the population growth of Villa del Carbón is noticeable (see figure 30 & figure 31).

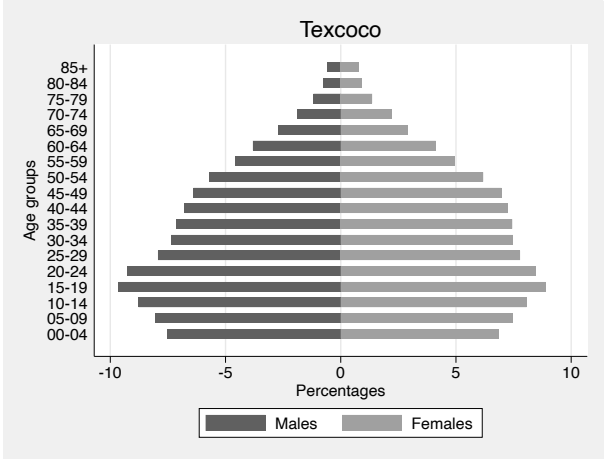
Successively, the distribution of the ZMVM's population deprived of electricity is analysed along with the municipal shares of the population with no electricity in their households concentrated in the municipality during 2020.

Figure 30: Population structure, Villa del Carbón.



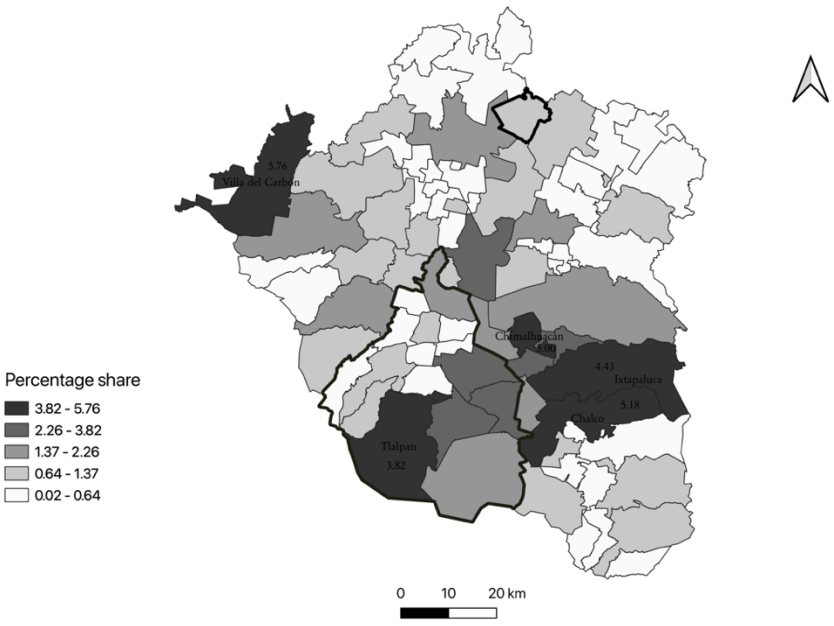
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Villa del Carbón for the year 2020.

Figure 31: Population structure, Texcoco.



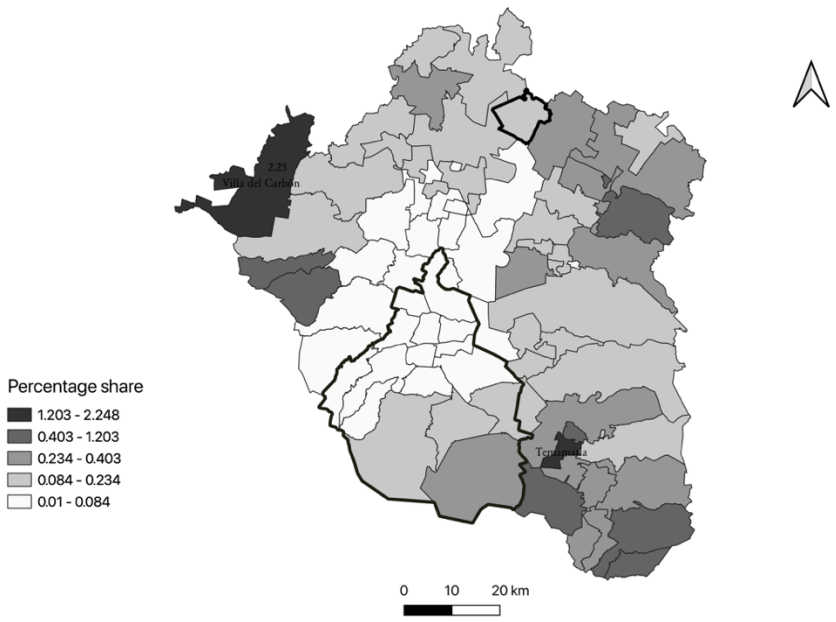
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Texcoco for the year 2020.

Figure 32: Map of distribution shares of ZMVM's population with no electricity.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021) and AGEM-INEGI. **Note**: Categories refer to the percentage shares from the total ZMVM's population with no electricity in their households concentrated in the municipality during 2020.

Figure 33: Map of municipal share of population with no electricity.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021) and AGEM-INEGI. **Note**: Categories refer to the percentage share of population with no electricity from the total municipal population, i.d., the proportion of how many municipality inhabitants had no electricity during 2020.

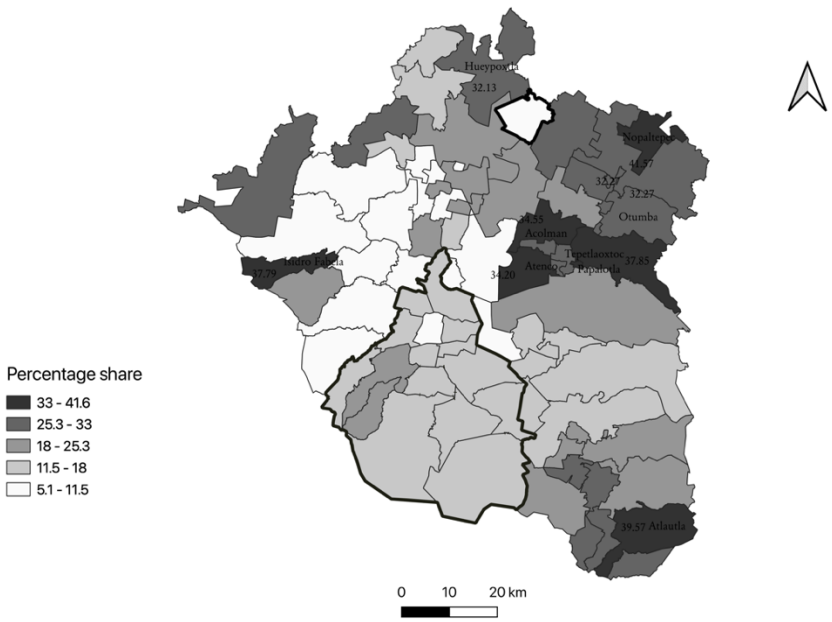
It is possible to observe that those municipalities concentrating the most significant shares of population with no electricity are Villa del Carbón, Chalco, Chimalhuacan, Ixtapaluca and Tlalpan (see figure 32). Nonetheless, the analysis of their share in their municipal population shows that, excluding Villa del Carbón, the people deprived of the access to electricity is less than one percent of each municipality (see figure 33). Consequently, it is possible to state that the provision of electricity has the best coverage in relation to the provision of water and drainage.

Finally, when analysed as a whole, these maps have revealed that the basic infrastructure deficiencies in the ZMVM are, to a greater extent, due to terrain conditions. Additionally, note that those municipalities which concentrate the most densely populated slums in the ZMVM (see figure 12 & figure 13), do not stand out in terms of basic services deprivations. Thus, the deficiencies experienced in the slums must be related to other types of difficulties such as transportation, education, access to health, but not to the provision of basic infrastructure.

4.4 Public infrastructure investment.

This final section presents a set of maps and figures that illustrate the public investment in infrastructure of the ZMVM's municipalities.

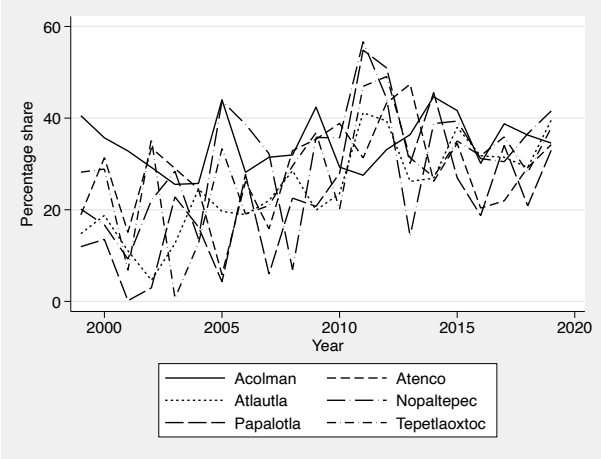
Figure 34: Map of municipal share of infrastructure investment to total expenditure.



Source: Own elaboration, using data from AGEM-INEGI and EFIPEM-INEGI. **Note**: Categories refer to the percentage share of municipal expenditure in *public works in public domain property* to total municipal expenditure, i.d., the proportion of how much money from the total expenditure was destined to infrastructure investment during 2019.

Figure 34 shows that the municipalities located more towards the outskirts of the ZMVM are the ones that destined bigger shares of their municipal budget in public infrastructure investment. This pattern may respond to the fact that those municipalities have experienced substantial population growths during the last decade; however, they are still very unpopulated areas. For instance, the population from Atenco and Acolman have increased by around a third from 2010 to 2020.

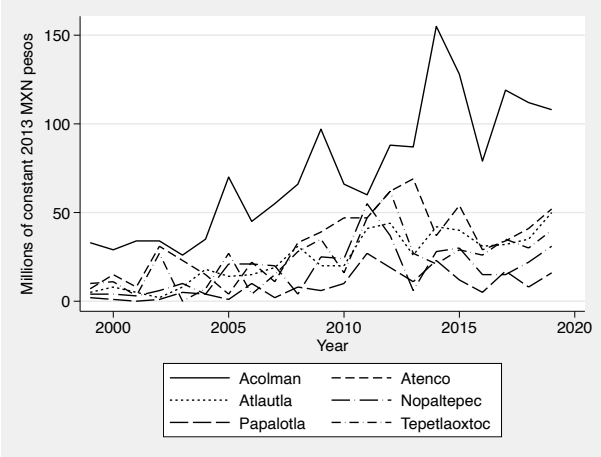
Figure 35: Evolution of municipal public infrastructure investment shares to total expenditure (Acolman, Atenco, Atlautla, Nopaltepec, Papalotla, and Tepetlaoxtoc).



Source: Own elaboration, using data from EFIPEM-INEGI.

Note: The selected municipalities have the highest infrastructure investment shares in relation with their total expenditure from the entire ZMVM. The graph shows the evolution of the municipal expenditure shares in *public works in public domain property* to *total expenditure* across the 21st century.

Figure 36: Evolution of municipal public infrastructure investment in absolute values (Acolman, Atenco, Atlautla, Nopaltepec, Papalotla, and Tepetlaoxtoc).

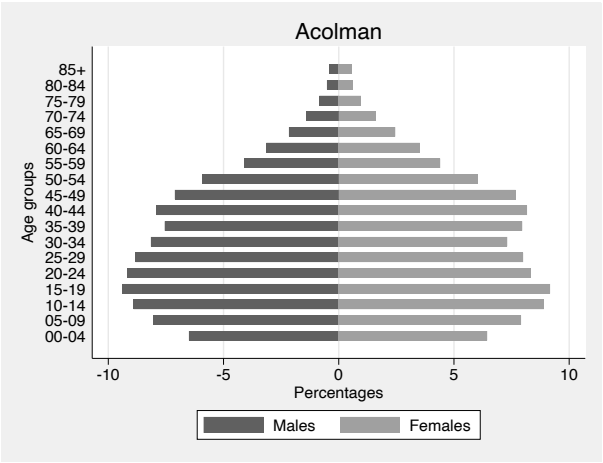


Source: Own elaboration, using data from EFIPEM-INEGI. **Note:** The selected municipalities have the highest infrastructure investment shares in relation with their total expenditure from the entire ZMVM. The graph shows the evolution of the municipal expenditure in *public works in public domain property* across the 21st century, measured in absolute terms in millions of constant 2013 MXN pesos.

When analysed together, the evolution of municipal public infrastructure investment shares to the total expenditure of the municipalities with the biggest shares, it is noticeable that, although with constant variations, the investment levels in these municipalities are revolving between 20 and 40 per cent during the last decade (see figure 35). Additionally, when the expenditure in infrastructure is compared in absolute terms for the same municipalities, Acolman invests the most considerable amount (see figure 36). This investment level can be partially explained because Acolman is more populated than the other mentioned municipalities; ergo, it has a larger budget.

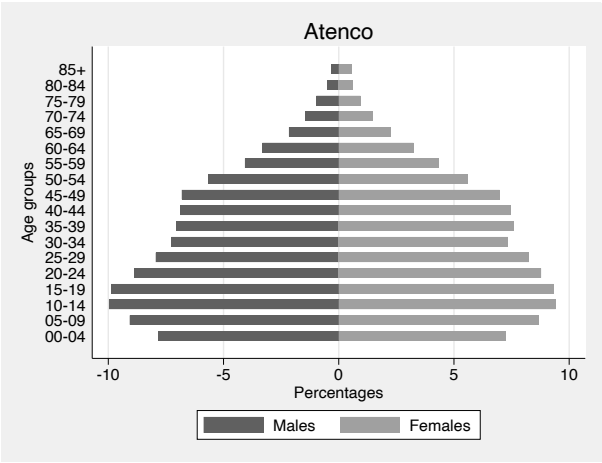
The population structures of these mentioned municipalities can be compared as well to illustrate their growth. Notice that Acolman and Atenco are undergoing a reduction of their young population (see figure 37 & figure 38), while Atlauta, Nopaltepec, Papalotla, and Tepextlaoxtoc exhibit large shares of young inhabitants (see figures 39, 40, 41, & 42).

Figure 37: Population structure, Acolman.



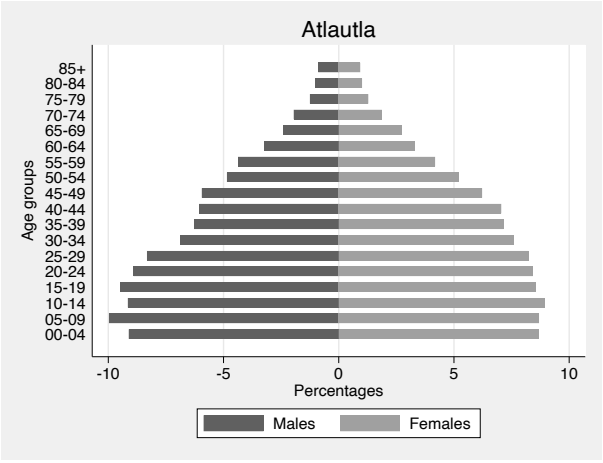
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Acolman for the year 2020.

Figure 38: Population structure, Atenco.



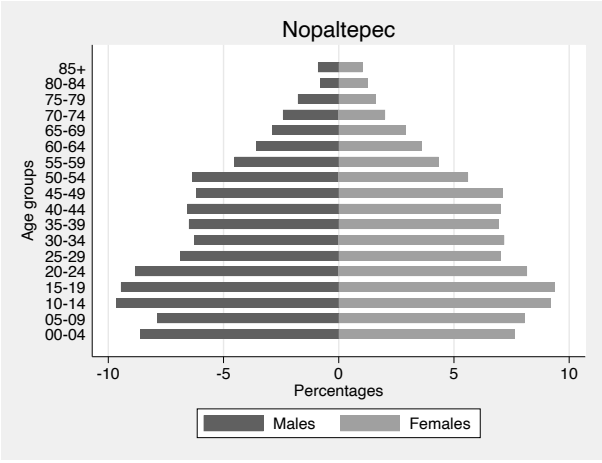
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Atenco for the year 2020.

Figure 39: Population structure, Atlautla.



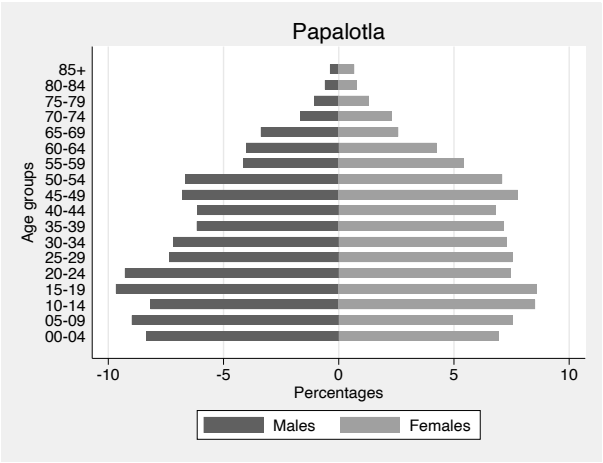
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Atlautla for the year 2020.

Figure 40: Population structure, Nopaltepec.



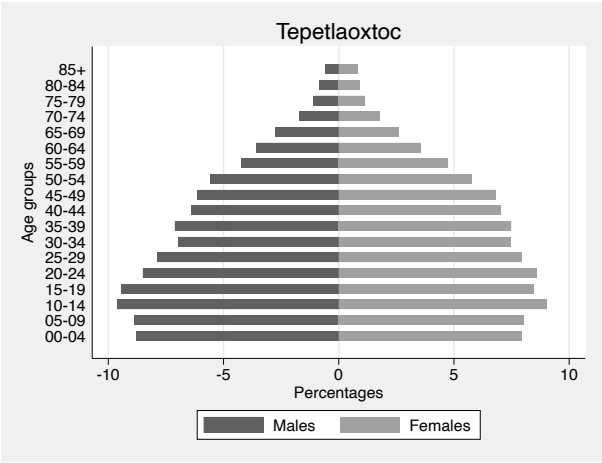
Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Nopaltepec for the year 2020.

Figure 41: Population structure, Papalotla.



Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Papalotla for the year 2020.

Figure 42: Population structure, Tepetlaoxtoc.

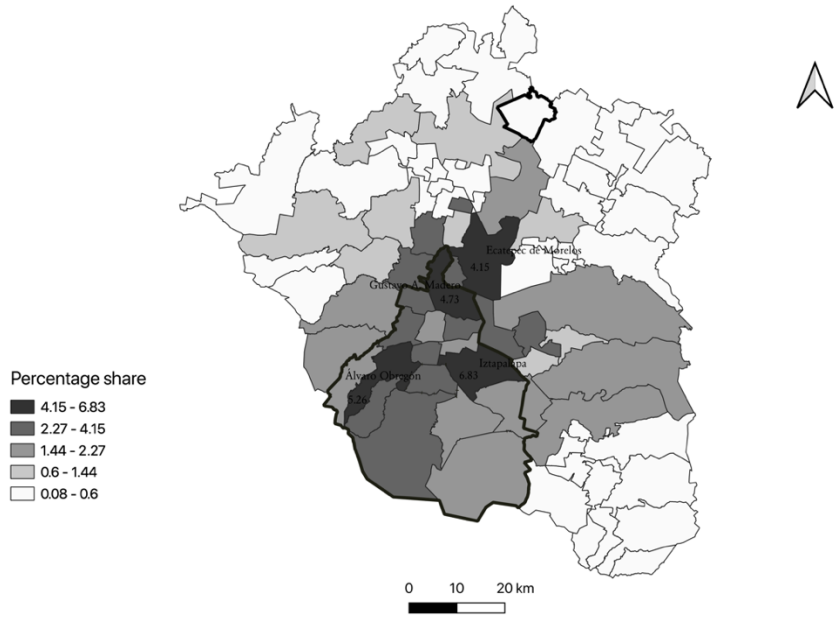


Source: Own elaboration, using data from National Population and Housing Census 2020 - INEGI (2021). **Note:** This graph presents the population structure of Tepetlaoxtoc for the year 2020.

Figures 39, 40, 41, and 42 corroborate the fact that these vaguely populated municipalities are undergoing a growth process; therefore, there is an understandable need to invest large budget shares into the establishment of their basic infrastructure.

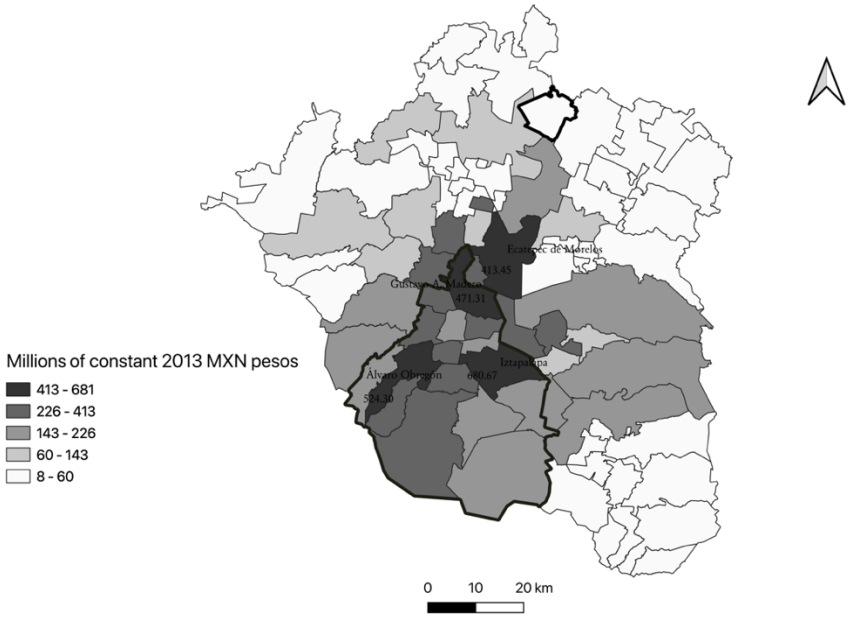
On the other hand, when the total amount of money destined for infrastructure investment by the local governments in the ZMVM is put together, the municipal shares can be analysed accordingly. Thus, it can be noticed that those municipalities with the largest population and budgets are the ones destining more money, in absolute terms, on infrastructure investment (see figure 43 & 44).

Figure 43: Map of municipalities with the largest investment in public infrastructure (shares from ZMVM's total infrastructure investment).



Source: Own elaboration, using data from AGEM-INEGI and EFIPEM-INEGI. **Note**: Categories refer to the percentage shares from the total ZMVM's expenditure in *public works in public domain property* concentrated in the municipality, 2019.

Figure 44: Map of municipalities with the largest investment in public infrastructure (MXN pesos).

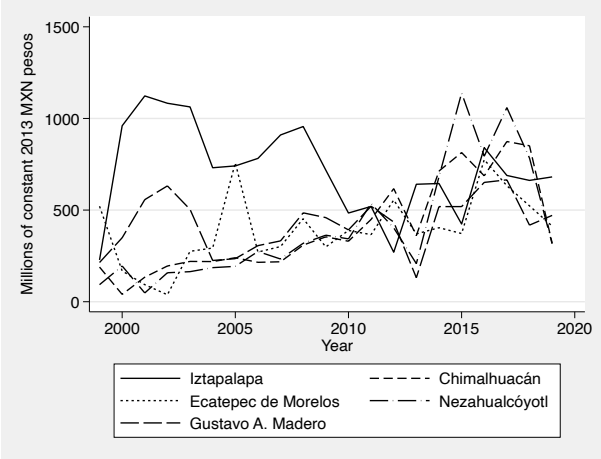


Source: Own elaboration, using data from AGEM-INEGI and EFIPEM-INEGI. **Note**: Categories refer to the municipal expenditure in millions of constant 2013 MXN pesos in *public works in public domain property* during 2019.

Figures 43 and 44 present the same information, visualised either in percentage shares from the ZMVM's municipalities total infrastructure investment or directly in millions of constant 2013 MXN pesos. They reveal that Iztapalapa, Álvaro Obregón, Gustavo A. Madero and Ecatepec de Morelos are the municipalities that invest the most in public infrastructure in absolute terms. Moreover, only Álvaro Obregón exhibit high levels of investment without belonging to the most populated municipalities.

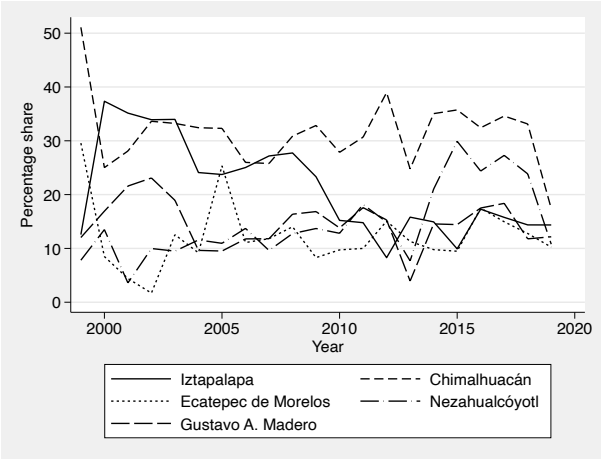
The comparative analysis of the evolution of said investment in these municipalities allows a better comprehension on their tendencies.

Figure 45: Evolution of municipal public infrastructure investment in absolute values (Iztapalapa, Ecatepec de Morelos, Gustavo A. Madero, Chimalhuacán, and Nezahualcóyotl).



Source: Own elaboration, using data from EFIPEM-INEGI. **Note:** The selected municipalities have the highest number of poor inhabitants from the entire ZMVM. The graph shows the evolution of the municipal expenditure in *public works in public domain property* across the 21st century, measured in absolute terms in millions of constant 2013 MXN pesos.

Figure 46: Evolution of municipal public infrastructure investment shares to total expenditure (Iztapalapa, Ecatepec de Morelos, Gustavo A. Madero, Chimalhuacán, and Nezahualcóyotl).



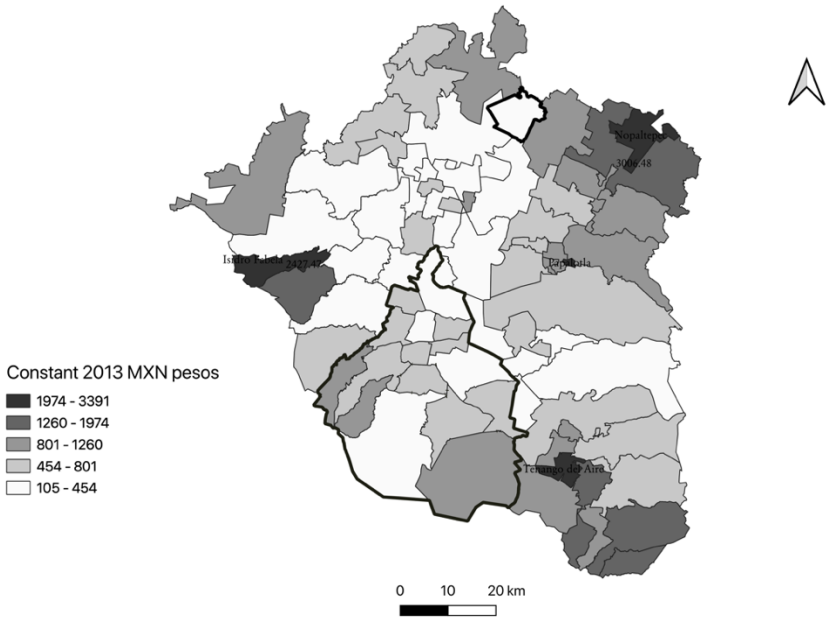
Source: Own elaboration, using data from EFIPEM-INEGI. **Note:** The selected municipalities have the highest number of poor inhabitants from the entire ZMVM. The graph shows the evolution of the municipal expenditure shares in *public works in public domain property* to *total expenditure* across the 21st century.

Figure 44 and Figure 45 help to analyse the municipal investment behaviour in the municipalities that encloses the most prominent slums. In this regard, the decreases in infrastructure investment in

Iztapalapa, both in absolute values and relative to its total expenditure, are noticeable. In contrast, the other municipalities seem to invest in similar proportions as their previous years; thus, exhibiting slight growth in their infrastructure investment through the years.

Additionally, the depiction of the Per Capita investment provides more relevant information on said investment levels.

Figure 47: Map of municipalities' public infrastructure investment per capita.

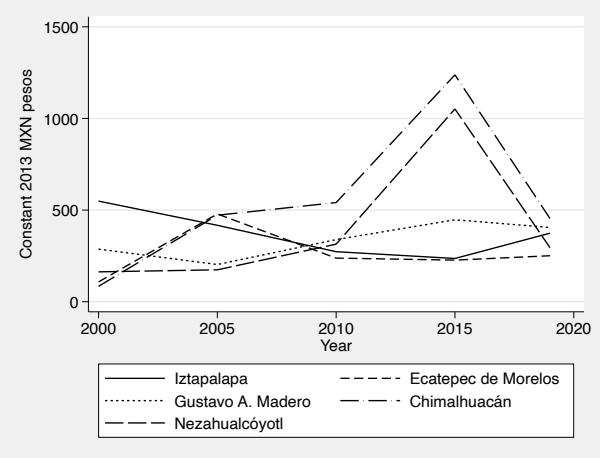


Source: Own elaboration, using data from AGEM-INEGI and EFIPEM-INEGI. **Note**: Categories refer to the municipal expenditure per capita in constant 2013 MXN pesos in *public works in public domain property* during 2019.

Figure 47 reveals that the public infrastructure investment per capita is insufficient in those municipalities where the most prominent slums are located. Such are Iztapalapa's and Ecatepec de Morelos' cases, which, although they exert the largest infrastructure investments in absolute terms (see figure 44), are among those that invest the lowest amounts per capita (see figure 47). On the other hand, those with the most significant investments per capita are lightly populated, although experiencing important population growth rates, and locate towards the bordering limits of the ZMVM (see figure 47)

Furthermore, the evolution of the municipal public infrastructure investment Per Capita is presented for the municipalities concentrating the major slums.

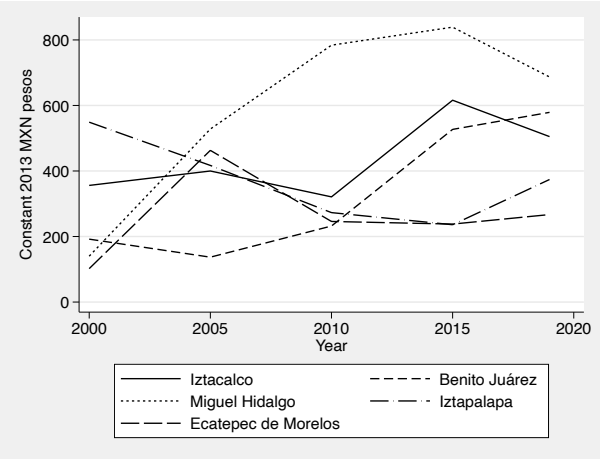
Figure 48: Evolution of municipal public infrastructure investment Per Capita (Iztapalapa, Chimalhuacán, Ecatepec de Morelos, Nezahualcóyotl, and Gustavo A. Madero).



Source: Own elaboration, using data from EFIPEM-INEGI. Note: The selected municipalities have the highest number of poor inhabitants from the entire ZMVM. The graph shows the evolution of the municipal expenditure in *public works in public domain property* per capita across the 21st century, measured in millions of constant 2013 MXN pesos.

Indeed, as stated above, the infrastructure investments measured in per capita levels show to be very scarce, except Chimalhuacán and Nezahualcóyotl (see figure 48). A clearer way to appreciate it is by comparing their per capita investment levels with those municipalities with the least number of poor among their inhabitants.

Figure 49: Evolution of municipal public infrastructure investment Per Capita (Iztacalco, Benito Juárez, Miguel Hidalgo, Iztapalapa, and Ecatepec de Morelos).



Source: Own elaboration, using data from EFIPEM-INEGI. Note: Two of the selected municipalities have the highest number of poor inhabitants from the entire ZMVM (Iztapalapa and Ecatepec de Morelos), while the other three have the lowest numbers of poor inhabitants (Iztacalco, Benito Juárez, and Miguel Hidalgo). The graph shows the evolution of the municipal expenditure in *public works in public domain property* per capita across the 21st century, measured in constant 2013 MXN pesos.

Figure 49 illustrates that the infrastructure investment per capita in the municipalities of Iztapalapa and Ecatepec de Morelos is considerably below the investment exhibited in the municipalities with fewer poor inhabitants. For instance, during the first decade of the 21st century, Iztapalapa's per capita expenditure

in infrastructure investment declined by fifty per cent, only to recover thirty-seven per cent during the second decade. Conversely, the investment of those with the least amount of poor has progressively increased over time.

Finally, although the analysis presented here seems to indicate that municipal investment in public infrastructure is insufficient in those areas that concentrate the largest population and the poor, some forethoughts must be considered. First and foremost, an adequate analysis on this matter should include information at the State government level regarding the allocation of infrastructure expenditure. Yet, the lack of a spatial breakdown of said information prevented its use in this research. Secondly, it is crucial to remark that the investment in monetary terms does not necessarily render quality in the services; the misuse of resources is not unusual for the administrations of the ZMVM. For instance, just as mentioned in the literature review, the availability of water services in a poor neighbourhood in Mexico does not imply that the dwellers can access water every day (Fay & Wellenstein, 2005, 99). Nevertheless, the municipalities encompassing the major slums of the ZMVM do not stand out when the deprivation of access to basic services of their dwellers is evaluated.

5 Conclusions

The previous analysis of the elements of under-investment in infrastructure in Mexican slums was raised on concerns about the limitations of the private sector to address the problems of urban poverty in densely populated areas. Said concern was nurtured by months of experience in seeking financing for basic infrastructure projects in rural areas of Africa through the NGO Travaux Publics Sans Frontières.

This research is based on data that reflects the most recently recorded characteristics and spatial distributions of the poor and deprived population from the Metropolitan Zone of the Valley of Mexico as well as on data concerning the municipal expenditure in public infrastructure during the 21st century. Are the slums' dwellers from the ZMVM suffering deprivations regarding basic infrastructure because of the negligence of their local governments? This does not seem to be the case; nonetheless several aspects must be considered.

First, the ZMVM's growth in the last century has created distribution patterns of its inhabitants, mainly originating from the land's orographic characteristics in which the metropolis sits. The poor population agglomerates in cheap lands that are rugged, irregular, and less suitable for construction; still, they offer the chance to seize opportunities that might arise from the city's proximity. Said areas are mainly located towards the edges of Mexico City, especially to the east, where the provision of certain services, such as the supply of freshwater, presents substantial challenges. On the other hand, the most attractive lands have been historically inhabited by the wealthiest groups of the population. Nonetheless, with the progressive territorial expansion of the population over the years, the periphery has reached remote territories with more challenging conditions for providing adequate services that ensure a dignified life. In this regard, the most prominent slums that now accommodate the largest amount of poor and vulnerable due to social deficiencies are located in Iztapalapa, Ecatepec de Morelos, Gustavo A. Madero, Chimalhuacán, and Nezahualcóyotl.

Secondly, despite said agglomerations, the analysis of the specific deprivations related to basic infrastructure provision and the population growth rates revealed that those municipalities have already

undergone a certain degree of integration into city life. For instance, there is relatively good coverage in the access to electricity, water and drainage system in these municipalities, and their population has been decreasing or just slightly increasing over the past two decades[18]. Nonetheless, it must be noticed that said access only indicates the service's existence and does not expose its quality; for instance, severe flooding and water scarcity issues have been described throughout this work. On the other hand, municipalities with a worse orography, are the ones suffering the largest deprivations of access to water and drainage, while the electricity seems to have a better coverage throughout the ZMVM.

Finally, the analysis of the expenditure in public infrastructure indicates that, although they invest the largest amounts in absolute terms, those municipalities that contain the most prominent slums of the ZMVM are at the bottommost in terms of per capita public infrastructure investment. Moreover, said per capita investment has been shrinking over the 21st century, while those municipalities with the most minor proportion of poor dwellers have steadily increased investment. Additionally, the budgetary shares destined for public infrastructure investment are the highest in some less populated municipalities located near the outer edges of the ZMVM. These municipalities have been absorbing migration influxes and experiencing growing demands for public goods during the last two decades.

Concerning the specific deprivations of the slums' dwellers, most people with social deficiencies agglomerate in municipalities like Iztapalapa and Ecatepec de Morelos. Yet, the majority of those with basic services shortcomings are located in other municipalities. In consequence, said distribution suggests that the job market, the educational backwardness, the access to health services, the social security, and the social cohesion take on more significant roles in affecting quality of life in the slums than the provision of basic services. Therefore, an assertion on the possible existence of government negligence towards basic infrastructure investment in the slums would be ill-founded. Nevertheless, the meagre per capita infrastructure investments in the slums may generate negligible marginal returns compared to other areas. In other words, such massive agglomerations of people demand higher investment levels to facilitate returning benefits. However, further research that breaks down the investment analysis at the neighbourhood level, including what is allocated by the state government, is required. Additionally, a better characterisation of the niches and distribution of the informal market in the ZMVM would add a vital contribution in understanding the slum's depiction and may enhance the guiding of policy interventions.

[18] They still are the most populated areas of the ZMVM.

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