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**Review Article**

# Urban Indicators in the Metropolitan Area of Pachuca, Hidalgo

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**Abstract:** The Metropolitan Area of Pachuca (MAP) is located very close to the Metropolitan Zone of the Valley of Mexico (ZMVM), which occupies a space of 7954 km$^2$ divided in 76 municipalities, with a population close to 20 million people, according to with official estimates, in fact the projections within a period of no more than 10 years, say the ZMVM will become a metacity with Metropolitan Area of Pachuca, Toluca, Puebla and Morelos. Metropolitan Area of Pachuca comprises seven municipalities, in an extension of 120 km$^2$ and has a population of 512,196 inhabitants according to the Census of Population and Housing 2010. Urban environmental problems originated from population and housing growth, have increased in the sense of citizens, however, there are no indicators or an urban observatory, which allows a timely, updated and frequent diagnosis, and with it, to carry out public policies aimed at solving said problems. The present article proposes a series of environmental urban indicators, considering the indicators proposed by the Habitat Sedesol program, Sustainable Development Indicators, Sustainable Seattle Indicators, Indicators of the Global Urban Observatory, among others, but adapting them to the conditions of the MAP.

**Keywords:** Observatories, Urban Policies, Cities, Polution, Index

## 1. Introduction

Actually, indicators, measurements, calculations are made to get a better idea of the magnitude of a phenomenon. Statistics have occupied a space in the work of decision makers, from planning, operation, to transparency and results. However, all this requires a degree of complexity, the development of indexes and indicators requires not only that they be replicable, representative, coherent, accurate, reliable, etc., but also that the population is aware of them and understands the magnitude of their own social problems.

Such is the case of urban indicators, of these we have more than 180 of various types and scales, ranging from transportation, social, economic, environmental, housing, among others.

Since 1970 with the Conference and Declaration of Human Settlements of Vancouver (Habitat I) and the creation of the UN Human Settlements Program, there has been a boost to the creation of information and indicators on urban issues, recognizing that the world was changing and moving towards cities as a way of life. The enormous distortions, disproportion, inequalities, and challenges of cities opened up new debates, urban poverty, environmental pollution, density, transport problems, gender violence, and so on. However, accurate information was needed to make diagnoses more accurately and to make decisions.

## 2. Background

Although social quantifications have a long history, since the Censuses of population more than four thousand years ago in China and Egypt, making their way through the quantification of the economic product, the development of statistics, national and satellite accounts, as well as Several leading indicators, projections and databases, to this must be added the methodology as they are done, either because of the lack of information or - even when it sounds contradictory - by the large amount of information that we face with digitization and The information technologies that have started phenomena such as Big Data.

Today we live in the information age, the technological revolution is changing habits, customs, ways of relating, but also the way of making decisions. Governments use up-to-date information to identify the direction of public policies. Likewise, citizen participation in this sense begins to take greater position within certain decisions and expectations of public life, which is also known as governance. In that sense the Internet, social networks play an important role, so it is, they have come to overthrow presidents or public officials, or change public policies inoperative or affecting the collective interest.

In this sense, several proposals have arisen that aim, on the one hand, to obtain information on different phenomena, on the one hand, and on the other to share this information. Citizen observatories, which involve governments, academia and citizens, are non-profit organizations that have made it possible to bring to light the problems that occur in cities, the economy, security, among others.

They are also an alternate source of information, to official information, where everything seems to be fine. The information from the observatories should be noted that it also uses official sources in some of its indicators, however, its purpose is to create indicators, disseminate them and that citizens participate in conjunction with institutions to propose solutions to the problems they face.

According to Piña G. (1) in 1988, the methodology of urban indicators was established, which served as the basis for the organization of the Global Urban Observatory, which aims to form the World Network of Urban Observatories, to carry out the control And evaluation of the Habitat and Agenda 21 programs.

This system of indicators aims to know the current state of the cities, as well as their urban environmental performance. Within this proposal, 53 cities with 49 basic indicators are grouped together in thematic units. These types of indicators assess urban integration from the political, economic, social and environmental dimensions.

Basic data range from land use, population, growth rate, households, urban per capita product, type of property, household size, among others. While in terms of socioeconomic development, there are urban poverty, jobs, hospital beds, infant mortality, life expectancy, literacy rate, number of school classrooms, crime rate.

As for infrastructure only four indicators, which are connections to supply networks to homes, access to drinking water, water consumption, average price of water. In transport, modal exchange, travel time, infrastructure spending, vehicle fleet. In environmental management, wastewater treatment, generation, collection and treatment of solid waste, destroyed homes. For local government, sources of income, per capita expenses, interest on loans, employees, wages, control of higher levels. In housing, the relationship of housing prices vs. income, rent, per capita area, multiplier of urban development, infrastructure spending, mortgages vs. credits ratio, housing production (see Table 1).

***Table 1.*** *Indicators of the Global Urban Observatory.*

| **Basic information** |
| --- |
| D1. Uses of land. |
| D2. Urban population. |
| D3. Population growth rate. |
| D4. Households headed by women. |
| D5. Average household size. |
| D6. Household creation rate. |
| D7. Distribution of income. |
| D8. Urban product per person. |
| D9. Tenancy of the dwelling. |
| 1. Socioeconomic development. |
| 1: Households below the poverty line. |
| 2: Informal or submerged employment. |
| 3: Hospital beds. |
| 4: Infant mortality. |
| 5: Life expectancy at birth. |
| 6: Adult literacy rate. |
| 7: Schooling rate. |
| 8: Classrooms. |
| 9: Crime rate. |
| 2. Infrastructures. |
| 10: Connections to the supply networks of houses. |
| 11: Access to drinking water. |
| 12: Water consumption. |
| 13: Average water price. |
| 3. Transports. |
| 14: Modal exchange. |
| 15: Travel time. |
| 16: Expenditure on road infrastructure. |
| 17: Car park. |
| 4. Environmental management. |
| 18: Wastewater treatment. |
| 19: Solid waste generation. |
| 20: Treatment of solid waste. |
| 21: Regular collection of solid waste |
| 22: Dwellings destroyed. |
| 5. Local government. |
| 23: Main sources of income. |
| 24: Per capita expenditure. |
| 25: Interest on loans. |
| 26: Employees in local administration. |
| 27: Wage budget chapter |
| 28: Recurrent contractual expenditure rate. |
| 29: Administrative departments that provide services. |
| 30: Control of higher levels of government. |
| 6. Housing. |
| 31: Relationship between the price of housing and income. |
| 32: Rentals in relation to income. |
| 33: Surface of housing per person. |
| 34: Structures and permanent supplies. |
| 35: Housing for rent. |
| 36: Multiplier of urban development. |
| 37: Infrastructure expenditure. |
| 38: Relationship between mortgages and total loans. |
| 39: Housing production. |
| 40: Investment in housing. |

Source: Conferencia de Naciones Unidas sobre Asentamientos Humanos (UNCHS, Hábitat 1997).

### *2.1. Criteria for the Indicators*

Some criteria for the elaboration and publication of indicators (2), as well as the experience acquired in the elaboration of these indicators, since it is not only Present numbers and quantities, but provide clear, accurate and accurate information, and also be disseminated so that the population is aware.

a Relevance.- Relevance serves to select or select the indicator among a number of similar indicators that can provide information on a particular phenomenon. In that sense, relevance analyzes and identifies the problem, and according to available information, the most representative one is selected. It is important to note that this criterion leads us to make a precise analysis of the problem in question. To give an example, in the case, of the problem of the transport in a city could be measured from different perspectives and methodologies, like vehicular park, number of people that travel in public transport, time of travels, expense in transport, number of accidents, etc. The information that will be selected will be determinant in the measurement and dimension of the problem of the transport, a selection sezgada can take to have a bad diagnosis or not to be pertinent.

b Availability of information.- This is often a problem that faces the moment of designing an indicator, the lack of information or its availability to access by the population. There are indicators in the theory that could solve a large number of public policy problems if they will be available, however, not all information is available, or even exists. The degree of information depends on each country, region, its legal frameworks, its offices of statistics, the level of statistical development and openness to information, among many other things.

c Credibility and reliability.- The development of indicators has as a characteristic that the methodology and the quality of the information are reliable, a sample case could be the measurement of inflation through the National Index of Consumer Prices, the reliability of the indicator does not Depends only on its correct methodology, but also on reliable and representative information, a measure of inflation that does not reflect the real situation of consumer prices loses reliability.

d Prediction ability.- An indicator should help prevent situations or serious complications of a given phenomenon, so that they can be useful for monitoring, for public policies, for promoting or investing, or for carrying out actions and projects. This is also clear from the constant elaboration of the indicator for different time intervals to generate historical series, which allows to know the trends that it has in the short term.

e Demonstrable or verifiable.- The methodology of the indicator and the information used must be available, so that the user can verify the reliability and credibility of these.

f Reproducibles.- The indicators according to their methodology must be reproducible, both by the users and by the institution that made them. An indicator that has only been done once, because of the nature of the information is not very useful, such is the case of some indicators that use surveys, censuses, but that could not be obtained again.

g Comparability.- The comparability of indicators is given both in the methodology and in the information used that are similar, to have comparative ranges between periods, regions, countries, segments, and so on.

h Representativity.- An indicator is not only sufficient to be relevant but must also be representative of a problem, region, sector, and so on. An example of this is GDP per capita, which if there is a large polarity in income, this is not representative of the population in general, high proportions will appear while a large part of the population is in poverty.

i Accurate.- The management of the information and the statistical tools, contributes to that the indicator is calculated with precision. Even though this part sounds simple, it does not always work like this, there are many methods and statistical tools and data management, however, you have to find the most appropriate.

Another type of more relevant indicators for sustainable urban development are those proposed for Sustainable European Cities (see Table 2), which are more precise and representative, which are divided into mandatory and voluntary, measuring from the opinion of the citizens Their satisfaction with the local community, local contributions to climate change, local mobility and passenger transport, green spaces and public services, air quality, moving children from home to school, local sustainable management, noise pollution, sustainable use Of the soil and products that promote sustainability.

***Table 2.*** *Indicators of Sustainable European Cities.*

| **Mandatory** |
|---|
| 1. Satisfaction of citizens with the local community. |
| 2. Local contribution to global climate change. |
| 3. Local mobility and passenger transport |
| 4. Existence of public green areas and local services. |
| 5. Air quality in the locality. |
| Volunteers |
| 6. Displacement of children between home and school. |
| 7. Sustainable management of local authority and local enterprises. |
| 8. Sound pollution. |
| 9. Sustainable land use. |
| 10. Products that promote sustainability |

Source: Conferencia de Naciones Unidas sobre Asentamientos Humanos (UNCHS, Hábitat) (1997).

By comparing the indicators of the IOUG with those of the ICES, we can see that the first ones try to be more a compilation of statistics and information for the urban observatories, this is basic information that must be counted to analyze the problems of the Urbes, as well as being a long list, since this type of indicators is also a proposal for all countries, large or small, with little or much information.

While in the case of ICES they are much more compact and focused on the main problems of the cities. Another characteristic of an indicator is that it must summarize and reflect information of one or several problems in a single number, whereas in the case of statistics we observe large amounts of information, with the indicators we will observe less numbers that summarize large amounts of information.

Just measuring the degree of satisfaction of citizens represents an enormous complexity, both theoretical and statistical, however, achieving a good indicator that is representative and accurate contributes to other types of measurements such as competitive cities, better cities to live, Which serves to attract capital.

We also note that the five mandatory indicators are representative of important current problems, such as quality of life, the second, climate change, this second indicator speaks especially of the actions taken to adapt to climate change and reduce greenhouse gas emissions greenhouse.

Climate change represents one of the greatest challenges of mankind according to the research of various scientific groups, but not only that, but also integrates a series of environmental issues around it, such as deforestation, emissions, use of renewable energy, Water management, natural disasters, etc., represents a complex issue, however, local actions and contributions are decisive in the quality of a city.

Similarly, the mobility and transportation of passengers, green spaces and local services within reach of all, and air quality.

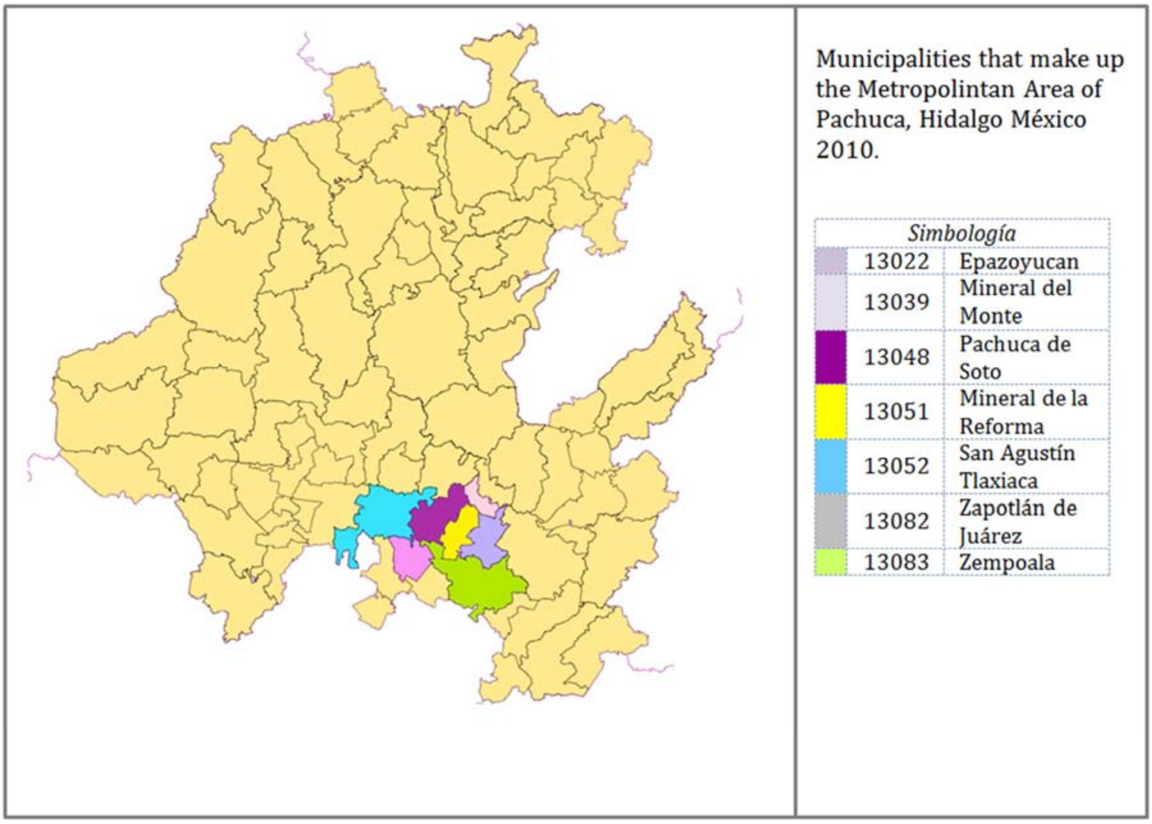
### *2.2. The Metropolitan Area of Pachuca*

In the 1970s the conditions for the urban development of Pachuca were established, consolidating it as a regional economic center, particularly for public administration and services. In 1980, was happen the greatest population growth, mainly due to the growing demand for housing; This real estate demand has favored the mass production of housing of social interest; Causing an uncontrolled urban growth that includes other neighboring municipalities, due to the lack of available land for housing complexes of social interest.

Since the nineties, the expansion of the city of Pachuca has undergone a process of conurbation with the municipality of Mineral de la Reforma, transforming itself into what was called the Urban Agglomeration of Pachuca. The expansion of the urban spot has led to an increase in population and its consequent commercial and service activities. Pachuca, has the status of central city, is the seat of the public administration and some federal representations that are based there, a condition that is underlined given its nature of state capital.

It is defined as a metropolitan area the set of two or more municipalities where a city of 50 thousand or more is located (3) originally contained it, incorporating as part of itself or its area of direct influence To neighboring municipalities, predominantly urban, with which maintains a high degree of socioeconomic integration (4).

Under this criterion the MAP was integrated by the municipalities of Epazoyucan, Mineral del Monte, Pachuca de Soto, Mineral de la Reforma, San Agustín Tlaxiaca, Zapotlán de Juárez and Zempoala (figure 1). The legal recognition of the MAP was published on June 18, 2008, in the Official State Journal, along with the Metropolitan Area of Tulancingo and Tula (5). According to the declaration of Metropolitan Zones 2010, Pachuca and Mineral de la Reforma are central cities. Together they represent 22% of the total area of the municipalities, which is 120,160.86 hectares (Table 3).




Source: Piña G. 2014 Marco Geoestadístico Municipal INEGI 2010.

***Figure 1.*** *Metropolitan Area of Pachuca, Geographical Delimitation.*

***Table 3.*** *Total Area per municipality.*

| Code | Municipality | Surface | Percentage |
|---|---|---|---|
| 13022 | Epazoyucan | 13,906.96 | 11.6 |
| 13039 | Mineral del Monte | 5,397.57 | 4.5 |
| 13048 | Pachuca de Soto | 16,373.45 | 13.6 |
| 13051 | Mineral de la Reforma | 10,587.27 | 8.8 |
| 13052 | San Agustín Tlaxiaca | 30,208.67 | 25.1 |
| 13082 | Zapotlán de Juárez | 11,709.13 | 9.7 |
| 13083 | Zempoala | 31,977.79 | 26.6 |
| Total | Metropolitan Area of Pachuca | 120,160.86 | 100 |

Source: Census of Population and Housing 2000 and 2010, INEGI

The MAP, according to the Population and Housing Count 2010, housed 512,196 inhabitants, of which Pachuca and Mineral de la Reforma account for 77% of the total population, while the municipalities with the lowest percentage of population are Mineral del Monte and Epazoyucan With 3%.

In this sense the weight of the municipality of Mineral de la Reforma has grown with the real estate development and redistribution of the City of Pachuca and its Conurbation Zone. In the case of Mineral of the Reformation for the year of 1980 only had a population of 7,142 inhabitants; While for 2005, the population amounted to 68,704 inhabitants, it was only twenty-five years for demographically growing almost ten times; While for 2010, this figure reached 127 404 inhabitants.

On the other hand, the municipality of Pachuca had a maximum of growth in 2005 with 275,578 inhabitants, however, in 2010 there was a reduction of 7,716 inhabitants, which probably have migrated to the neighboring municipalities, among them Mineral de The Reform (Table 4).

***Table 4.*** *Total population by municipality, 2000, 2005 and 2010.*

| Code | Municipality | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| 13022 | Epazoyucan | 11,054 | 11,522 | 13,830 |
| 13039 | Mineral del Monte | 12,885 | 11,944 | 13,864 |
| 13048 | Pachuca de Soto | 245,208 | 275,578 | 267,862 |
| 13051 | Mineral de la Reforma | 42,223 | 68,704 | 127,404 |
| 13052 | San Agustín Tlaxiaca | 24,248 | 27,118 | 32,057 |
| 13082 | Zapotlán de Juárez | 14,888 | 16,493 | 18,036 |
| 13083 | Zempoala | 24,516 | 27,333 | 39,143 |
| Total | Metropolitan Area of Pachuca | 375,022 | 438,692 | 512,196 |

Source: Census of Population and Housing 2000 and 2010, and Population count 2005, INEGI

## 3. Sustainable Urban Development Indicators

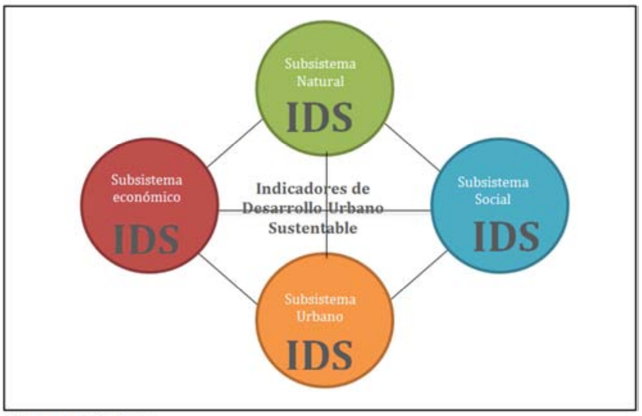
To know better a city, it is necessary to have instruments that can establish parameters that make possible the recognition of its problems; These instruments must be easy to apply and accessible, as well as functioning at different levels of social organization (social, political, academic, etc.).

An urban indicator is a tool that allows comparisons in time and space over a specific area or area; Provide a perspective or knowledge of relevant or priority aspects of social reality. In this way sustainability is interrelated conceptualizing the problem, then seeks the development of public policies to solve it and finally its application; With this procedure, the analysis and measurement of sustainability is materialized through the use of indicators (6).

The methodology for the elaboration of Sustainable Urban Development Indicators applied to the MZP had different stages, however, the concept of sustainable urban development is an essential part of these indicators and of a model to which it aspires as a city.

It can be said that urban sustainability and its indicators have been aimed at satisfiers of the population in urban localities, where in general terms the dimensions of society, economy and the environment and their different interrelations are analyzed (7).

Starting from the basis of the three dimensions of sustainability and its relation to urban development, it is necessary to integrate the element that takes them into account to achieve equilibrium, with one more edge: the urban; Giving rise to the four dimensions of sustainability, according to this research: natural subsystem, economic, social and urban Figure 2.




Fuente: Piña G. (2014)

***Figure 2.*** *Dimensions for the construction of Indicators of Sustainable Urban Development.*

A first stage has to do with the identification of the basic problems of the MAP, with which a diagnosis was made through various statistics at the municipal level. Once identified the main problems of the MAP, we continued the investigation of various indicators and similar case studies as we pointed out at the beginning, by different institutions, both internationally and nationally.

Within the sources of availability of information to feed the indicators proposal, the General Population and Housing Census for 2010, the General Population and Housing Count of 2005, prepared by INEGI, can be found, however in some cases The information they provided was not sufficient, so there was a need to investigate other information tools of INEGI, such as Letters of Land Use and Vegetation years 2005 and 2010, System for Consultation of Historical Statistics of Mexico and SIMBAD.

Other information providers included the Mexican Institute of Competitiveness (IMCO), the Secretary of Environment and Natural Resources (SEMARNAT), the State Institute of

Ecology of the State of Hidalgo, the Municipal Institute of Research and Planning, Development Plans Urban of Pachuca of the years 2009 and 2012 and the Plan of Urban Development and Territorial Ordering of the ZMP, among others.

With the available information, it was analyzed statistically and structurally, comparing it with the variables that were raised in a beginning according to the diagnosis. Note that we were working different things at the same time, on the one hand theoretical concepts, which are fundamental to raise and to understand a complex problem as the city, on the other hand, the part of the availability of information, its sources, quality of Information, comparability, etc., on the other hand the data themselves, which do not give an idea of the impact or size of the phenomenon under study, and finally, the case studies or experiences as well as the indicators developed by them.

This process had as main objective, to make a proposal of Indicators of Sustainable Urban Development for the MAP (see Table 5). As a result of the research, we obtained 24 indicators divided into four dimensions that seek to cover the urban reality, under subsystems which consist of:

a) Natural-Environmental Subsystem. It includes those variables related to the physical and environmental dimension of the urban space, as well as their relationship in ecological terms with other ecosystems.
b) Urban subsystem. It considers characteristics such as housing, the distribution of land uses, etc. Framed in what can be called design and urban structure.
c) Social subsystem. This dimension encompasses aspects related to the population and its characterization, along with others of a social nature.
d) Economic subsystem. Where the classic elements of socio-economic analysis, such as economic activity, wages and employment, are integrated into the local sphere.

***Table 5.*** *Indicators of Sustainable Urban Development for the MAP.*

| Natural System | Economic System | Social System | Urban System |
|---|---|---|---|
| Urban land growth | Economic units | Population growth rate | Urban population density |
| Protected Natural Areas | Staff and salaries | Child mortality | Number of private urban dwellings |
| Environment Actions | Minimun Wage | Child survival rate | Quality of housing |
| Urban green areas | Economically active population | Health index | Quality housing Index |
| Loss of green areas | | Units of health per inhabitant | Urban habitability |
| | | Health rights holders | Building density |
| | | Average degree of schooling | Vehicular park rate of change |
| | | Alphabetization rate | Public trasport rate of change |
| | | School enrollment | |
| | | Population with professional and postgraduate studies | |

Source: Own elaboration

### *3.1. Indicators of the Natural Subsystem*

For the elaboration of an indicator that provides environmental information, a series of indicators were constructed that contain associated data on aspects of change in the soil conditions in the territory.

#### *3.1.1. Urban Soil Growth*

This indicator allows an analysis of the growth of the urban spot in each municipality, due to different factors such as population growth, economic growth and the intensification of anthropogenic activities in the natural environment. This change indicates the expansion of urban land at the expense of other types of land such as agricultural or forestry, due to the impact of real estate or urban projects that promote the development of localities by transforming the territory and serving as a basis for The identification of problems related to urban sustainability.

The calculation of this indicator is based on the following formula:

$$TCSU = \frac{AU_2 - AU_1}{AU_1} x100 . \quad (1)$$

$C.\ S.\ U$ = Rate growth of urban land
$A.U_1$ = Initial urban area in the reference period
$A.U_2$ = Final urban area in the reference period

In addition to obtaining the rate of change in urban land use, with the database constructed, the annualized rate can be obtained, in addition to the percentage of urban territory represented by the MPZ and the municipalities that comprise it. This calculation can be applied on the previous formula, dividing between five that are the number of years that make up the period of study.

The information to build the database comes from INEGI, from the document Land Uses and Vegetation of the year 2005 (Table 6).

***Table 6.*** *Rate growth of urban land.*

| Code | Municipality | Surface | Urban Areas Percentage 2005 | Urban Areas Percentage 2010 | Urban Land Rate Change |
|---|---|---|---|---|---|
| 13022 | Epazoyucan | 13,906.96 | 0.85 | 1.56 | 83.90 |
| 13039 | Mineral del Monte | 5,397.57 | 3.39 | 9.15 | 169.95 |
| 13048 | Pachuca de Soto | 16,373.45 | 22.44 | 42.42 | 89.01 |
| 13051 | Mineral de la Reforma | 10,587.27 | 7.75 | 25.96 | 235.12 |
| 13052 | San Agustín Tlaxiaca | 30,208.67 | 0.43 | 5.92 | 1,247.62 |
| 13082 | Zapotlán de Juárez | 11,709.13 | 2.23 | 10.99 | 393.10 |
| 13083 | Zempoala | 31,977.79 | 0 | 4.44 | ND |
| Total | Metropolitan Area of Pachuca | 120,160.86 | 4.32 | 12.40 | 187.26 |

Source: Land use and vegetation chart 2005 and 2010, INEGI

With the above, it can be observed that the MAP has an exchange rate in the period from 2005 to 2010 of 187.26 per cent as a whole, while it has a percentage of urban areas of 4.32% for 2005 and 12.40% for 2010, and an annualized urban land growth rate of 37.45 percent; Which indicates a change in the use of accelerated urban land, coupled with this when reviewing the data of the municipalities by individually observed disparity in each one of them.

For example, the highest rate of change is for San Agustín Tlaxiaca with 1274.62%, but a percentage of urban areas of 5.92% in 2010, this is explained given the urban growth of the town of San Juan Tilcuautla, which today In the day it houses different educational services, government and houses type of average residential interest. This places this community as a potential subcenter of development that generates an urban location outside the municipal head, which was the one that had the urban category.

The lowest rate of change is for Epazoyucan with 83.90%, municipality that also has the lowest percentage of urban areas with 1.56% for 2010, this data allows to understand that the growth of this municipality is not accelerated given their geographical conditions and The presence of forest areas such as "El Guajolote", territory that empowers the municipality to continue and promote the declaration of areas of environmental protection.

Pachuca de Soto, is the second lowest rate of urban land use change with 89.01%, due to the expansion and urban growth of the city has reached its limit, surpassing the geographical borders, extending to the Mineral of the Reforma, San Agustín Tlaxiaca and Zempoala. However, it is the municipality with the highest percentage of urban areas with 42.42%, a figure that does not represent the entire territory, which indicates the existence of areas in which urban growth has not been possible.

In such a way that Mineral of the Reformation, San Agustín Tlaxiaca and Zapotlán of Juárez, are the three municipalities that lead the list of change of urban use within the ZMP and given the conditions of growth of Pachuca de Soto, the previous warns That these three municipalities will be those that absorb the urban development and the population that is outside the city.

Zempoala is another municipality, which currently presents urban development with the creation of social interest divisions and the establishment of the Polytechnic University of Pachuca, unfortunately there is no data on the surface of urban areas in 2005, to make the Compared with the year 2010.

#### *3.1.2. Protected Natural Areas (PNA)*

This indicator determines the area and number of terrestrial units destined to protect and conserve biodiversity for environmental restoration and conservation purposes. Natural protected areas provide important environmental services such as water harvesting, carbon sequestration, biodiversity conservation and other associated values of cultural, landscape and scientific interest (8).

According to data from the National Commission for the Knowledge and Use of Biodiversity (CONABIO) in Mexico, it is recommended for states to have a recommended minimum of 10 percent; Although this work refers to a Metropolitan Area, given the integration of at least seven municipalities, this same dimension will be taken to qualify this indicator.

The objective will be the measurement in hectares of state areas under state and federal protection regime. The information comes from the Ministry of Environment and Natural Resources of Mexico (SEMARNAT), as well as the Secretary of Ecology of the State of Hidalgo.

The formula for obtaining the information is:

$$ANP_{ZMP} = \frac{S.R.P}{S.T_{ZMP}} \times 100 \tag{2}$$

Where:

$ANP_{ZMP}$ = Protected natural areas

$S.R.P$ = Surface protected.

$S.T$ = Total área.

The database to feed the indicator contains information of the type of protected area, since they can be of federal and state competence, however in this case also public lands are found (Table 7).

***Table 7.*** *Protected Natural Areas.*

| Name | Surface (has) | Municilpality | Type |
|---|---|---|---|
| El Chico National Park | 2,739.02 | Mineral del Chico, Real del Monte, Pachuca. | Federal Natural Area |
| Cubitos Ecological Park | 90.43 | Pachuca y Mineral de la Reforma | Estatal Natural Area |
| Huiloche Forest State Park | 100.06 | Mineral del Monte | Estatal Natural Area |
| Las Lajas or El Lobo Hill | 21.85 | Pachuca de Soto | Public utility land |
| Total | 2,951.36 | | |
| Percentage of Protected Natural Area | 2.46% | | |

Source: Protected Natural Areas, SEMARNAT, México 2005.

In the world for 2012, there is a 14.3% of ANP, in this same sense Latin America and the Caribbean, possess 21.2%, North America 11.8 and Europe 21.5% (8). According to SEMARNAT in Mexico, there are 25,394,779 hectares of ANP, representing 12 percent of the national territory, which is above the minimum recommended 10 percent.

The world average predicts that Mexico should have about 0.7 ha of tree cover per capita for the present decade. Current data, however, indicate that Mexico harbors only 0.5 ha of forest cover per capita, and the prediction for 2025 will be 0.3 ha per capita; below the world average (9).

For the case of the MPA, the value is 2.46 percent, which area is well below this parameter, so it is necessary to incorporate at least 10 000 hectares to reach 10 percent of the metropolitan area that is included In areas of protection.

It is important to mention that not all municipalities of the MPA, there are protected natural areas, for example of the MMP only Real del Monte and Pachuca in conjunction with Mineral del Chico have a natural area of federal competition called National Park el Chico with a Territorial extension of 2 739.02 hectares.

This National Park presents a series of conflicts that are mainly due to the lack of follow-up on management, clandestine logging, lack of control of pests and diseases, together with irregular human settlements, construction of clandestine works, establishment of boundaries, Are some aspects that compromise their well-being. (10)

The case of areas of state competence, corresponds only to the municipalities of Pachuca de Soto and Mineral de la Reforma with the Ecological Park Cubitos, which has an area of 90.43 hectares. Unlike the El Chico National Park located in a forest area, Cubitos is located within the urban area between the municipalities mentioned above; Does not have forest vegetation or dense foliage since its vegetation is mostly composed of xerophytic scrub.

The declaration of the Ecological Park of Cubitos, was made with the aim of the municipalities have a protected area, which also carries out the valuation of the environment through recreational practices application of ecotecnias and educational and cultural talks.

Another area of state competition is the so-called El Hiloche State Park with an area of 100.06 hectares. It is located in the municipality of Mineral del Monte and the land use that it has is forest, urban and tourist; Land tenure is municipal property.

Finally, the area known as "Las Lajas" or "Cerro del Lobo", is considered for this study within the classification of protected area given its declaration by the Government of the State of Hidalgo, declaring them as public space utilities; In this one has limited the urban development avoiding settlements and works. It is the one that has the smallest territorial extension with 21.85 hectares.

Although the ZMP is made up of seven municipalities, the protected areas are only included in the municipalities mentioned above, so that Epazoyucan, Zapotlán and Zempoala have no protected areas, which can lead to an excessive urban growth that Do not take into account reserve areas and recharges and that in the long term occasions an environmental imbalance.

### *3.1.3. Environmental Actions*

It describes some dimensions on which information is analyzed that contains data on activities in favor of the environment, this results in an indicator on the interest of different actors in collaborating to improve the environment in the MPA. The categories on which the indicators are obtained are (Table 8):

a) Planted trees
b) Reforested area
c) Volume of garbage collected
d) Complaints received in environmental matters
e) Unique environmental licenses in force.

a) Planted trees

Indicates the number of trees planted during 2010 and 2005 in the MPA, in this case in total 113,500 and 343,700 were planted respectively, of which the largest amount occurred in 2010 with 28,000 and in 2005 with 62,100. The municipality with the least amount of trees planted in 2010, is Pachuca with 11,000 and in 2005 Zapotlán de Juárez with 4500. In the municipalities of Mineral del Monte, Mineral de la Reforma and Zapotlán de Juárez in 2010 there is no information on this aspect. It is noteworthy given the Mineral del Monte forest characteristics that there are no actions to guarantee the conservation and recovery of vegetation in the El Chico National Park or the El Hiloche Forest State Park.

***Table 8.*** *Environmental Actions.*

| Code | Municipality | Planted trees | Reforested area | Volume of garbage collected | Complaints received in environmental matters | Environmental licenses |
|---|---|---|---|---|---|---|
| 13022 | Epazoyucan | 20,000 | 25 | 4 | 1 | 0 |
| 13039 | Mineral del Monte | 0 | 0 | 5 | 9 | 0 |
| 13048 | Pachuca de Soto | 11,000 | 10 | 139 | 14 | 0 |
| 13051 | Mineral de la Reforma | 0 | 0 | 37 | 6 | 0 |
| 13052 | San Agustín Tlaxiaca | 28,000 | 35 | 8 | 4 | 2 |
| 13082 | Zapotlán de Juárez | 0 | 0 | 2 | 0 | 0 |
| 13083 | Zempoala | 54,500 | 55 | 7 | 3 | 1 |
| Total | Metropolitan Area of Pachuca | 113,500 | 125 | 202 | 37 | 3 |

Source: Selected environmental actions 2011, INEGI.

b) Growth of Reforested Area

Reports the area that has undergone reforestation plans, measured in hectares within the MPA. This indicator is a complement of the planted trees as it reflects the surface they cover. In total, 125 hectares were reforested in 2010 and 393 in 2005. The municipality with the least reforested area in 2010 is Zempoala with 55 in 2010 and in 2005 Zapotlán with only 5 hectares.

According to (11), in Latin America and the Caribbean for 2010 there were 181,540 $km^2$ of reforested forests, in North America 343,260 and in Europe 523,580. As in the ANP indicator, Europe has primacy in actions that seek the environmental benefit.

In addition to the quantitative information provided by this indicator, it is possible with the database developed, to construct an indicator that provides the growth represented by the reforested area of the year 2010, compared to the area of 2005.

To construct the indicator, the following formula is used:

$$CSR = \frac{AR_2 - AR_1}{AR_1} x100 \ A.U_1 \qquad (3)$$

*C. S. U* = Rate of growth of reforested soil

$AR_1$ = Initial urban area in the reference period

$AR_2$ = Final urban area in the reference period

The indicator reflects that the reforested area of the year 2010, compared to that of 2005, has a negative growth, representing 68.19%. This means that the data to be negative, is not optimal for the objective of the ZMP, have a sustainable urban development.

c) Volume of garbage collected

The finding of this indicator reports in the MPA in 2005, collected 208,000 tons of garbage, while for 2010, they were 202,000, representing a little more than 30 percent of the total state garbage.

The municipality with the highest volume of garbage collection is Pachuca with both for 2010 and 2005, with 192,000 and 139,000 tons respectively, followed by Mineral de la Reforma with 37,000; The municipality with the lowest volume is Zapotlán with just 2,000 tons in 2010 and 2005.

d) Complaints Received in Environmental Matters

In this case, the indicator reports for the year 2010, according to data from the Information Bank of INEGI, the number of complaints received in environmental matters before the Federal Office of Environmental Protection (PROFEPA). Thus, at the national level there are a total of 19,521 complaints, while for the state of Hidalgo there were 147.

For the ZMP in 2010 (table 9), there are a total of 37 complaints, Pachuca being the municipality with the largest number of them with 14, the rest are concentrated in Mineral del Monte, Mineral de la Reforma, San Agustín Tlaxiaca and Zempoala; In Zapotlán de Juárez there are no reports. There is no information about the type of complaint to which it refers.

e) Environmental Licenses in Force

This indicator reports on the environmental licenses in force in the MPA. This license is required for industries: chemical, petroleum and petrochemicals, paints and inks, automotive, pulp and paper, metallurgy, glass, electric power generation, asbestos, cement and lime and treatment of hazardous waste. Its objective is to comply with the General Law of Ecological Equilibrium and Protection to the Environment in the Prevention and Control of Air Pollution.

In spite of the above, the information provided by the INEGI's Information Bank reports that in the ZMP (table 9), only three licenses are currently in force for the year 2010, specifically in the municipalities of San Agustín Tlaxiaca where there are Two and Zempoala with one. The rest of the municipalities of the ZMP does not report any license, which creates the question about the non existence of the same or the lack of registration.

### *3.1.4. Green Spaces for the Population*

This indicator provides information about the availability of playgrounds and neighborhood gardens in the municipalities of the MPZ. However, the area that these spaces represent is not available.

Green areas play a fundamental role in the urban environment as well as improving the quality of life of the inhabitants, especially air quality. The World Health Organization (WHO) recommends that cities should have at least 10 to 15 square meters of green areas per inhabitant, but these should also be distributed in relation to the population density distributed in urban areas. These areas do not account for protected natural areas.

The availability of this information only provides information for Mineral del Monte, San Agustín Tlaxiaca, Zapotlán de Juárez and Zempoala according to data from the State and Municipal System of Databases of Inegi (SIMBAD). Epazoyucan, Pachuca de Soto and Mineral de la Reforma appear with information not available (ND).

The survey indicates that the ZMP has 149 playgrounds and 52 neighborhood gardens, of which the municipality with the least amount of both is Mineral del Monte. As far as playgrounds are concerned, the largest amount is in Zempoala with 91 and in what concerns to neighboring gardens is Zapotlán de Juárez who has the largest number with 11.

For the city of Pachuca exists the availability of more precise information that the surface of the green spaces offers. In Pachuca de Soto, the green areas are in five parks with 26,315 $m^2$, seven green areas with 11,854 $m^2$, 11 gardens with 41,666 square meters, 22 ridges with 83,624 $m^2$, five roundabouts with 1,320 $m^2$ and 12 boulevards with 266,118 $m^2$ (12). This means that Pachuca has a total of 430,897 $m^2$ of green areas available to the population.

With this data, an indicator called the Urban Green Area Indicator can be constructed which measures the availability of green areas per inhabitant, given the characteristics of the information, can be made for Pachuca de Soto, with the following formula:

$$I.A.V. = \left( \frac{AV}{POBtot} \right) \tag{4}$$

Where:
I. A. V = Indicator of green areas
AV = Available green areas measured in $m^2$
POBtot = Total population

The importance of this indicator lies in offering the population of cities an urban balance between the functional spaces of this and the spaces dedicated to leisure and contact with nature. The green areas, gardens and parks in the cities are considered as a mosaic where the population, vegetation, equipment and services that together constitute the urban fabric interact.

Therefore assessing the proportion of green spaces per capita is a strategy to offer a better quality of life and at the same time contribute to the urban landscape and the promotion of biodiversity.

The results indicate that at least in the city of Pachuca, the area recommended by WHO, is far below what is required reaching only 1.61 $m^2$ per inhabitant. The foregoing warns of the need for green spaces not only as pollution mitigators, but to restructure the city and cushion the impact of urban density.

### 3.1.5. Change of Green Area Soil

As a complement to the previous indicator and as an element that serves later for the construction of a composite indicator of DUS, one can build one that measures the growth of green areas between the years 2005 and 2010. Likewise this data is only Available for the city of Pachuca.

The calculation is made using the following formula:

$$CAV = \frac{AV_2 - AV_1}{AV_1} x100 \tag{5}$$

CAV = Rate of growth of urban land
$AV_1$ = initial urban area in the reference period
$AV_2$ = final urban area in the reference period

The result obtained is that from one period to another the green areas only grow by 1.675%, which is countered by the indicator of green areas per inhabitant, indicates a considerable deficit of green areas, which likewise deplete development Sustainable urban development.

## 3.2. Indicators of the Urban Subsystem

The urban reality warns of several basic elements that make sustainability possible in cities, infrastructure, equipment, services, roads, and the quality of housing, should be taken into account if we are looking to qualify this aspect. Information on these elements is not available in all cases to carry out the analysis. For this work, we chose housing and some factors that determine the quality of life to construct the indicator.

***Table 9.*** *Indicators of Urban Subsystem.*

| Components | Description | Formula |
|---|---|---|
| *A. Urban Habitability* | It evaluates the average number of people inhabiting urban dwellings on the surface of the same nature.. | It is integrated with the measurement of the urban population among available urban dwellings. $Hu = \frac{PU}{VU}$ Where: I $Hu$= Urban Habitability $PU$= Urban Population $VU$= Urban Housing |
| *B. Building Density* | Provides information on the number of dwellings distributed per hectare in the urban areas that make up the MAP | $DE = \frac{VU}{SU}$ Where: $DE$= Building Density $VU$= Urban Housing $SU$=Urban Surface |
| *B. Urban Housing Quality Index* | It assesses whether the MAP offers its citizens coverage and accessibility in the services that are available for housing. It is composed of three dimensions; Accessibility to drinking water, drainage and electricity, measured through Housing Index with access to potable water, drainage and electricity. | $I.C.V_{urb} = \frac{IAP + IDr + IEe}{3}$ Where: $I.C.V_{urb}$ = Urban Housing Quality Index $IAP$ = Housing with Drinking Water Index $IDr$ = Housing with Drainage Index $IEe$ = Housing with electricity Index |

Source: Piña G. 2014

### *3.2.1. Urban Habitability*

It can be found that in the MAP for the year 2005, the habitability was of 3.18 average inhabitants by housing and for the year 2010, it amounted to 3.68. In 2005, the municipality with the highest overcrowding is Mineral del Monte with 4.49 inhabitants per household, followed by San Agustín Tlaxiaca with 4.08, the lowest habitability is for Mineral de la Reforma with 2.06, which gives notion of the existence of houses Uninhabited in the newly created subdivisions. In 2010, the municipality with the most overcrowding is San Agustín Tlaxiaca, and the second is the Reforma Mineral, exchanging papers according to those observed five years before. The lowest overcrowding is in Epazoyucan with 3.52 inhabitants, however there are no municipalities that have a density lower than 3.5.

### *3.2.2. Building Density*

In the ZMP for the year 2005 the density of building was of 18.74 houses per hectare, where the greater density was in Mineral of the Reformation with 19.52 houses per hectare, followed by Pachuca with 19.07, where although the city has exceeded Its geographical edges are not so high, which indicates that the density is shared with other land uses not considered in this study. The lowest density occurs in Epazoyucan with 5.78 homes, however, the municipality that follows this, is Mineral del Monte where the density rises to 12.46.

### *3.2.3. Quality in Housing*

The index of quality in the housing and the relation of its variables, shows that the conditions of quality and availability in the services of the MPA are positive, in addition to that they have meant growth between the years 2005 and 2010 of almost 2%. This implies a better quality of life in the inhabitants of the urban zones of the MPA, having houses that access services such as potable water, drainage and electricity.

## 4. Findings

With the application of this indicator in the natural dimension, it is possible to identify the accelerated growth rate of urban land, which almost reached 200% between 2005 and 2010. Unfortunately, this is not the case with the rest of the indicators That integrate the subsystem, in the case of the PNA, the area they occupy is the same in both periods, which warns of the need to have a determination of new areas that maintain a balance of growth with urban land.

Something more lamentable, happens with the growth of reforested soil, whose growth is negative, that is to say that the 68.19% of the reforested soil decreased between 2005 and 2010. The third indicator does not reflect a growth that maintains the rhythm of urban land. For the present work of research, the object of study of the urban subsystem has focused on the subject of housing, qualifying the elements that allow to improve the quality of life when inhabiting it.

Thus it is found in habitability index, which is the overcrowding of the population in the inhabited houses. For this case in 2005 was 3.18 and for 2010 3.68, although the result is not alarming, if it is necessary to identify that between both periods there has been an increase of 0.5, inhabitants per dwelling in the MAP.

The building density represents a decrease between 2005 and 2010, which means a decrease in the number of homes built on the urban surface. Even so, it is necessary to take into account that this indicator is not taking into account other types of soil that are shared in the MAP with the housing soil.

The urban housing quality index shows an improvement between 2005 and 2010, which were 93.96 and 95.50 respectively. This denotes the expansion of service coverage for the MAP population in the area of water, drainage and electricity. The ideal is 100% coverage, however given the topographic and accessibility conditions of some areas of the MAP, they make compliance with the indicator complicated.

***Table 10.*** *Values of Indicators.*

| Indicator | Values |
|---|---|
| *A. Growth of urban land (percentage of urban land in relation to the total area, for the years 2005 and 2010.)* | TCSU = 187.26% |
| *B. Protected natural áreas (Percentage of protected natural areas in relation to the total area).* | Year 2005 y 2010 = 2.46% |
| *C. Selected actions in environmental matters (reforested soil growth)* | CSR = -68.19 |
| *D. Green Spaces for the Population of the MPA (growth of green areas)* | CAV = 1.67 |
| Indicators of the Urban System | |
| *A. Urban Habitability* | Year 2010 = 3.68<br>Year 2005 = 3.18 |
| *B. Building Density* | Year 2010 = 7.16<br>Year 2005 = 18.74 |
| *C. Urban Housing Quality Index* | Year 2010 = 95.50<br>Year 2005 = 93.96 |

Source: Own elaborated

## 5. Conclusions

The contribution of research is the application and construction of statistical data and basic indicators to understand the urban reality of MAP. The information it contains is composed of urban data and indicators, which contribute to the measurement and qualification of sustainability conditions. These constitute the basis for the construction of a model of urban indicators, which serve as an application tool to interpret the urban problematic of MAP.

Another of the characteristics of this work is that it is replicable, which means that it serves as a basis to be carried out in other metropolitan areas, other cities or territories. The whole work process has concluded in a closing phase within which the urban indicators focus on the environmental and urban dimension, but also the social and economic dimension can be integrated. The dynamics of urban development in the MAP requires that in the short term, research models that use tools such as IDUS for decision-making and the establishment of effective planning policies to follow up should be followed. In the research process, there were different aspects that were an obstacle in the process. One of them is the lack of coherent information, which makes it possible to relate study elements to the municipal scale, given their availability at the state level. Another problem is the dispersion of information, since in some cases it is necessary to inquire about the existence of information that is apparently not available, but which is nonetheless lacking classification and availability.

Despite the characterization of statistical data and indicators, for each subsystem, it was not possible to integrate all of them into the indicator model of each of the subsystems. In the case of the natural subsystem, for example, we used those indicators on which it is possible to calculate a rate of change between the periods of study. The result contributes to the interpretation that the environmental dimension of development in the MAP requires actions that guarantee the orderly growth of urban areas, where protected areas or conservation soil are also determined. The trend of urban development far surpasses the growth rate of other factors that contribute to environmental conservation, even in some cases as reforested soil, have negative growth. The quality of urban housing and the conditions under which it is evaluated in this study, denote the importance of involving other factors that are part of the dynamics of cities, yet the indocators of the urban subsystem reflects the need to establish limits of Urban development for housing, and the application of a territorial order, which allows establishing limits between housing development and other uses that are involved in cities. Throughout this work, analyzes have been developed on some of the aspects that have been considered key to achieve urban sustainability. Each of the subsystems and topics addressed are accompanied by an analysis of the effective information that shows the situation that is experienced in the dynamics of the urban development of the MAP. The indicators generated in this work allow to relate the environmental and urban dimension, which are fundamental for local planning and land management. With them you can have an individual view of the municipalities or overall on the metropolitan scale.

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