

Urban Resilience Diagnosis

TERESINA

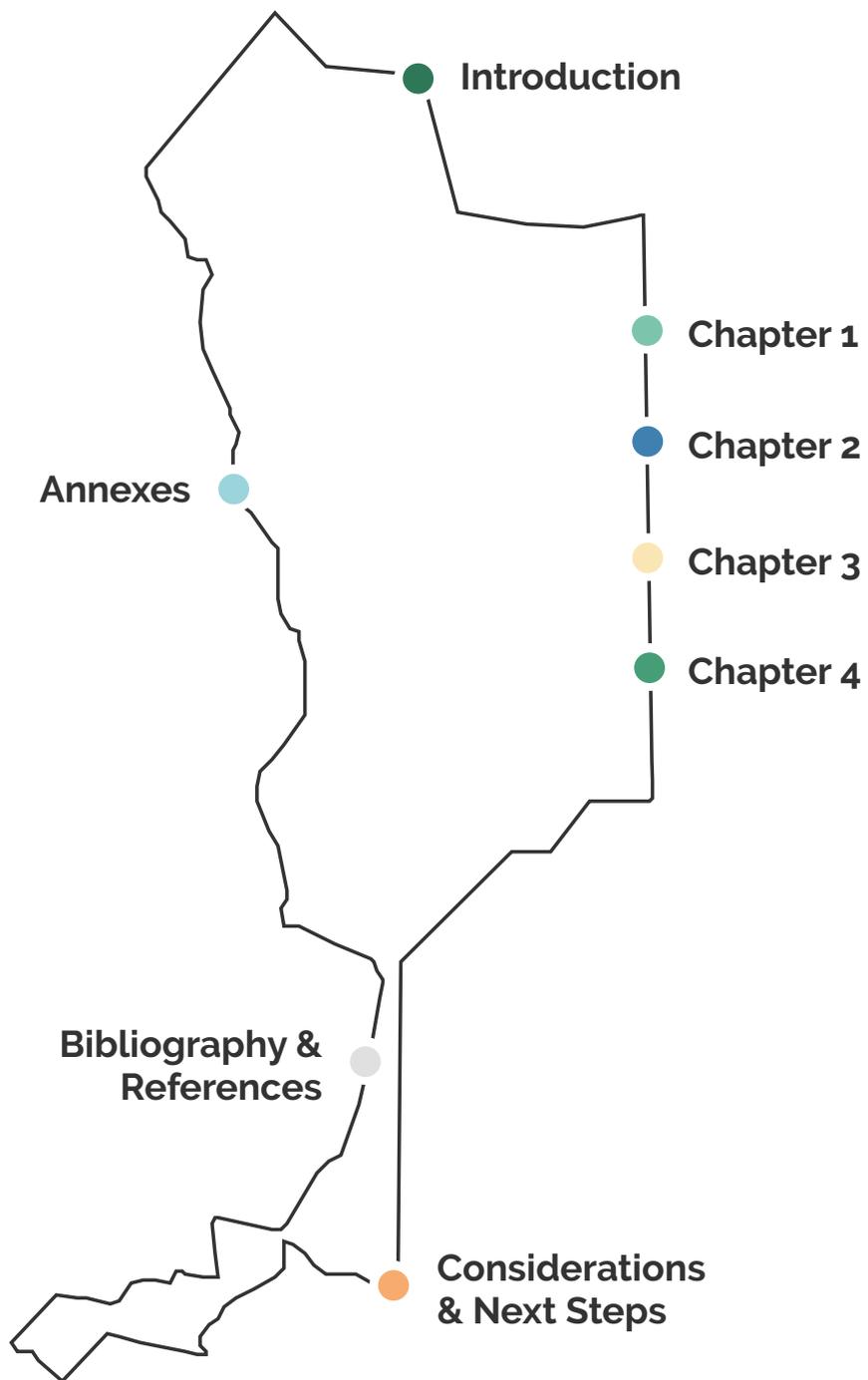


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This report has been written with the collaboration of an extensive inter/trans-disciplinary team and, as such, some of the terms have been translated directly from Portuguese.



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Glossary

Access

Ability of the rights-holders to use or benefit of a certain service or product.

Note: Restrictions can be caused by distance to the source (e.g., water supply network does not reach a certain neighbourhood) and unaffordability (e.g., service is too costly for a certain household or group of people), amongst others.

Alternative sources

Sources that differ from the main city source(s).

Note: Particularly applicable for electricity (e.g. generators) and water (e.g. bottled water) supply.

Basic Social services

Set of services delivered in education, health, and social areas, as a means to fulfil basic needs.

Biodiversity

Variability among living organisms from all sources including, land, marine and other aquatic ecosystems, and the ecological complexes of which the organisms are part.

Note 1: This includes diversity within species, between species, and of ecosystems. Biodiversity is thus not only the sum of all ecosystems, species, and genetic material, but rather represents the variability within and among them.

Note 2: Bio-diversity can also be referred to as biological diversity.

[Source: Chan, L., et al. User Manual on the Singapore Index on Cities' Biodiversity (also the City Biodiversity Index), 2014]

Built-up areas

Developed area based on built-up pixels.

Note 1: Can be urban, suburban or rural.

Note 2: Built-up area is considered urban if the built-up pixels have urban values greater than 50%, suburban if between 10-50%, and rural if less than 10%.

[Source: Atlas of Urban Expansion. The City as a Unit of Analysis and the Universe of Cities. 2016].

Captured open land

All open space clusters of less than 200 hectares that are fully surrounded by urban and suburban built-up land pixels and the fringe open space around them.

Challenges

Long-term contextual changes and pressures originated outside the urban system that also undermine the city's capacity for sustainability and resilience.

Civil society

Wide range of individuals, groups of people, networks, movements, associations, and organisations that manifest and advocate for the interests of their members and others.

Note 1: They can be based on philanthropic, cultural, religious, environmental, or political values and convictions.

Note 2: This definition excludes for-profit companies and businesses, academia, and all government-dependent entities.

Civil Society Organisations (CSOs)	<p>Formal associations in which society voluntarily organises around shared interests.</p> <p>Note 1: They include political, cultural, environmental, and faith-based organisations, as well as non-profit and non-governmental organisations.</p> <p>Note 2: <i>CSOs</i> are institutionalised organisations, bearing some form of legal status that represent particular groups of society and are involved in service delivery.</p>
Climate change adaptation	<p>Increased ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production.</p> <p>[Source: UNEP]</p>
Climate change mitigation	<p>Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impact of climate change.</p> <p>[Source: UNFCCC]</p>
Connectivity	<p>How a landscape is configured and how it allows species to move through its different elements.</p> <p>Note: A high degree of <i>connectivity</i> is generally linked to low fragmentation.</p>
Contingency planning	<p>Management process that analyses disaster risk and establishes arrangements in advance to enable timely, effective, and appropriate responses.</p> <p>[Source: UNISDR, 2017]</p>
Coverage	<p>Capacity of the duty-bearer to provide a service or product.</p> <p>Note: It may be influenced by its financial capacity, by geospatial setting and the normative and institutional frameworks.</p>
Critical facilities	<p>Physical structures, networks, and other assets which provide services that are essential to the social and economic functioning of a community or society.</p> <p>[Source: UNISDR, 2017]</p>
Decentralised authority	<p>Local authorities, distinct from the state's administrative authorities, who have a degree of self-government, elaborated in the framework of the law, with their own powers, resources, and capacities to meet responsibilities and with legitimacy underpinned by representative, elected local democratic structures that determine how power is exercised and that make local authorities accountable to citizens in their jurisdiction.</p> <p>[Source: UCLG, GOLD I, 2008]</p>

Disaster risk	Possibility of loss and injury.
	<p>Note: <i>Disaster risk</i> includes potential loss of life, disruption to lives and livelihoods (including injury, illness, danger, loss of sense of security or displacement), damage to or loss of property, and disruption of community activities which could occur to a system, a society, or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability, and/or capacity.</p>
	[Source: ISO/DIS 22327:2017 and UNISDR, 2017]
Disaster risk assessment	Qualitative or quantitative approach to determine the nature and extent of disaster risk by identifying and analysing potential hazards, and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods, and the environment on which they depend.
	[Source: UNISDR, 2017 with modification]
Disaster risk management	Coordinated activities to direct and control an organisation with regard to disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk, and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.
	<p>Note: Activities should encompass:</p> <p>Mitigation - the lessening or minimising of the adverse impacts of a hazardous event; and,</p> <p>Preparedness - the knowledge and capacities developed by governments, response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from the impacts of likely, imminent, or current disasters.</p>
	[Source: UNISDR, 2017 with modification]
Disaster risk reduction	Aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and, therefore, to the achievement of sustainable development.
	[Source: UNISDR, 2017]
Drinking water	All water either in its original state or after treatment, intended for drinking, cooking, food preparation, or other domestic purposes, regardless of its origin.
	<p>Note 1: Safe <i>drinking water</i> is water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on <i>drinking water</i> quality.</p>
	<p>Note 2: Sources of <i>drinking water</i> include household connections, public standpipes, boreholes, protected and unprotected dug wells, protected and unprotected springs, rainwater collection and surface sources, such as river, dam, lake, pond, stream, canal, and irrigation channels.</p>
	<p>Note 3: Access to <i>drinking water</i> means that the drinking water source is less than one kilometre away from its place of use and that it is possible to reliably obtain at least twenty litres per member of a household per day.</p>
	[Source: ISO 5667-5:2006 (en), 2.2 with added notes to entry]

Duty-bearers	<p>Individuals or institutions who have a particular obligation or responsibility to respect, promote, and realise human rights and to abstain from human rights violations.</p> <p>Note 1: The term is most commonly used to refer to State actors, but non-State actors can also be considered <i>duty-bearers</i>.</p> <p>Note 2: Depending on the context, individuals (e.g. parents), local organisations, private companies, aid donors, and international institutions can also be <i>duty-bearers</i>.</p> <p>[Source: UNICEF - Gender Equality, UN Coherence & You]</p>
Ecological footprint	<p>A quantitative measure looking at how much of the available biologically productive land and water an individual, a population, or an activity requires to produce the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices. It is measured in standard units called global hectares.</p>
Economic diversity	<p>Extent to which economic activity of a given defined geography is distributed among a number of categories such as industries, sectors, skill levels, and employment levels.</p>
Ecosystem	<p>Dynamic complex of plant, animal, and microorganism communities and the non-living environment (e.g. soil, air, sunlight) interacting as a functioning unit of nature.</p> <p>Note: Everything that lives in an <i>ecosystem</i> is dependent on the other species and elements that are also part of that ecological community.</p> <p>[Source: ISO 14055-1:2017(en), 3.1.1 with addition of Note]</p>
Ecosystem services	<p>Benefit people obtain from ecosystems.</p> <p>Note: These include provisioning services such as food, water, timber, and fibre; regulating services that affect climate, floods, disease, waste generation, and water quality and cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling.</p> <p>[Source: ISO 14055-1:2017(en), 3.1.2 with addition of Note]</p>
Urban Governance	<p>It is the software that enables the urban hardware to function, the enabling environment requiring the adequate legal frameworks, efficient political, managerial and administrative processes, as well as strong and capable local institutions able to respond to the citizens needs.</p> <p>[Source: UN-Habitat's New Urban Agenda]</p>
Green infrastructure	<p>Strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of <i>ecosystem services</i>.</p> <p>Note 1: It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas.</p> <p>Note 2: <i>Green Infrastructure</i> is a tool for providing ecological, economic, and social benefits through natural solutions. It helps avoid relying on 'grey infrastructure' that is expensive to build when nature can provide cheaper, more durable alternatives.</p> <p>[Source: 2016 European Commission. Environment]</p>

Greenhouse gas emission(s) (GHG)	<p>Total mass of a <i>GHG</i> released to the atmosphere over a specified period of time.</p> <p>Note 1: Greenhouse gases (<i>GHGs</i>) are long-lived gases in the atmosphere that absorb infra-red radiation which would otherwise escape to space absorbing the radiation contributes to rising surface temperatures.</p> <p>Note 2: There are six major <i>GHGs</i>: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulphur hexafluoride (SF₆).</p> <p>Note 3: <i>GHGs</i> remain in the atmosphere for long periods of time, ranging from months to millennia.</p>
Grievance redress mechanisms	<p>System by which queries or clarifications about a certain matter are responded to, problems that arise out of implementation are resolved, and complaints and grievances are addressed.</p>
Gross Domestic Product (GDP)	<p>Measure of all final goods and services produced in the city within a certain period of time.</p>
Human rights	<p>Rights inherent to all human beings, whatever our nationality, place of residence, sex, national or ethnic origin, colour, religion, language, or any other status.</p> <p>Note 1: People are all equally entitled to <i>human rights</i> without discrimination.</p> <p>Note 2: <i>Human rights</i> are: interrelated, universal, and inalienable, interdependent and indivisible, equal and non-discriminatory, and both rights and obligations.</p>
Improved drinking water sources	<p>Sources that, by the nature of their design and construction, have the potential to deliver safe water.</p> <p>Note 1: It includes piped water, boreholes or tube-wells, protected dug wells, protected springs, rainwater, and packaged or delivered water.</p> <p>Note 2: In order to meet the criteria for a safely managed drinking water service, people must use an improved source meeting three criteria: it should be accessible on premises, water should be available when needed, and the water supplied should be free from contamination.</p> <p>[Source: WHO-JMP-UNICEF, 2017]</p>
Inadequate structure	<p>Walls, ceilings, and floors built with materials, such as asbestos or zinc, or using techniques linked to the absence of appropriate know-how and maintenance, or loss of traditional knowledge based on experience.</p>
Indicator	<p>An indicator refers to a unit of measurement of the <i>urban system</i> and consists of a collection of Supporting Indicators and Related Questions. Each Component is composed of a small number of Indicators.</p>
Inequality	<p>State of not being equal, especially in status, rights, and opportunities.</p> <p>Note: <i>Inequality</i> can be measured economically (or monetarily), regarding living conditions, or based on rights and associated obligations (e.g. when people are not equal before the law, or when people have unequal political power).</p> <p>[Source: UNDP, 2015]</p>

Inflation	<p>Sustained increase in general price levels for all goods and services in an economy over time.</p> <p>Note: <i>Inflation</i> describes an erosion of the purchasing power of a unit of currency. It is usually expressed as an annual percentage rate of change on an index number.</p>
Informal business	<p>Unincorporated small or unregistered enterprises or productive units.</p> <p>Note 1: A productive unit is a formal or informal organisation that provides goods and/or services to the market.</p> <p>Note 2: An <i>informal business</i> is neither taxed nor formally monitored by any form of government.</p>
Informal sector	<p>Private unincorporated enterprises that are unregistered or small in terms of the number of employed persons (e.g. less than five employees).</p> <p>Note 1: An enterprise is unincorporated if it is not constituted as a separate legal entity, independently of its owner(s), and does not maintain a complete set of accounts.</p> <p>Note 2: Units engaged in the production of goods or services exclusively for own final use by the household are excluded from the <i>informal sector</i>, as are enterprises engaged in agriculture, hunting, forestry, and fishing.</p>
Investment	<p>Allocation of resources to achieve defined objectives and other benefits.</p> <p>Note: <i>Investment</i> takes two main forms: direct spending on buildings, machinery and similar assets, and indirect spending on financial securities, such as bonds and shares.</p> <p>[Source: The Economist, 2017; ISO/IEC 38500:2015(en), 2.13]</p>
Land consumption	<p>Expansion of built-up area which can be directly measured; absolute extent of land that is subject to exploitation by agriculture, forestry, or other economic activities; and over-intensive exploitation of land that is used for agriculture and forestry.</p> <p>[Source: EEA. 1997]</p>
Land tenure	<p>Relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land, determining how land is used, possessed, sold, or in other ways disposed.</p>
Local public debt	<p>Gross debt of the local public organisation under the following liabilities: 1) currency and deposits; 2) debt securities (bonds); 3) loans; 4) insurance pensions and standardised guarantees; and 5) other accounts payable (commercial debt, arrears).</p>
Municipal solid waste (MSW)	<p>Waste stream consisting of end-of-life-materials consisting mainly of waste generated by households, but may also include similar wastes generated by commerce and trade, small businesses, office buildings, and institutions (schools, hospitals, government buildings), and collected by or on behalf of municipal authorities.</p> <p>Note: The term 'municipal' is used in different ways from municipality to municipality and from country to country, reflecting different waste management practices.</p> <p>[Source: Eurostat, 2017 as modified by ISO 16559:2014(en), 4.134]</p>

Natural protected area (NPA)	<p>Clearly defined geographical space, recognised, dedicated, and managed through legal means or other types of efficient means to achieve the long-term conservation of nature with associated <i>ecosystem services</i> and cultural values.</p> <p>[Source: ISO 18065:2015(en), 3.6]</p>
Open access	<p>Specific rights are not assigned to anyone and no one can be excluded.</p>
Open area	<p>All the vacant areas - public or private - within the urban footprint.</p> <p>Note: Urbanised <i>open areas</i> are all fringe open space and captured open space pixels associated with the urban extent.</p>
Open data	<p>Publicly available data (preferably online) disseminated in a user-friendly way (metadata and machine readable format) which is reusable and license free for distribution and publication.</p> <p>Note: It must also be universally accessible.</p>
Own-source revenue	<p>All governmental revenues that are raised directly by the municipality</p> <p>Note: Common own-source revenues include property/land taxes, fees, and charges for services and permits, locally imposed sales, use or income taxes, investment or rental income generated from city assets, among others.</p>
Para-transit	<p>Transport services that are available to be shared, without prior arrangement, by the general public.</p> <p>Note 1: Para-transit, however, is not considered as a part of the traditional public transport regulatory system.</p> <p>Note 2: Para-transit, in general, has the following characteristics: Services are usually unscheduled and often, though not always, are on demand-responsive routes; and, The vehicles operated are typically small, including motorcycles and mini-buses.</p> <p>Note 3: Para-transit services are usually provided by informal operators with the following characteristics: They are non-corporate, usually operating as single-person enterprises; and, They are often outside the tax system or benefit from favourable treatment of the non-corporate sector.</p> <p>[Source: Roy, E. L., Rosemary, G. M, Transportation Engineering and Planning, Paratransit Systems, 2009]</p>
Participation	<p>Informed process of engagement with stakeholders, where key groups actively participate in defining the process and content of policy making.</p> <p>[Source: UNISDR, 2017 and ISO 22300:2018 (en), 3.187]</p>
Poverty	<p>State or condition of having little or no money/goods/means of support.</p>
Preparedness	<p>Activities, programmes, and systems developed and implemented prior to an incident that can be used to support and enhance prevention, protection from, mitigation of, response to, and recovery from disruptions, emergencies, or disasters.</p> <p>[Source: ISO 22300:2018 (en), 3.172]</p>

Private modes of transport	<p>Transportation means that are not available for the general public, as they are not shared by strangers without prior arrangement.</p>
Private sector	<p>For-profit enterprises, companies or businesses, regardless of size, ownership, and structure.</p> <p>Note: It covers all economic sectors and economic activities, ranging from local farmer organisations, cooperatives and small and medium enterprises to large international corporations. It includes private financial institutions, industry and trade associations, and consortia and coalitions that represent private sector interests (e.g., cross-industry multi-issue groups, cross industry issue-specific initiatives, industry-focused initiatives).</p>
Pro-poor land administration	<p>Inclusive system that extends land rights to all and recognizes all rights existing in a continuum.</p> <p>Note: It implies that a new, streamlined, affordable form of land recordings must be developed to record these different types of rights and link them to existing deeds and title systems.</p>
Product share	<p>Proportion of the overall market (defined in terms of either units or revenue) accounted for by a specific product.</p>
Public modes of transport	<p>Shared passenger transport services that are available to the general public and are shared by strangers without prior arrangement.</p> <p>Note: It ideally has well designed 'stops' and demarcated 'routes' that are both officially and/or formally recognised.</p> <p>[Source: UN-HABITAT, Unpublished manuscript, 2016]</p>
Public open space	<p>Areas within the urban footprint that are accessible for public use.</p> <p>Note 1: These are delimited by local planning.</p> <p>Note 2: <i>Public open spaces</i> encompass open air, outdoor areas in the city that are accessible by the public for recreational use, e.g. public parks, squares, recreational green areas, public playgrounds and widened pedestrian areas. It does not include streets, unless the city specifically indicates them as recreational space, nor areas devoted to public facilities that are not open to the general public.</p>
Recovery	<p>Restoration and improvement, where appropriate, of livelihoods and health, as well as economic, physical, social, cultural, and environmental assets, systems, and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and <i>build back better</i>, to avoid or reduce future disaster risk.</p> <p>[UNISDR, 2017 and ISO 22300:2018 (en), 3.187]</p>
Related Question	<p>Related Questions are structured similarly to Supporting Indicators, but the data collected are of secondary importance and generally not subject to a benchmarking process.</p>

Resilience	<p>Ability to absorb and adapt in a changing environment.</p> <p>Note: In the context of urban resilience the ability to absorb and adapt to a changing environment is determined by the collective capacity to anticipate, prepare, and respond to threats and opportunities by each individual component of an urban system.</p> <p>[Source: ISO 22300:2018 (en)]</p>
Rights-holders	<p>Individuals or social groups that have particular entitlements in relation to specific duty-bearers.</p> <p>Note: All human beings are <i>rights-holders</i> under the Universal Declaration of Human Rights. A human rights-based approach does not only recognize that the entitlements of <i>rights-holders</i> need to be respected, protected, and fulfilled, but it also considers <i>rights-holders</i> as active agents in the realisation of human rights and development, both directly and through organisations representing their interests.</p> <p>[Source: UNICEF, Gender Equality, UN Coherence & You]</p>
Risk mitigation	<p>Lessening or minimizing of the adverse impacts of a hazardous event.</p> <p>[Source: UNISDR, 2017]</p>
Shocks	<p>Uncertain, abrupt, or long-onset events that have potential to impact upon the purpose or objective of an urban system.</p>
Social accountability	<p>Approach to governance that involves citizens and civil society organisations in public decision making.</p>
Social protection	<p>Preventing, managing, and overcoming situations that adversely affect people's well-being.</p> <p>Note: It consists of policies and programmes designed to reduce poverty and vulnerability by promoting efficient labour markets, diminishing people's exposure to risks, and enhancing their capacity to manage economic and social risks, such as unemployment, exclusion, sickness, disability, and old age.</p> <p>[Source: UNISDR]</p>
Social protection floor (SPF)	<p>Nationally defined sets of basic social security guarantees that should ensure, as a minimum that, over a life cycle, all in need have access to essential health care and to basic income security which together secure effective access to goods and services defined as necessary at the national level.</p>
Stakeholder	<p>Person or organisation that can affect, be affected by, or perceive itself to be affected by a decision or activity.</p> <p>Note: Stakeholders may include government entities, private sector, civil society, academia, and other major institutions from the local to the international level operating in the city.</p> <p>[Source: ISO 9000:2015, 3.2.3 and ISO 22300:2018 (en), 3.124]</p>
Stresses	<p>Chronic and ongoing dynamic pressures originated within an urban system with potential for cumulative impacts on the ability and capacity of the system to achieve its objectives.</p>

Stressor	Factors, processes, activities or interactions that individually or conjointly lead to the generation of a stress in the urban system.
Supply chains	<p>Two-way relationships of organisations and/or people with processes, logistics, information, technology, and resources engaging in activities and creating value from the sourcing of materials through the delivery of products or services.</p> <p>Note 1: The supply chain may include vendors, subcontractors, manufacturing facilities, logistics providers, internal distribution centres, distributors, wholesalers, and other entities that lead to the end user.</p> <p>[Source: ISO 22300:2018 (en) 3.251]</p>
Supporting Indicator	A Supporting Indicator is the principal data collection unit for the City Resilience Profiling Tool (CRPT), consisting of a question or group of questions requiring a quantitative and/or qualitative response. The majority of data generated by Supporting Indicators are benchmarkable or quantitatively measurable.
Sustainable modes of transport	Transport that has zero or minimum effect on the environment due to the use of sustainable or regenerated energy.
Trade balance	<p>Measure of how a given entity's (city, region, country, etc.) total imports by value compare to its total exports by value.</p> <p>Note 1: An excess of imports over exports is referred to as a trade deficit while an excess of exports over imports is described as a trade surplus.</p>
Urban	Any town, city, or other human settlement.
Urban agglomeration	The physical structure and composition of an urban area or continuity of large urban clusters where the built-up zone or population density of an extended city or town area or central place and any suburbs are linked by continuous, connected urban development.
Urban footprint	Built-up area, the fringe open land, and the captured open land.
Urban green space	<p>Urban space covered by vegetation of any kind.</p> <p>Note 1: This includes:</p> <ol style="list-style-type: none"> 1. smaller green space features (such as street trees and roadside vegetation); 2. green spaces not available for public access or recreational use (such as green roofs and facades, or green space on private grounds); and 3. larger green spaces that provide various social and recreational functions (such as parks, playgrounds, or greenways). <p>[Source: 2017. Urban Green Space interventions and health. World Health Organisation. Regional Office for Europe]</p>
Urban open area	<p>All the vacant areas – public or private – within the urban boundaries.</p> <p>Note 1: Urban open areas are all fringe open space and captured open space associated within the scope and parameters of the urban system.</p> <p>Note 2: State, national parks, or open areas in the countryside outside the parameters of the urban area are not considered, here, as urban open areas.</p>

**Urban
resilience**

bility of any urban system, with its inhabitants, in a changing environment, to anticipate, prepare, respond to, and absorb shocks, positively adapt and transform in the face of stresses and challenges, while facilitating inclusive and sustainable development.

Note 1: A more resilient urban system is characterised by its ability to continue through disruption in the short-to-medium term, combined with a capacity to reduce pressures and adapt to changes, risks and opportunities. Urban resilience therefore is dependent upon not just the ability of an urban system to deal with shocks, but also with chronic stresses and challenges.

Note 2: Urban resilience is dependent upon the individual and collective resilience of the separate components of a complex urban system. Although a city, town, or community within an urban area may individually demonstrate enhanced resilience within their respective boundaries, urban resilience encompasses the broader geographic scope of urban agglomeration. Resilience of an urban system is measured by the capacity of resilience for each individual system component and dependent upon the resilience of the weakest performer among the urban agglomeration within the system scope.

Note 3: In order to assess, plan and act accordingly in the face of shocks, stresses, and challenges, an urban system's capability for resilience should be measured and analysed through qualitative and quantitative data.

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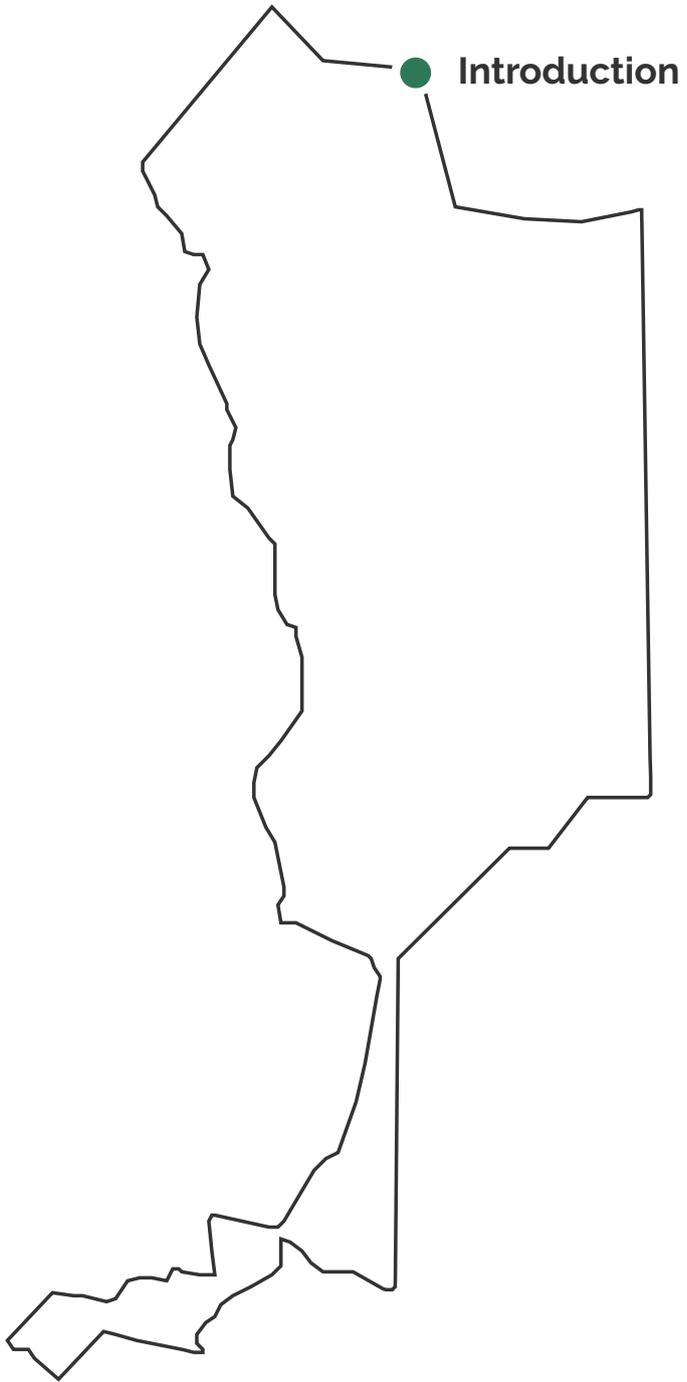
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List of Acronyms and Abbreviations

A4R	Actions for Resilience
AGESPISA	Águas e Esgotos do Piauí
ANEEL	Agência Nacional de Energia Elétrica
BNDES	Banco Nacional de Desenvolvimento Econômico e Social (National Bank for Economic and Social Development)
BNH	Brazil's National Housing Bank
BRT	Bus Rapid Transit
CAF	Corporación Andina de Fomento
CAIXA	Caixa Econômica Federal
CDL	Câmara de Dirigentes Lojistas de Teresina
CODEVASF	Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba
CONAMA	Conselho Nacional do Meio Ambiente
CRGP	City Resilience Global Programme
CRPT	City Resilience Profiling Tool
CTA	Consórcio Teresina Ambiental
DRR	Damage and Risk Reduction
EEE	Estações Elevatórias de Esgoto (Sewage Lift Stations)
ETA	Estações de Tratamento de Água (Water Supply Treatment Plants)
ETE	Estações de Tratamento de Esgoto (Sewage Treatment Stations)
FIEP	Federação das Indústrias do Estado do Piauí
FTL	Ferrovia Transnordestina Logística
GDP	Gross Domestic Product
GEF	Global Environment Facilities
HDI	Human Development Index
IBGE	Instituto Brasileiro de Geografia e Estatística
ICLEI	Local Governments for Sustainability
ICMS	Imposto sobre Circulação de Mercadorias e Serviços (Tax on Circulation of Goods and Services)
IDEB	Índice de Desenvolvimento da Educação Básica
INMET	Instituto Nacional de Meteorologia (National Institute of Meteorology)
INPE	Instituto Nacional de Pesquisas Espaciais

INSS	Instituto Nacional do Seguro Social
IPCA	Índice Nacional de Preços ao Consumidor Amplo (Broad National Consumer Price Index)
IPCC	Intergovernmental Panel on Climate Change
SEBRAE	Serviço Brasileiro de Apoio às Micro e Pequenas Empresas



Introduction

Introduction

In 2019, the Municipality of Teresina, the Government of Brazil and the United Nations Program for Human Settlements signed a Cooperation Agreement for the implementation of the Teresina Urban Resilience Program. Through this agreement, for 2 years, the parties will work together to build technical capacity for urban resilience in the municipality and to produce a strategic action plan for the city, called Actions for Resilience and Sustainability.

With the support of the City Resilience Global Programme (CRGP), the municipality will implement the City Resilience Profile Tool (CRPT). The CRPT provides a universal framework that uses verifiable and contextualised city data to establish a resilience profile and create an analysis and diagnosis of its most urgent challenges. This profile and diagnosis provide a basis for the creation of evidence-based and implementable Actions for Resilience, which are designed to be incorporated into current urban development strategies and management processes of the city. This process is intended to support Teresina and its partners in making informed decisions and, in turn, support long-term resilient and sustainable urban development.

The aim of this report is to better inform the Local Government, in this case the Municipality of Teresina, of the current state of the city with regards to resilience and ongoing related trends, based on conclusions derived from the CRPT implementation process described in this document.

The introduction of this report briefly presents the CRPT methodology, which serves as the basis for the analytical findings presented in the following chapters. Although the report seeks to summarize the multifaceted implementation process, the analytical and diagnostic efforts, towards the development of concrete recommendations for actions to build resilience in Teresina, it does not seek to provide details of the methodological basis from which the CRPT was developed, nor of the analytical process in its entirety, given its extensiveness. Please refer to the CRPT Implementation Manual for a detailed description of the CRPT implementation process.

CRGP: City Resilience Global Programme

CRGP is the UN-Habitat's flagship programme for Urban Resilience in partnerships with local governments.

UN-Habitat's flagship tool for urban resilience, the City Resilience Profiling Tool (CRPT), provides a cross-cutting, action-oriented approach to resilience and sustainable urban development. Its methodology is based on UN-Habitat's definition of urban resilience, shown below, which encompasses a theoretical approach followed by a more practical description on what resilience-building efforts entail and target.

"The measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming toward sustainability. A resilient city evaluates, plans and acts to prepare and respond to threats - natural or man-made, sudden and slow onset, expected and unexpected - in order to protect and improve the lives of people, to ensure development, foster an investment environment and drive positive change".¹

This definition and understanding of resilience outline the overall objective for each city implementing the CRPT. A shared understanding of resilience is crucial in catalysing stakeholder engagement and garnering buy-in from partners.

In addition to the definition of urban resilience, the following Urban Resilience Principles, which are integrated into the structure, design, and implementation of the CRPT, guide cities in urban resilience development.

¹ UN-Habitat CRGP, (2018).

CRGP: Urban Resilience Principles



Principle 1

Dynamic nature of urban resilience

Resilience is not a condition but a state that cannot be sustained unless the system evolves, transforms and adapts to current and future circumstances and changes. Therefore, building resilience requires the implementation of context-specific and flexible plans and actions that can be adjusted to the dynamic nature of risk and resilience;



Principle 2

Systemic approach to cities

Recognising that cities are comprised of systems interconnected through complex networks and that changes in one part have the potential to propagate through the whole network, building resilience requires a broad and holistic approach that takes into account these interdependencies when the urban system is exposed to disturbances;



Principle 3

Promote participation in planning and governance

A resilient system ensures the preservation of life, limitation of injury, and enhancement of the 'prosperity' of its inhabitants by promoting inclusiveness and fostering comprehensive and meaningful participation of all, particularly those in vulnerable situations, in planning and various governance processes. Such an approach can ensure a sense of ownership, thus achieving successful implementation of plans and actions.



Principle 4

Multi-stakeholder engagement

A resilient system should ensure the continuity of governance, economy, commerce and other functions and flows upon which its inhabitants rely. This necessitates promoting open communication and facilitating integrative collaborations between a broad array of stakeholders ranging from public entities, private sector, civil society, and academia to all city's inhabitants.



Principle 5

Strive towards development goals

Resilience building should drive towards, safeguard and sustain development goals. Approaches to resilience should ensure that efforts to reduce risk and alleviate certain vulnerabilities does not generate or increase others. It must guarantee that human rights are fulfilled, respected and protected under any circumstances.

CRPP: Methodology and alignment with the international Agenda 2030

The implementation of the CRPT is characterized by four overlapping steps: 1) data collection, 2) analysis, 3) diagnosis, and 4) recommended actions for resilience. In order to better understand how the data collected leads to derived actions, clarity regarding how these key implementation processes are pursued and relate to one another is required. The methodological framework is discussed briefly and illustrated in **Figure 1**.

At the data collection phase, the programme adopts different techniques combining stakeholders participatory workshops, for deriving local knowledge and expertise, with an in-depth indicators-based approach - known as Urban Performance for assessing the urban system and corroborating the findings derived from these workshops. Initially, the collected data feed the Urban Context which explores the development narrative through the city's historical background and its spatial, social, economic and cultural context. It introduces the administrative structure, characteristics and strategies, highlighting those related to resilience and presents resilience related challenges and opportunities. These contextual information, allow for Urban Performance to be attuned to current realities.

Urban Performance is an in-depth indicators-based approach for assessing the urban system and validating the findings derived from local knowledge and stakeholders participatory workshop. It is focused on collecting objective data, information and knowledge, localised through Urban Context and centred around specific Priority Matters for urban resilience co-identified and co-prioritised with stakeholders.

Furthermore, these data provide a basis to analyse the current strengths and weaknesses of the urban system and its performance, – the WHAT. They are complemented by qualitative sources collected through workshops and expert readings in an attempt to capture the nuances of the city and the realities of the context. Information are then grouped and interrelated per each of the three main lenses:

- **The Who lens:** Local Government and Stakeholders, analyses the role and relationships of the different institutions and organisations acting in the city and determines the most influential actors – the WHO. It provides a brief mapping of the local government's structure, roles, and responsibilities, in addition to key stakeholders from outside the local government (e.g. regional, provincial, national government, private companies, community organisations, NGOs, etc.). Moreover, a focused mapping of potential stakeholders for the recommended actions for resilience, in regards to their roles and influence, is conducted for each Action for Resilience that will be recommended later on as part of CRPT implementation in Teresina in a separate report.
- **The Why Lens:** Shocks, Stresses and Challenges, provides analysis regarding the existence of, and interactions between shocks, stresses in the presence of existing challenges and constraints in the city. In this report, these aspects are described and analysed in detail in Chapter 2 - The Current State of Urban Resilience in Teresina.
- **The How Lens:** Plans, Policies and Initiatives, provides Information on the existing development efforts, based on established policy and/or legal frameworks, which guide the future development of the city (i.e. existing policies, plans and initiatives) including those concerning risk reduction measures. This information is organised in an inventory that coherently maps these in relation to WHAT the issues are, WHO has a stake, and WHY certain actions are needed, to determine current areas of focus, gaps and overlaps – to formulate HOW to act.

The three analytical lenses lead to the formulation of Diagnosis. The Actions phase, through the Actions for Resilience (A4R), is where a roadmap will be co-produced with the local government and relevant stakeholders, based on the Diagnosis and potential trends of risk and resilience in the city to initiate positive change through verifiable evidence.

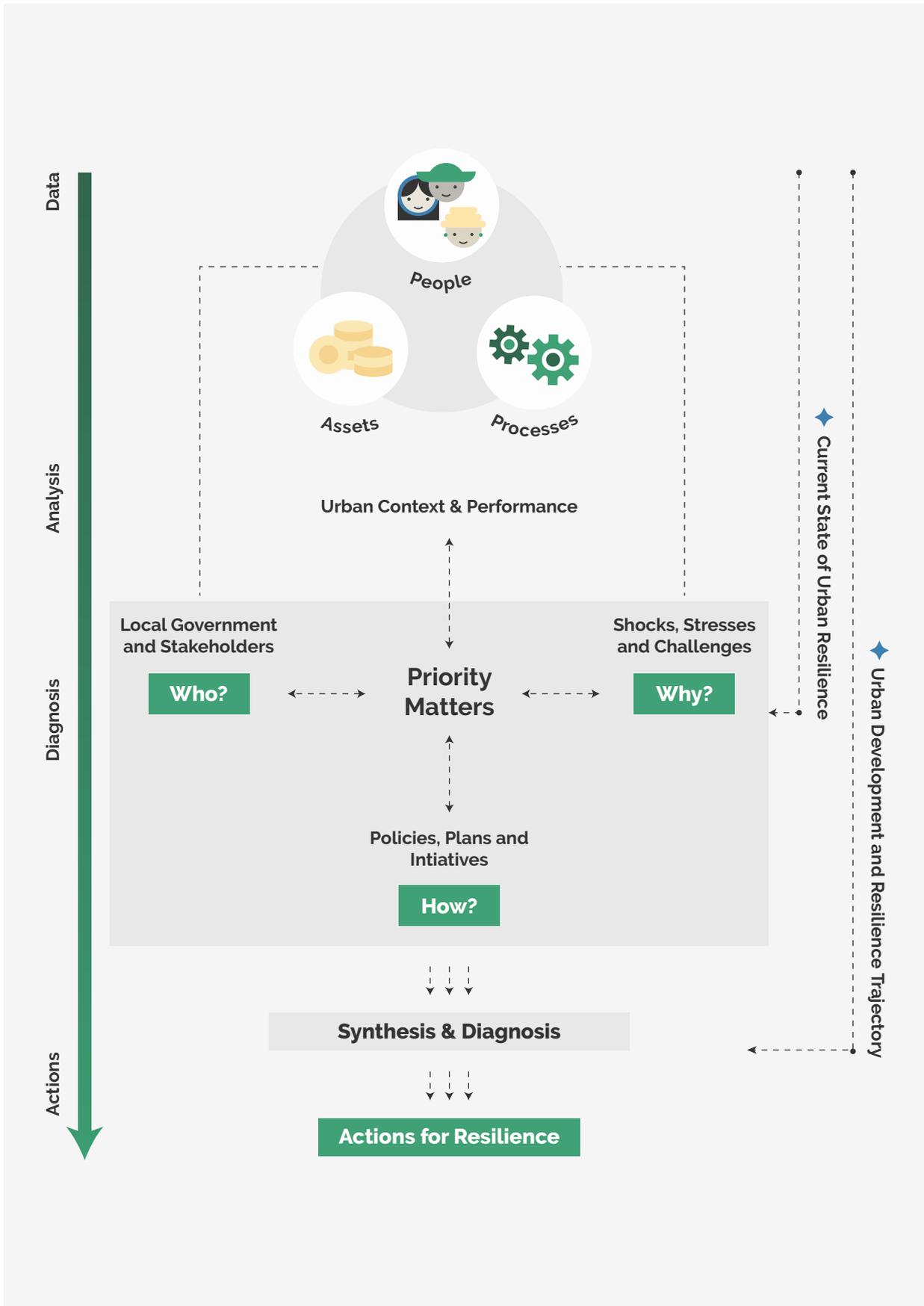


Figure 1: CRGP methodological framework diagram. Source: CRGP (2018).

The result of these analyses and diagnosis is prioritised and implementable Lines of Actions or thematic areas of prioritisation, which will be identified and agreed upon with the local government. Following a consolidation of CRPT analytical and diagnostic findings and integration of input from the local government and other key stakeholders, a focused, consensus-derived path towards resilience is formed. The Lines of Actions explore these resulting themes, presenting a culmination of collected data findings and preliminary analytical efforts, in combination with key stakeholder input derived from the workshops conducted in conjunction with the local government. These Lines of Action can vary in scope but relate directly to both quantitative and qualitative information, representing a synthesis of each methodological step in the CRPT implementation.

From these Lines of Action, Recommendations for Actions for Resilience are developed and proposed in order to co-create a resilient and sustainable roadmap for the city. These Actions are intended to be both implementable and feasible, yet precise in targeting and ambitious in their expected impact.

Alignment with international frameworks and agendas

CRPT methodology was developed in alignment with globally agreed inter-governmental frameworks, namely: Sustainable Development Goals, Sendai Framework for Disaster Risk Reduction, Paris Agreement on Climate Change, World Humanitarian Summit - Agenda for Humanity, and the New Urban Agenda. Aligning CRGP with these frameworks enables the local governments who have implemented CRPT to better understand, report, and deliver on targets.

Sendai Framework for Disaster Risk Reduction



The Sendai Framework requires resilience at all levels of planning, local, regional, and national. The CRPT contributes to the overall objective of the document: reduce vulnerability to disasters and increase preparedness for response and recovery, and contributes to the four priorities for action:

- **Priority 1:** Build knowledge based on evidence on disaster risk reduction.
- **Priority 2:** Strengthen governance frameworks against disaster risk through the adoption of plans.
- **Priority 3:** Invest in risk reduction and resilience.
- **Priority 4:** Expand the preparation of the stakeholders and an "early recovery" approach.



Sustainable Development Goals

Urban resilience is related to key elements of sustainable urban development and to the objectives of the Post-2015 Sustainable Development Agenda, in particular with Objectives 1, 2, 3, 9, 11, 13 and 14, where reference is made to resilience, but also with other objectives where it appears implicitly. Resilience is an important component of many of the objectives set out in the entire preamble and paragraphs 7, 9, 14, 23, 29 and 33 of the Declaration to the SDGs.



Paris Agreement on Climate Change

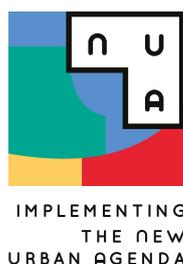
Article 7 requires the strengthening of resilience in the face of climate change as a premise of sustainable development. Resilience in cities requires the involvement of local governments in the following principles of the Paris Agreement:

- Adaptation to the impacts of climate change
- Minimisation of losses and damages related to climate change
- Local resilience construction



World Humanitarian Summit – Agenda for Humanity

The main responsibilities defined in the World Humanitarian Summit are related to the construction of resilience. The approach adopted by UN-Habitat for building resilience contributes to priorities 1D, 4A, 4B, 4C and 5A.W



New Urban Agenda

Resilience is related to some of the key objectives of the New Urban Agenda agreed by Member States during Habitat III:

- a. New paradigms of urban planning for resilience.
- b. Legal and regulatory frameworks that allow adequate governance in urban development.
- c. Analysis of inherent risks in urban areas.
- d. Promotion of good practices related to the local economy and strategies to promote safe and sustainable cities.

CRGP: Implementation Process in Teresina

Programa de Resiliência Urbana de Teresina

The Program's approach is, first, to generate metrics of urban resilience to establish a baseline (or 'profile') that covers the entire urban system in search of weaknesses, vulnerabilities and strengths, and to prioritise lines of actions, to develop concrete and actionable strategies for strengthened resilience. Following a multi-sectoral, multi-hazards stresses, and multi-scales approach, based on the understanding that cities function as a set of integrated and interdependent systems, regardless of their size, culture, location, economy and or political environment.

The implementation process in Teresina is divided into two main phases. The first year of implementation (2020), concentrates efforts on data collection, analysis, diagnosis and proposition of Actions for Resilience. The second year of the project concentrates on strategic actions, implementation roadmaps, financing and communication of the proposed lines of action. In this first year, three main products are produced from the program's activities: The City Profile (City ID), consolidating the information from the Urban Context; the City Resilience Diagnosis (City Diagnosis), an analysis of data collection and urban performance findings, actors and processes; and, finally, the Actions for Resilience report, a strategic planning document that guides paths towards a more resilient Teresina.



Image 1: Teresina, Brazil. Source: David Jales.



Figure 2: CRPT implementation in Teresina. Source: CRGP (2020).

Report Structure

The organisation of this report does not necessarily follow the steps mentioned above in the methodological framework. It is rather structured around the main findings as a result of the different activities conducted as part of the implementation process - namely data collection, analysis and diagnosis. The report is comprised of four main interrelated chapters: Chapter 1 - Urban Context, Chapter 2 - The current state of Urban Resilience in Teresina, Chapter 3 - Urban development and Resilience Trajectory in Teresina, and Chapter 4 - Synthesis and Diagnosis.



Chapter 1: Urban Context

Urban Context presents an overview of the findings of both CRGP desk research and stakeholders participatory workshops. It brings together qualitative and quantitative data on various aspects including historical background, population and demographics, spatial dimensions, local economy and livelihood, the composition of local government and municipal departments, and presents resilience related challenges and opportunities.



Chapter 2: The Current State of Urban Resilience

The current state of Urban Resilience in Teresina displays the main priority matters for urban resilience in Teresina that were co-identified and co-prioritized through stakeholders participatory workshops, validated and further characterised through indicators-based urban performance assessment. Particularly, this analytical chapter illustrates the different combinations of shocks and stresses that are shaped by present urban challenges (see chapter 1 - Challenges and opportunities) leading to the emergence of each priority matter. It further presents the characterisation of each priority matter through urban performance assessment which rely on CRPT indicators for evaluating the strengths and weaknesses of different urban elements linked to these priority issues.



Chapter 3: Urban Development and Resilience Trajectory

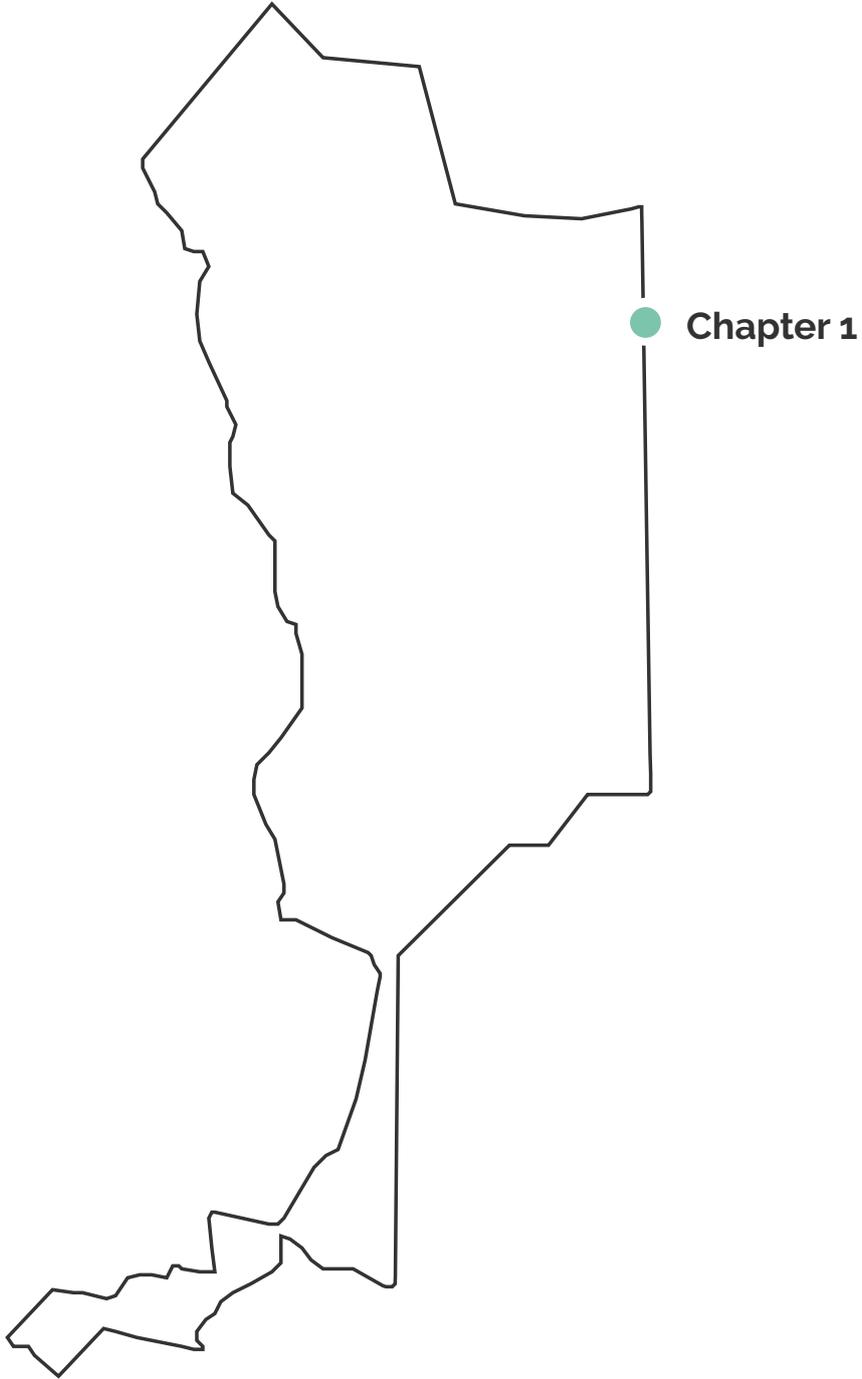
Urban Development and Resilience Trajectory in Teresina presents ongoing context-related trends, namely climate change, the unfolding impacts of Covid-19 pandemic, and urban development trends that have the potential to directly or indirectly promote or undermine resilience building. To this end, the chapter illustrates the result of an extensive review of policies, plans, initiatives and risk reduction measures in place or under-development that have the potential to influence, on different levels, priority matters for resilience in Teresina.



Chapter 4: Synthesis & Diagnosis

Synthesis and Diagnosis brings together the findings of the three chapters above with the aim of drawing a picture of the urban trajectories in terms of resilience given the priority matters identified, challenges and constraints encountering the local government in Teresina and ongoing urban and territorial development trends. It is hoped that this synthesis of analysis will establish the ground for a well-informed roadmap to be jointly co-designed by CRPT's Actions for Resilience experts, the municipality of Teresina and local stakeholders for strengthening urban resilience and sustainability.





Chapter 1

Urban Context

Chapter 1

Urban Context

1.1. City Context and History of Teresina

The city of Teresina is the capital of the state of Piauí, located in the northeast of Brazil, very close to the Equator. It is a unique capital of the northeast that is not located on the coast. In this case, it is surrounded by the Poti and Parnaíba rivers, the one that separates Teresina from the neighborhood of the city Timon, in the state of Maranhão. Teresina is a reference in education and health services in the region, in addition to the strong trade in products and services, or what attracts people from neighboring cities and states on daily commuting and overloads the capacity of municipal public facilities.

Teresina has an area of 1391 km², located at 72 meters above sea level. In the Koeppen-Geiger climate classification, Teresina is part of the Tropical Group (A) with Savanic climate (Aw), with two well-controlled climatic seasons (summer and winter), in addition to an annual seasonal variation with very dry periods (September-December) and very rainy (January-April). The average annual rainfall is approximately 1,349 mm, with a maximum monthly average in March of 307 mm and a minimum monthly average in August of 06 mm. The rainy season concentrates more than 70% of the year's rainfall in just four months. During the summer, the average temperature is around 29.3 ° C with October or the hottest month of the year. In winter, the temperature in February is 26.5 ° C, the lowest average in the year. As the media are so high that Teresina does not have heating demand days and throughout the year, there is a demand for cooling.

Regarding the demographic and socioeconomic characteristics, it is important to highlight the strong population growth, originating from the rural scenario after a decade of 1960. The development of the infrastructure is not accompanied at the same pace and the city goes through the climate scenario with the displacement of the population of the urban center. Table 1 briefly presents some important information about Teresina's biophysical, demographic, and socioeconomic resources.



Image 2: Teresina, Brazil. Source: Bruno Vinelli.

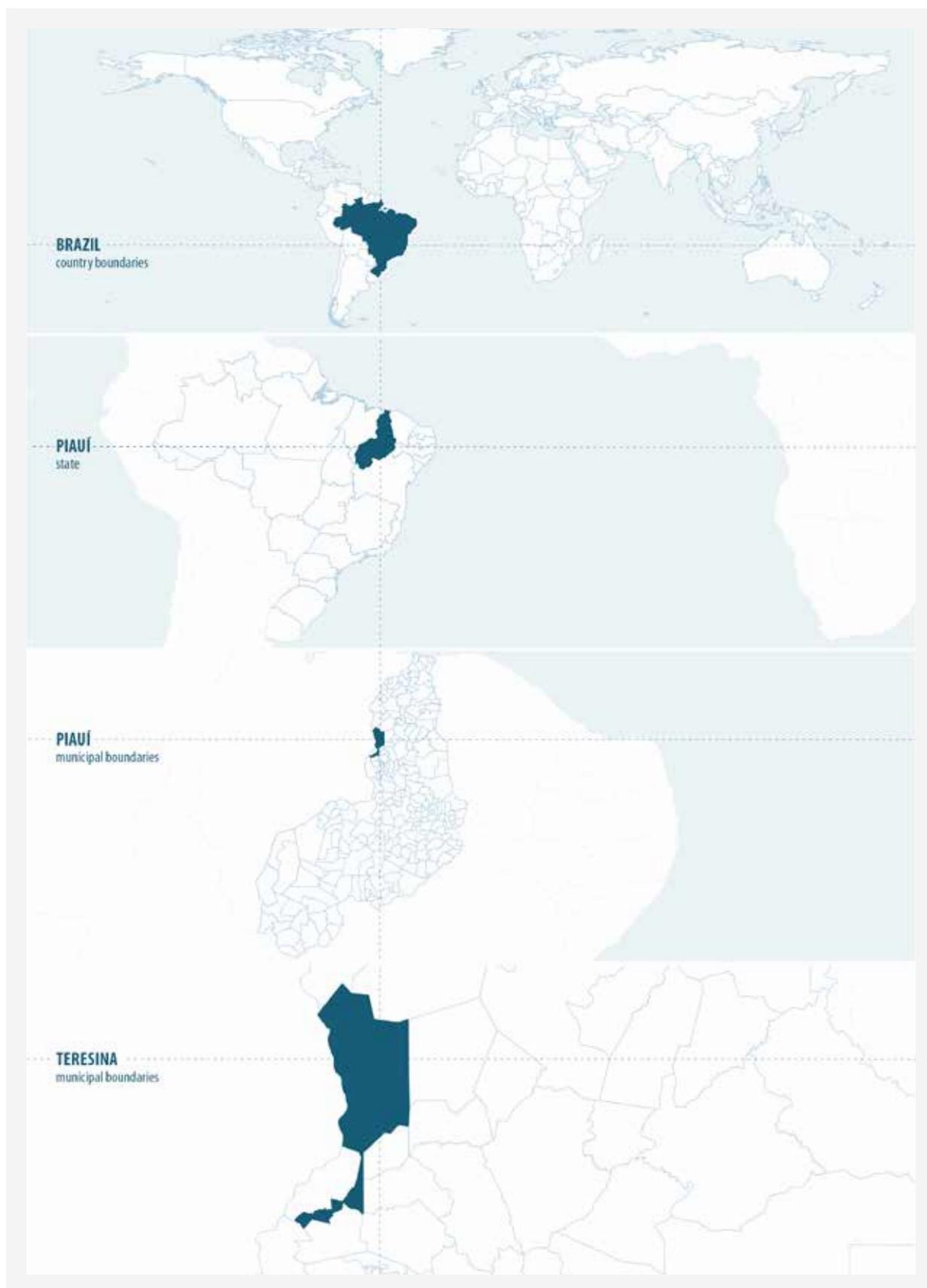
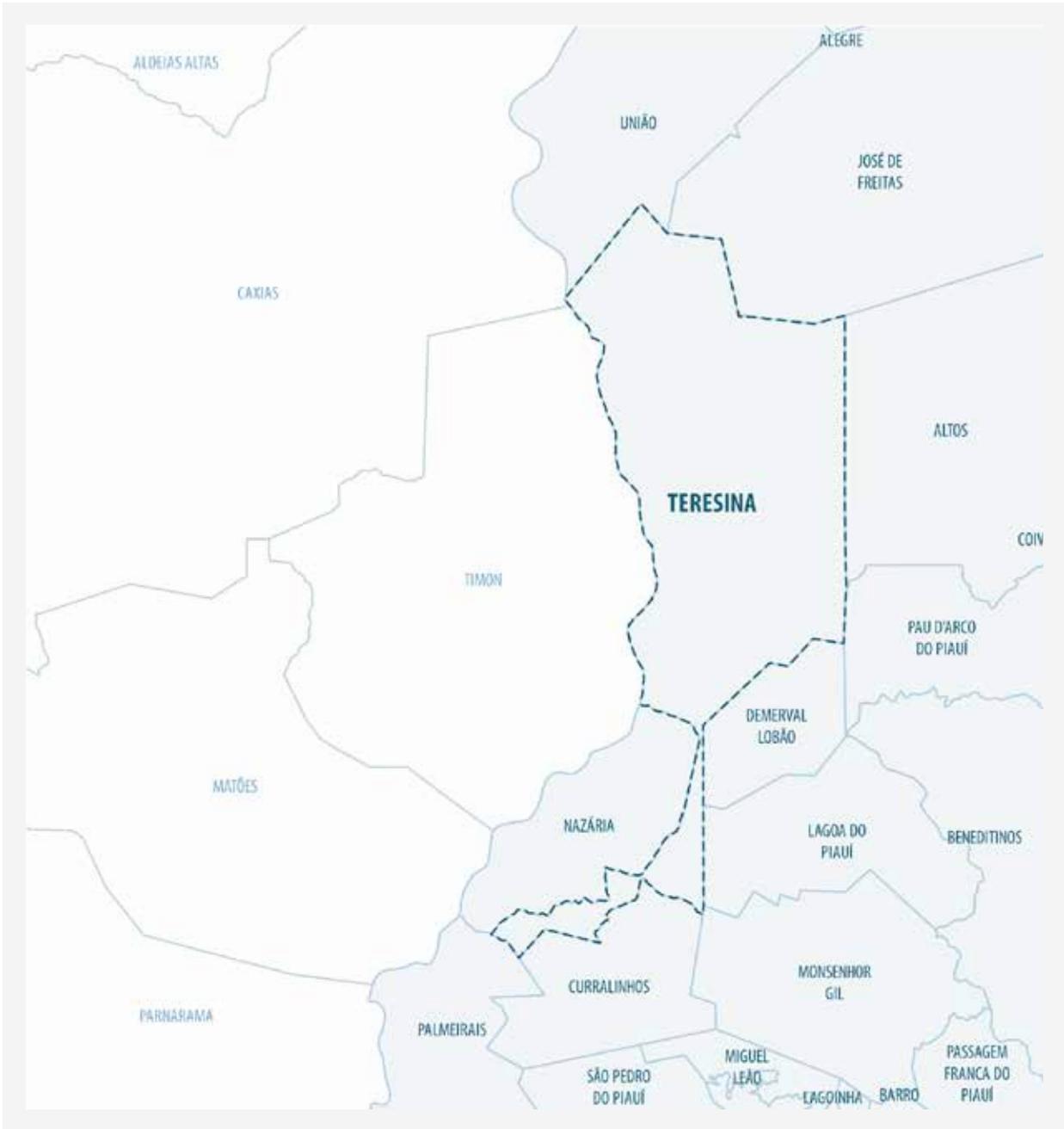


Figure 3: Teresina spatial location. Source: IBGE Brazil.



TERESINA | MUNICIPAL BOUNDARY

Municipal Location



Municipal boundary and neighboring municipalities

▭ Teresina Municipal Boundary.

Piauí State
 ▭ Municipal Boundaries

Maranhão State
 ▭ Municipal Boundaries

Source: Municipality of Teresina, IBGE Brazil



Figure 4: Municipal boundaries of Teresina. Source: Municipality of Teresina and IBGE Brazil.

Foundation of the City

Teresina has its origins at the confluence of the Parnaíba and Poti rivers. The oldest occupation was called Barra do Poti in 1760. The privileged location between the rivers was the passage route for merchants traveling from Oeiras, then the capital of Piauí, to Parnaíba, a city on the coast of the state. Trade and agriculture activities were developed in the region and small occupation was raised to the category of Vila, Vila do Poti, and later came to be called Vila Nova do Poti.

In the middle of the 19th century, the President of the Province of Piauí intended to change the capital of the Province of Piauí aiming at a more strategic location, with better access to waterway transportation, fleeing the arid backlands of the then distant capital Oeiras. Cities such as Campo Maior, Amarante, and Parnaíba coveted the position, however in 1852 Vila Nova do Poti was chosen to become the capital, from then on called Teresina. The definitive transfer of the headquarters took place on August 16 of the same year.

The new capital was the first in Brazil to grow in a geometric layout, designed by the President of the Province, José Antônio Saraiva. The city would be developed between rivers with parallel lines, symmetrically arranged, all starting from the Parnaíba River, towards the Poti River. The City Hall, public agencies, and Churches were the references for the following urban projects.

Population growth has proved to be a problem since the city's emergence. The organized city idealized by Saraiva did not support the large number of migrants arriving at Rua dos Viajantes coming from the interior of Piauí and from the neighboring provinces of Maranhão, Ceará, and Pará in search of better social conditions and fleeing the severe drought that hit the wild in the late 19th century.

Without infrastructure, sanitation, water, or energy supply, the newly arrived immigrants crowded into thatched houses on the outskirts of Teresina's center, which included high-end houses from the Teresian elite. According to records at the time, the huts were so close to each other that it was difficult for people to pass between them; sewage ran in the open, spreading disease. The conditions were conducive to tragedies and in the 1940s many fires occurred in the surroundings of Teresina due to the high temperatures that were already punishing us. There are also chances that they were arson because they usually started at the same time. However, the unquestionable fact is that thousands of people died and many others were made homeless due to the precarious living conditions at the time.

From the 1950s with President Juscelino Kubitschek's plans, Teresina has followed the strong national trend of accelerating population growth, spatial growth in a horizontal way, expanding urban limits to areas far from the center. The rise of agribusiness since the 1970s brought great prosperity to the large Brazilian producers with the replacement of labor by powerful agricultural machinery. Despite this, on the other side of the coin, there were hundreds of thousands of rural workers and small farmers who, in the face of hunger and unemployment, lost space in the countryside, from where they were forced to migrate to the already crowded urban centers, among them, Teresina.

Still during this period, during the military dictatorship, there was strong support from the federal government for urbanization, when there was a complete redesign of local architecture with the construction of important urban corridors, which are still relevant today, such as Avenida Marechal Castelo Branco, Avenida Maranhão, Avenida Duque de Caxias, "Albertão" Stadium, among others. The wave of gray infrastructure flooded "Cidade Verde", the city's old title, devastating our vegetation cover and increasing temperatures even more.

In this context, popular neighborhoods such as Buenos Aires and Água Mineral appeared. Their names refer to the distance from the center and the lack of basic instruments, such as water and energy supply and public transport, which until today is unsatisfactory, at that time it was non-existent.

The 1980s, known as the lost decade, brought a strong economic crisis with stratospheric levels of inflation and unemployment. The city was growing, but its infrastructure remained below the Teresian needs. Favelas multiplied and were made up with the name of village-neighborhood. There, vulnerabilities were externalized and the population suffered from diseases, floods, and complete abandonment.



Image 3: São Benedito Church. Early 20th Century. Source: Arquivo Público do Estado do Piauí.



Image 4: Parnaíba River, Teresina (PI) - 1957. Source: IBGE.

Functions of the City

Teresina is the main city in the Integrated Development Region of Greater Teresina, concentrating most of the territory's resources and opportunities. However, there is not much diversity in local activities. To a large extent, it can be said that the main activities of the city are related to public services, commerce, health and education.

In this sense, it is important to highlight the health area, as according to a recent IBGE survey, Teresina is the Brazilian city with the largest number of trips to highly complex health services, being the destination of 300 Brazilian cities. Education here is also a national reference. We are the city with the highest IDEB score for early childhood education among Brazilian capitals. Private schools in the city always perform excellently on national exams. Strong trade also generates many job opportunities and all of these factors contribute to a significant commuting to Piauí capital. 2010 IBGE data indicate that Teresina was the destination of 8568 commuting movements made for study purposes and 19373 for work reasons.

The data show the great responsibility that it is to think about resilience and sustainability for Teresina due to its role in the region and reinforces the need to search for integrated and innovative solutions that result in impacts not only within territorial limits, but in all the surroundings.

Teresina key data	
Area	1.301km ²
Altitude	72m
Climate (Köppen-Geiger)	Aw Tropical Savanic
Average temperature	27,6°C
Annual Precipitation	1.349 mm
Municipality Area	1391,99 km ²
Urban area	263,94 km ²
Population	864.845 (2019)
Population Density	621,72/km ²
Life expectancy	74,2 years
Official Languages	100% Portuguese
Mortality rate	0,6%
Infant Mortality	1,62%
Illiteracy rate	8,78%
GDP / Municipal Capita	USD 3.889,09 (2017)

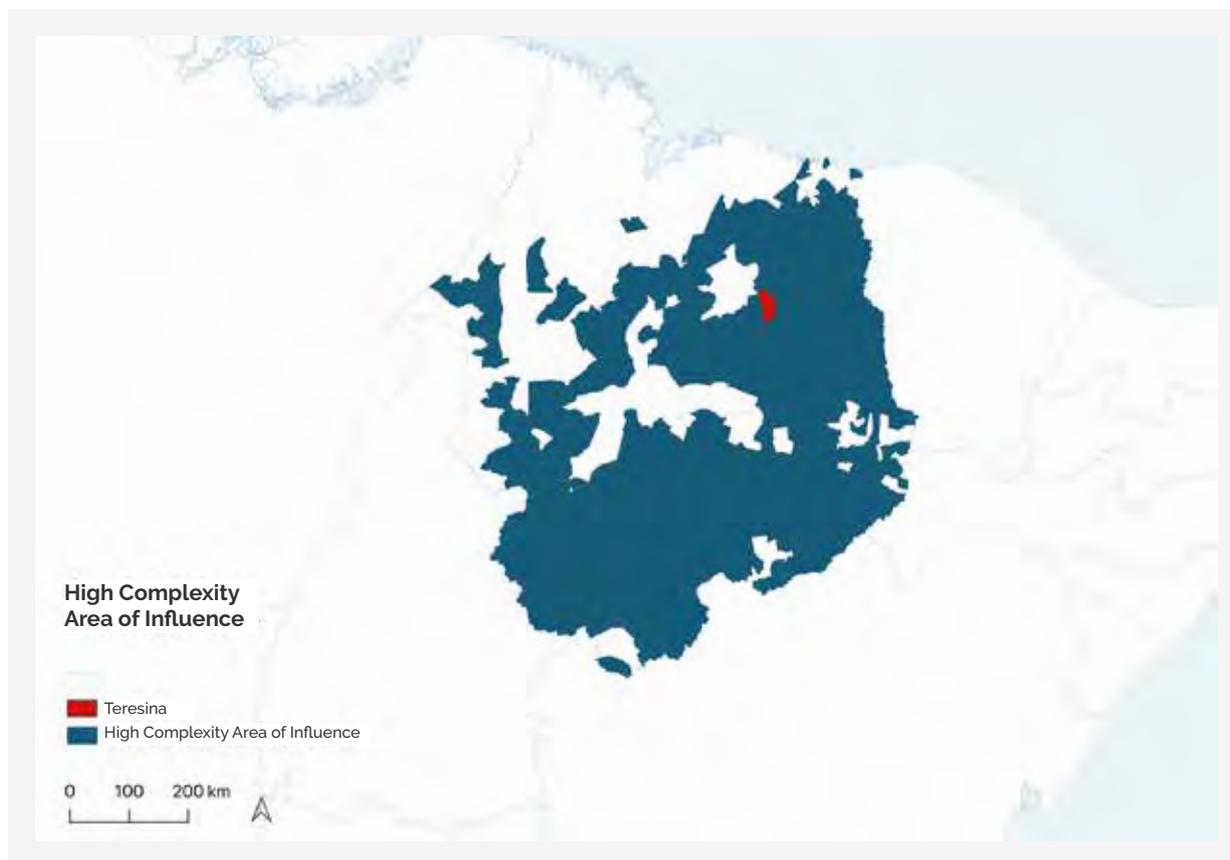


Figure 5: Area of Influence of High Complexity Health Services. Source: CRGP, with data from IBGE (2018).

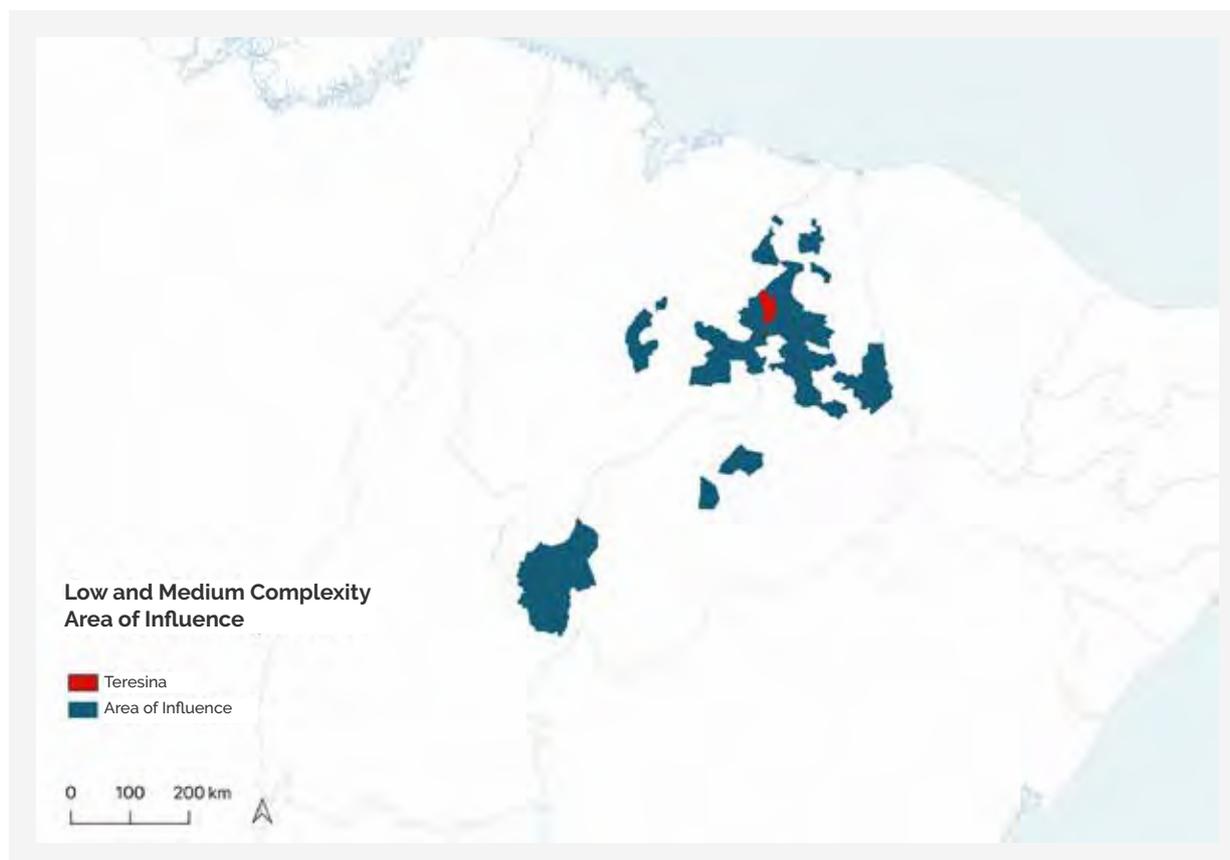
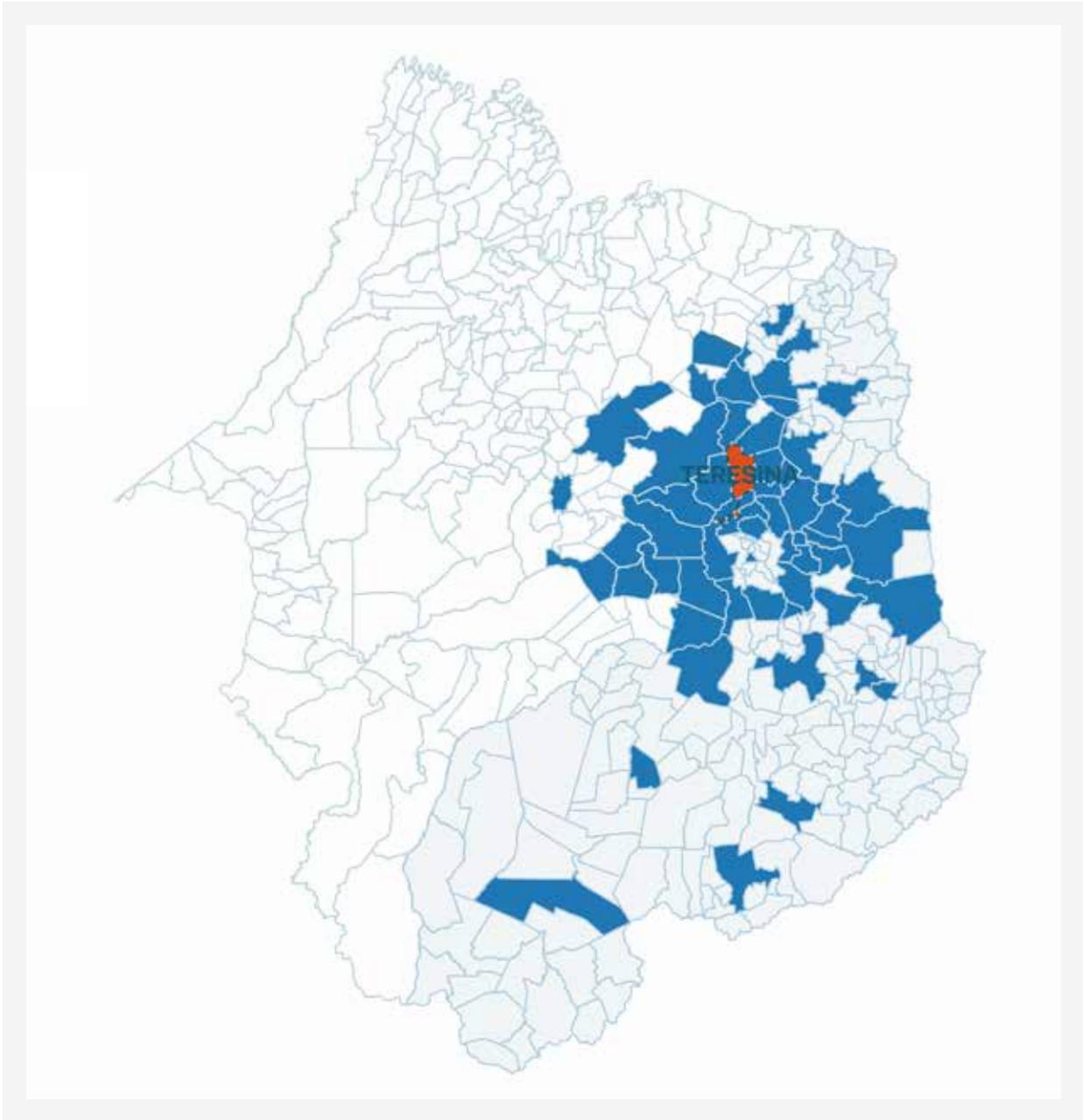


Figure 6: Influence Area of Medium and Low Complexity Health Services. Source: CRGP, with data from IBGE (2018).



TERESINA | INFLUENCE AREA

Municipal Location



Influence Area for Shopping

▭ Teresina Municipal Boundary

Piauí State

▭ Municipal Boundaries

Maranhão State

▭ Municipal Boundaries

Source: Municipality of Teresina, IBGE Brazil

0 50 100 km

N

Figure 7: Teresina Trade Influence Area. Source: CRGP, with data from IBGE (2018).

1.2. Population and Demographics

The last national census in Brazil was carried out in 2010 and found that the country's population was 190,755,799 inhabitants. Now, the population estimated for 2019 by the IBGE was about 210,147,125 inhabitants, an increase of more than 10.16%. Of this total, approximately 48.97% were men and 51.03% were women in 2010.

Teresina's Population

Based on the most recent national census (2010), Teresina has a population of approximately 814,230 inhabitants. Of this total, approximately 46.75% were men, and 53.25% were women. The urban population represented 94.27%, while the rural population 5.73%.

Although the city experienced rapid growth among the national censuses of 1960 and 1990, increasing its population by more than 70% in 1980 (57.28% - IBGE, 1960, 54.52% - IBGE 1970, 71.34% - IBGE 1980, 58.63% - IBGE 1990), there was a reduced growth rate in the last decades, with 9.38% in 2000 and 24.22% in 2010. This rate decrease was noticeable for 2019, with a population estimated by the IBGE of 864,845 inhabitants, representing an increase of only 6.22% - below the Brazilian average.

Regarding race, 60% self-declared mixed-race; 26,19% white; 11,00% black; 2,49% asian; and 0,21% indigenous people. The predominant religion is the Christianity - about 93,80% of the population self-declared to be Cristian; 4,49% answered the don't have a religion; 0,85% identifies with Spiritism; and 0,30% with African Matrix Religions; among others of reduced representativeness.

Population	
Population	864.845 (2019)
Density	621,72 hab/km ²
Life expectancy	74,2 years (IBGE, 2010)
Race	60% mixed-race; 26,19% white; 11,00% black; 2,49% asian; and 0,21% indigenous people.(IBGE, 2010)
Predominant religions	Christianism (93,80%); Without Religion (4,49%); Spiritism 0,85%); African Matrix Religions (0,30%); among less expressive others. (IBGE, 2010)
Schooling 6 to 14 years	97,8% (IBGE, 2010)
Mortality rate	0,6%
Child mortality rate	1,62%

Households Information

According to the last national Census (IBGE, 2010), there were 222.154 households in the city. The land tenure types were distributed in the following way: 79,65% owner-occupied; 13,51% rented; 5,55% lent by employer or others; and 1,29% under other conditions. The predominant household typology is single houses that represent 90,36% of total habitations. The other typologies were apartments (8,20%); House in Villas or Gated-Communities (1,17%); and tenement housing were about 0,27%. The most prevalent construction materials are masonry (bricks), being 42,75% stucco brick walls and 25,63% with unfinished exposed bricks. The second most common type is made from vernacular techniques, as wattle and daub cob wall - were 12,42% has a finishing layer, and 13,69% are raw. Additional materials, as makeshift wood, straw houses, and others represent 5,49%.

Regarding the occupancy, 26,23% of the housing had less than 2 dwellers; 61,84% had between 3-5 residents; 11,93% had more than 6 residents. The density of residents per dormitory was 34,5% with 1 or less residents/dormitory; 48% between 1-2 residents/dormitory; 13,65% between 2-3 residents/dormitory; and 3,78% with more than 3 residents/dormitory.

Households Information	
Household Occupancy	1 Dweller: 8,55%
	2 Dwellers: 17,68%
	3 Dwellers: 23,32%
	4 Dwellers: 24,22%
	5 Dwellers: 14,30%
	6 or More Dwellers: 11,93%
Housing Tenure Types	Rented 13,51%
	Owned 79,65%
	Lent 5,55%
	Other conditions: 1,29%
Housing typologies	Single House 90,36%
	Multi-Unit Single Building Housing (Apartments) 8,20%
	Housing in Villa or Gated Community 1,17%
	Tenement Housing 0,27%
Housing Materials	Stucco Brick Walls 42,75%
	Exposed Brick Walls 25,63%
	Wattle and Daub Cob Walls 26,11%
	Others 5,49%
Density of Residents/ Dormitory	1 or less: 34,5%
	1-2: 48,00%
	2-3 13,65%
	Above 3: 3,78%

1.3. Spatial Dimension

The spatial dimension overview offers a summary of factors that shape the geographic space and urbanisation of the city. In this section we highlight the main information that characterizes the Climate, the Ecosystem, Urbanization, Water Supply, Energy, Basic Sanitation, and Mobility.

Climate

Due to specific factors such as continental geographical location and altitude in relation to sea level (below 100 m), the temperature in Teresina does not suffer significant variations throughout the year. Located close to the Equator, the sun's rays fall on the city with an angle close to 90°, which results in intense radiation, so Teresina is in a zone of tropical savanna climate with high temperatures during most of the year.

The most intense heat occurs from September to December (dry winter) and this period is characterised by maximum temperatures above 40° C, with relative humidity reaching 20%. It causes thermal discomfort and low labour productivity. Also, it increases the incidence of respiratory illnesses, in addition to causing spontaneous fires in several points of the urban and rural areas (see: distribution of fire alerts). The months of February and March are those with the highest air humidity, and August to October, with the smallest averages.

Climate and Ecosystem	
Climate	Aw - Tropical Dry Winter Savannah
Altitude	72m
Average temperature	27.6°C
Highest recorded maximum	41.1 ° C (October 24, 2012)
Average Annual Precipitation	1,349 mm
Highest Accumulation Accumulation	138.2 mm (24 November 1966)
Ecosystems	Seasonal Mixed Semi Deciduous Forest: contact area between Cerrado and Mata dos Cocais Tropical

Table 5: Climate and Ecosystem. Source: CRGP, with data from IBGE.

The average annual precipitation is approximately 1349 mm, with concentrated rainfall during the rainy summer, that is, between January and May, and with a few rain showers starting in November, with March being the month with the highest average accumulation of precipitation.

The highest accumulation of precipitation recorded in 24 hours corresponds to 138.2 mm, on November 24, 1966. The predominant rainfall regime in Teresina is torrential, due to the conditions of regional circulation of air masses. It defines variations of the ITC (Intertropical Convergence) position, which are characterised by the meeting of the North, Equatorial Continental and the Atlantic Masses. Torrential rains are marked by intensity and speed, which results in flash floods throughout the city. In the municipality, convective rains also occur, which generally fall in a punctual and discontinuous manner in space (PMSB, 2018).

Notwithstanding, the average temperature in Teresina increased by 2° Celsius in the last century, at a rate twice higher than the global warming average, which is 1°C. The trend is that the temperature will rise even more, while the relative humidity of the air will continue to decrease.

Ecosystems

According to the IBGE Biomes map (2003), Teresina is part of the Cerrado Biome, the second largest ecosystem in South America, occupying about 22% of the national territory, characterised by medium and dense vegetation cover. The Cerrado has a rich abundance of endemic species but suffers a constant loss of habitat due to anthropisation processes.

The Municipality of Teresina is located in an intersectional area between Cerrado and Mata dos Cocais, with mixed seasonal semi-deciduous forest vegetation. Brazilian seasonal forests are classified as semi-deciduous when the percentage of tree individuals defoliated in the dry season is between 20% and 50% of the total. The dual climatic seasonality is also a condition of the ecological concept of this type of vegetation, including a tropical season with intense summer rains, followed by a season of severe drought (IBGE 1992).

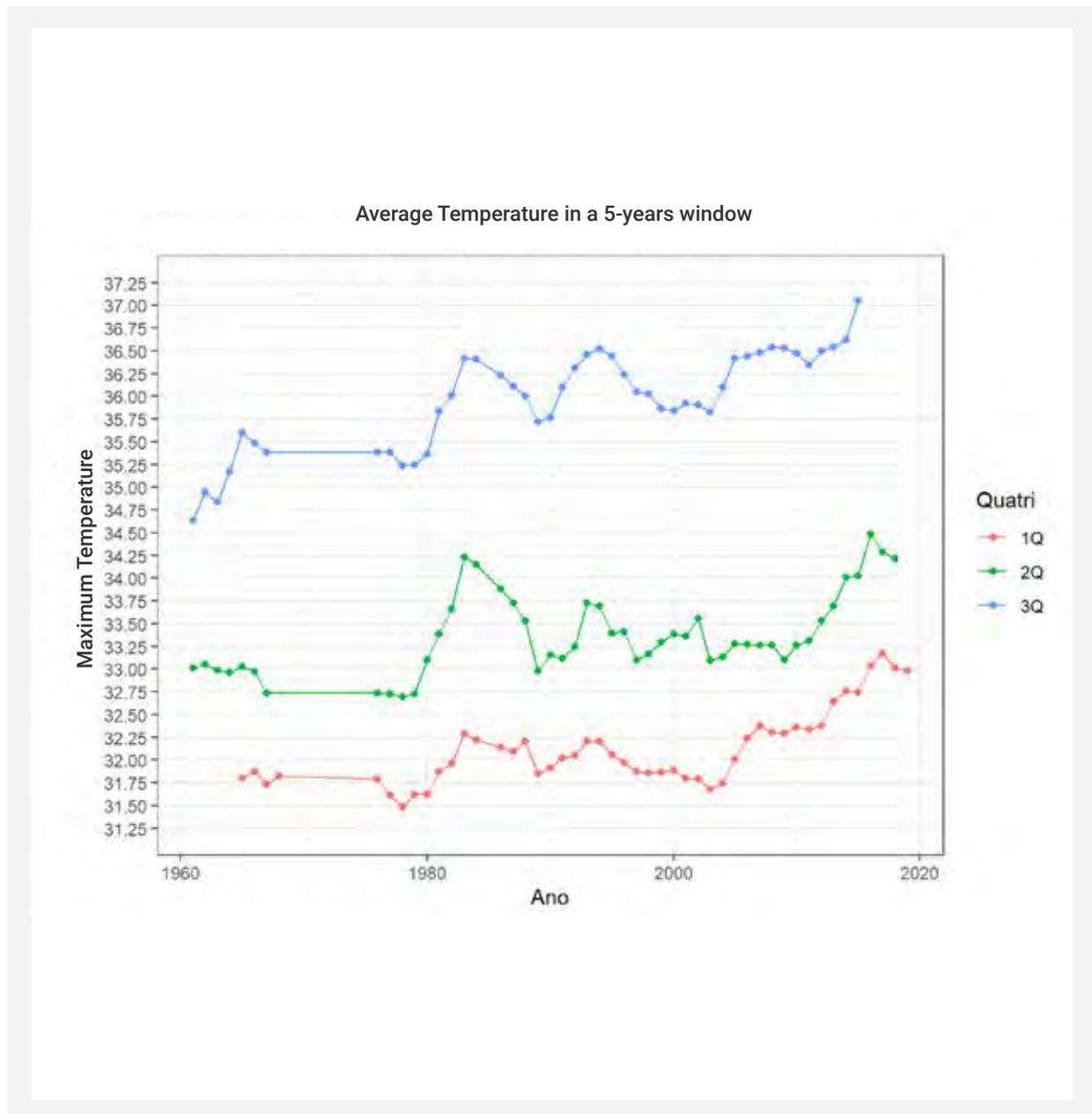


Figure 8: Maximum temperature averages with a 5-year window, per year and per four-month period. Average annual rainfall with a 3-year window. Source: CRGP, with data from INMET (2020).

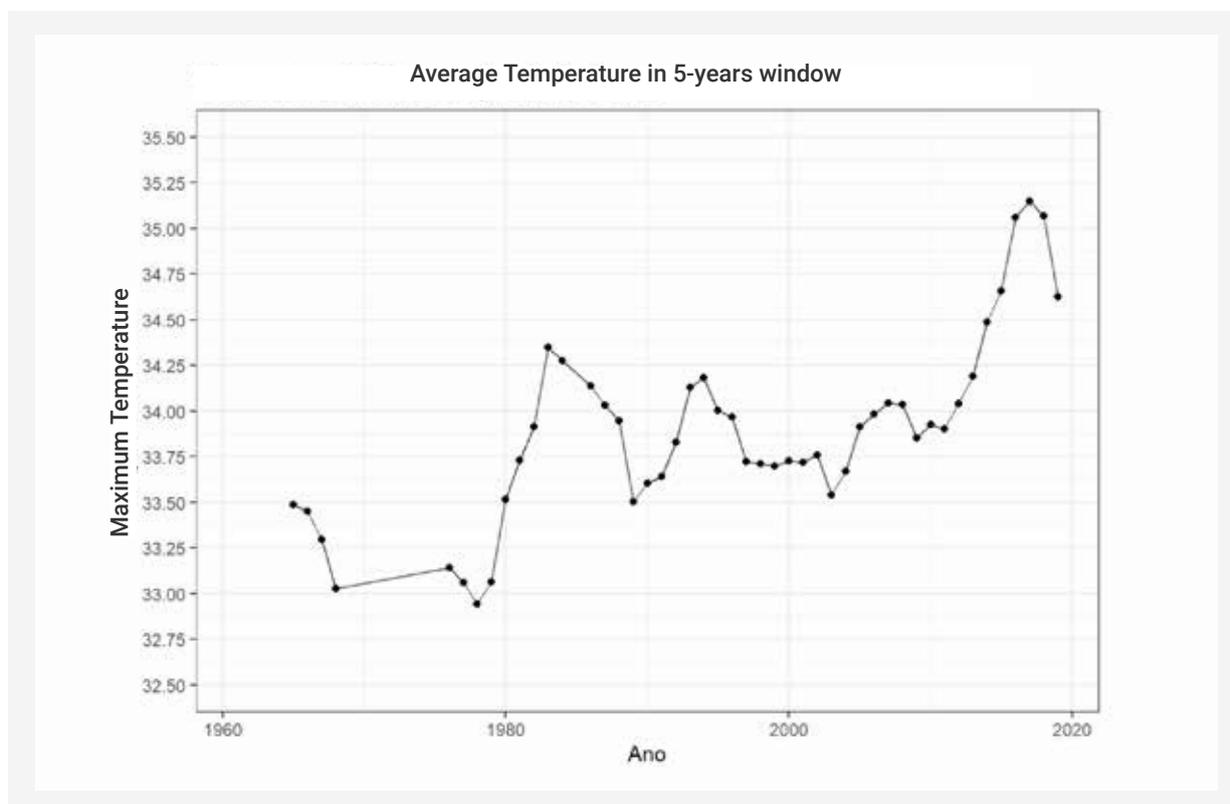


Figure 9: Maximum temperature averages with a 5-year window, per year and per four-month period. Source: CRGP, with data from INMET (2020).

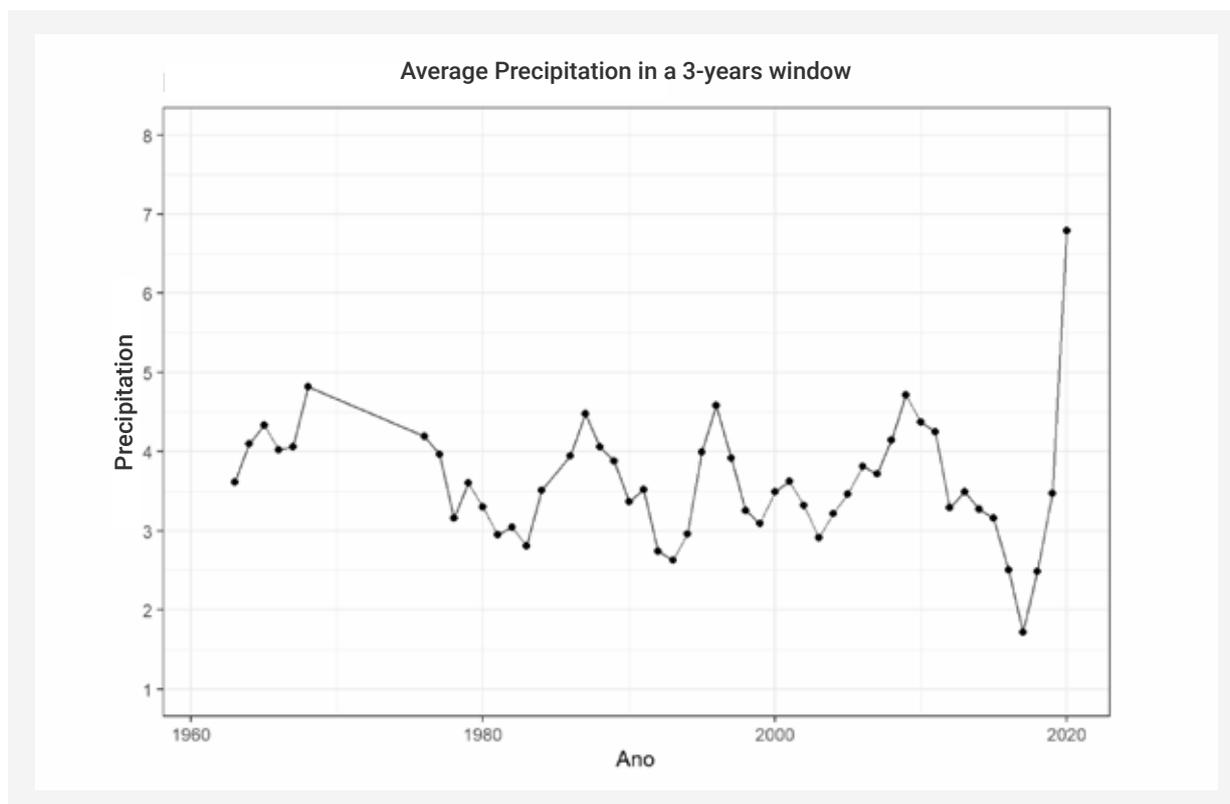


Figure 10: Average annual rainfall with a 3-year window. Source: CRGP, with data from INMET (2020).

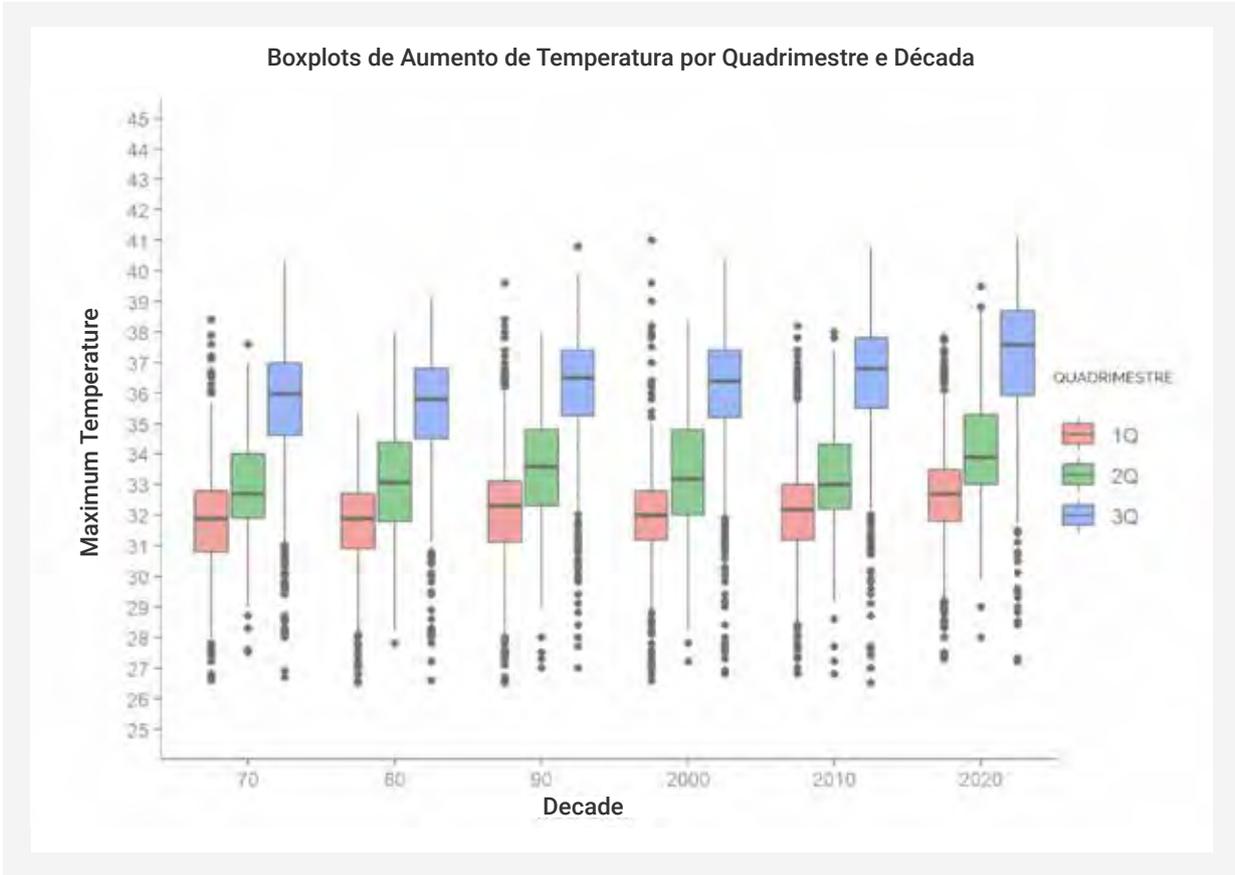


Figure 11: Increase in maximum temperatures per four-month period. Source: CRGP, with data from INMET (2020).

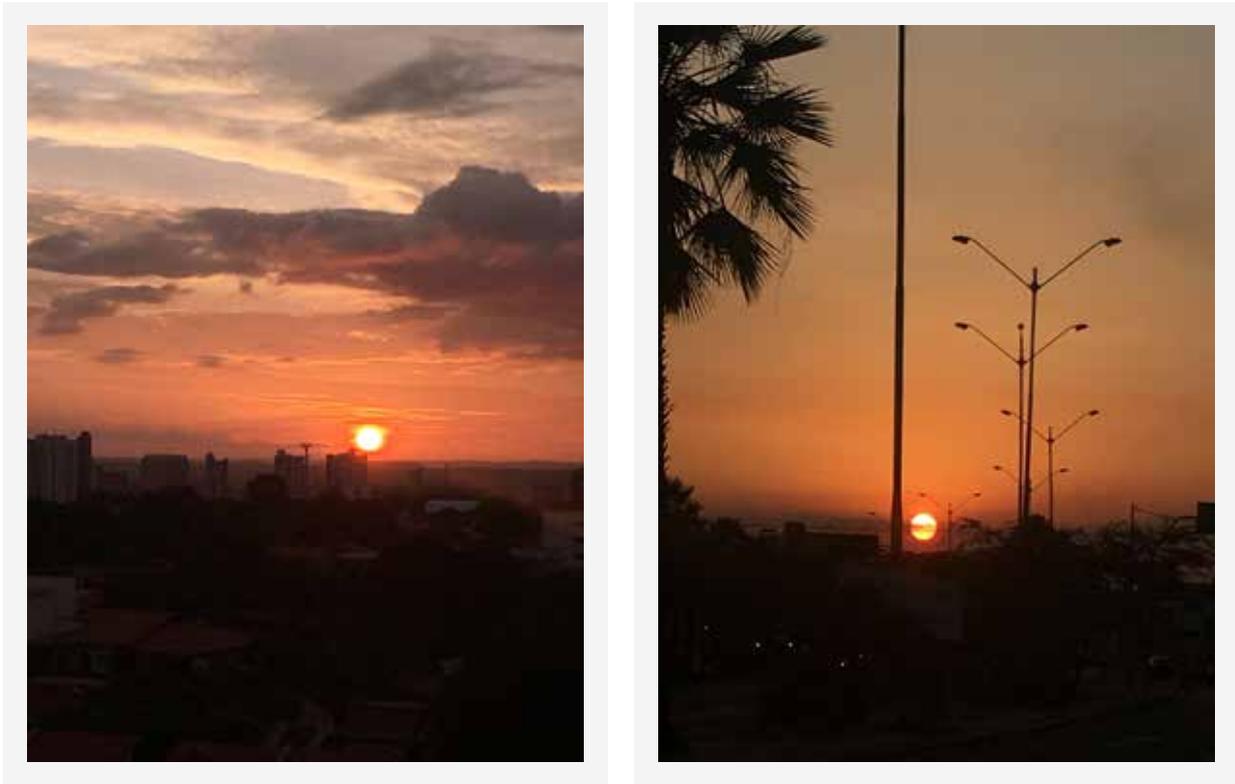


Image 5/6: City of Teresina during the 3rd Quadrimester. Source: CRGP (2019).

Water Provision

The Municipality of Teresina has its administrative limits within three sub-basins of the Parnaíba River: the Longá river basin to the North, the Parnaíba II basin and the Poti River basin (where most of the urban perimeter). About 75% of the Parnaíba basin area is located in the State of Piauí, 19% in Maranhão and 6% in Ceará. Teresina is crossed by two rivers (Poti and Parnaíba) and its streams, making up a total of 70 micro basins. Thus, a considerable part of its territory is classified as an area prone to floods, floods and landslides.

Since July 7, 2017, Águas de Teresina is the concessionaire responsible for the water supply service in the municipality. The company currently serves 853,463 people with treated water (99% of the population). The concessionaire aims to universalise water supply in up to three years and reduce the loss rate from 59% to 25% in 10 years, avoiding the waste of 4,304,541 m³ per month. The company's term of operations in the municipality is 30 years, and pledged investments are about R\$ 1.7 billion.

Teresina has two Water Supply Treatment Plants: ETA Sul and ETA Norte, both drawing water from the Parnaíba River. Besides, the treated water supply system in the city has 75 additional active deep tubular wells; about 2470 km of distribution network; 19 water pumping stations; 32 large reservoirs and 53 small reservoirs. The water consumption tariff structure in Teresina is divided into metered and non-metered connections. Hydro-metered connections have different tariffs according to the type of activity (Residential Subsidised and Non-Subsidised, Small Commerces, Commercial, Industrial and Public) with lower prices for smaller consumption ranges. Non-metered connections are charged according to use (residential, commercial, industrial, and public).

Power

The primary source in the Teresina energy matrix is the hydroelectric, produced at the Boa Esperança Plant. The plant is located approximately 340 km south of the capital, on the banks of the Parnaíba River. Electricity distribution in Teresina is under the responsibility of Equatorial Piauí, which serves 224 other municipalities in the State.

In the capital, the company serves 377,147 consumer units (equivalent to 99.79% of the population) with service at 220V and 60Hz, at low voltage, and 69KV at high voltage. Based on data from Equatorial Piauí, the company points as the main threats for energy distribution operations: increasing tariffs during economic crisis periods directly reflecting on energy consumption reduction; annual consumption retraction (1.59% of the commercial users, directly related to the Free Contracting Environment scheme migration); and hydrological risks.

Teresina follows the Tariff Flags System, established by ANEEL (National Electric Energy Agency) in January 2015. It aims to signal to consumers the real costs of electricity generation, using colour-coded tariff schemes (green, yellow and red) to inform additional costs to energy production and distribution.

The average electricity tariff in the State of Piauí corresponds to R\$0.569/ kWh (equivalent to approximately 0.10 USD/ kWh), slightly above the national average of R\$0.560/kWh (equivalent to approximately US\$0.10/kWh). The Electricity Social Tariff (TSEE) is a special discount on the electric bills created by the National Government, aiming to support low-income families.

As for the participation of other renewable energy sources in the internal energy supply matrix, a total of 7,450.20kW of solar energy was produced in Teresina in 2018.

Water Provision and Power

Hydrological sub-basins	Rio Parnaíba II, Rio Poty and Rio Longá
Number of Micro-Basins	70
Water supply	over 99% of the population
Main Energy Sources	Hydroelectric Plant (Usina BoaEsperança)
Participation of alternative sources of clean energy	Solar: 7 450.20 kW
Electricity Coverage	99.79% of the population

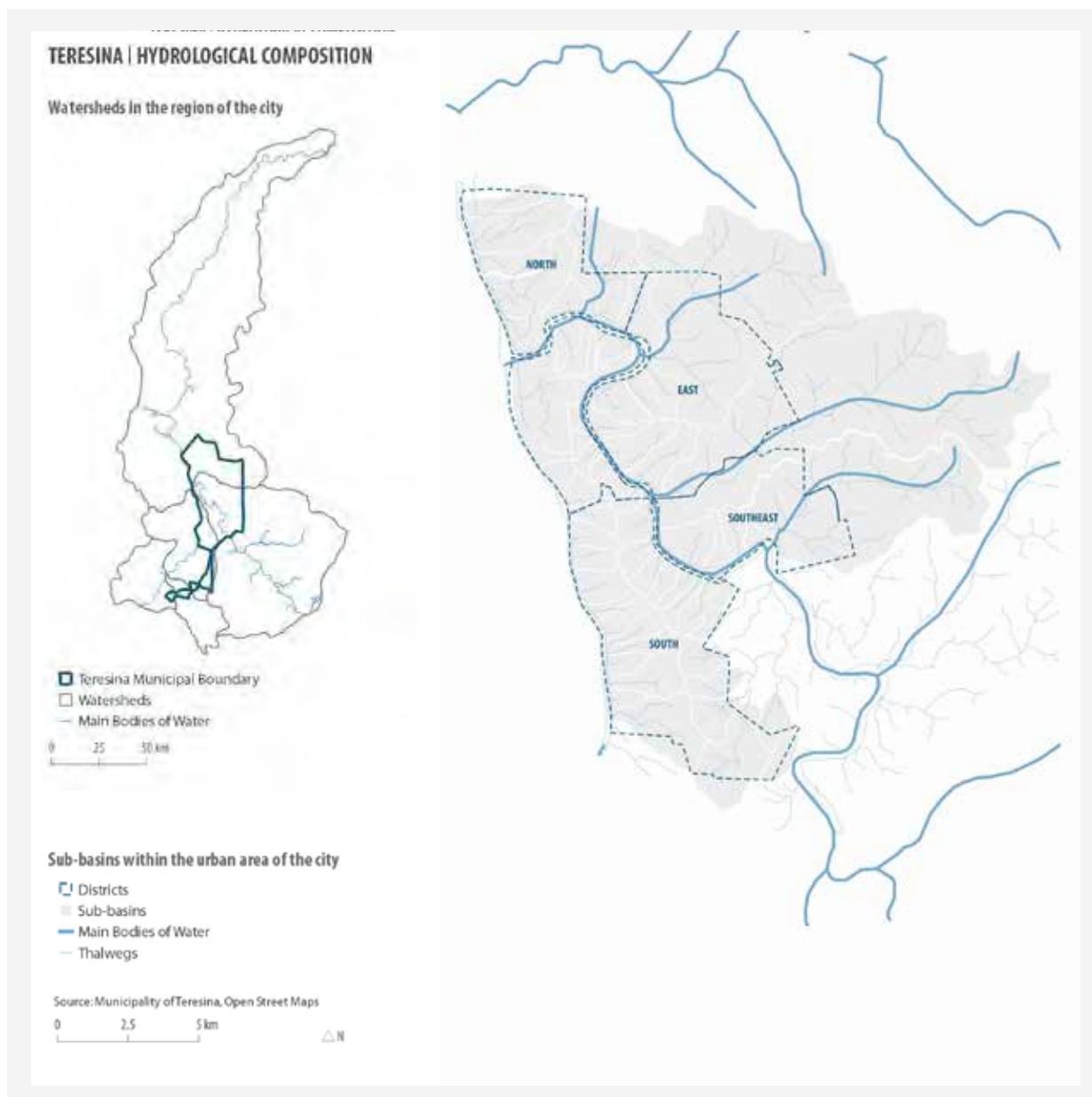


Figure 12: Hydrological Composition. Source: CRGP, with data from the PMT (2019).

Wastewater Treatment

In addition to the water supply service, Águas de Teresina is also responsible for sewage treatment in Teresina. The Sewer network reaches 269,039 residents in the municipality, that is, only 31% of the total population, through 505.14 km of the collection system. According to the Teresina Municipal Basic Sanitation Plan (2018), the city's sewage system consists of:

17 Sewage Lift Stations (EEE): Sewage Lift Stations (EEE) are installations capable of transporting sewage from a suction or inlet level to a discharge or outlet level. It has the function of lifting grey waters in lower levels and depression areas.

5 Interceptors: Interceptors are pipes installed along with watercourses with the function of receiving and leading the collected sewage to outfall installations, which, in turn, leads to the treatment plants.

3 Sewage Treatment Stations (ETE in the Portuguese acronym): Various operations and processes are used in sewage treatment units to separate suspended and dissolved pollutants and water to be discharged into the receiving body - one of which is stabilisation ponds. The Teresina ETEs are East ETE, Pirajá ETE and Alegria ETE. East and Alegria ETEs discharge their effluents into the Poti River, and ETE Pirajá discharges them into the Parnaíba River.

Wastewater Treatment	
Sewerage Coverage	31% of the population
Sewerage Extension	505.14km
Annual Volume of Wastewater	22,727,000 m ³ / year
Annual volume / Inhabitant	76.42 liters / day
% without access to any type of sewage system	2.65% (IBGE, 2010)
% rudimentary sanitation (ditches, rudimentary pits, etc.)	35.50% (IBGE, 2010)

The best-served neighbourhoods are those located close to ETEs, such as Frei Serafim and Vila Operária (both with 96%), Jockey and São Cristóvão (both with 95%). Due to the lack of infrastructure, the option available to residents of urban and rural areas without sewage network coverage is individual sewage systems, such as septic tanks, sinks and infiltration ditches.

According to the Teresina 2030 Agenda document (2013), of the 112 neighborhoods in the municipality, only 15 reached a rate higher than 70% of the sewage service - however, with the expressive increase in the network in recent years, these values need to be revised. Due to the lack of infrastructure, the option available to residents of urban and rural areas without sewage coverage are individual sewage systems, such as septic tanks, sinks and infiltration ditches.

In the urban area, individual sewage treatment systems are the majority. According to IBGE (2010), there were about 210,000 urban permanent private households; which 41% have a septic tank system and 31% have a rudimentary cesspool system. The survey, however, does not provide information on the conditions of these systems. It is estimated that, in the urban area of Teresina, a total volume of 22,712,000 cubic meters of sewage is produced per year, which is equivalent to approximately 76.42 liters per inhabitant / day. The sewage tariff, managed by Águas de Teresina, corresponds to 80% of the water supply consumption bill.

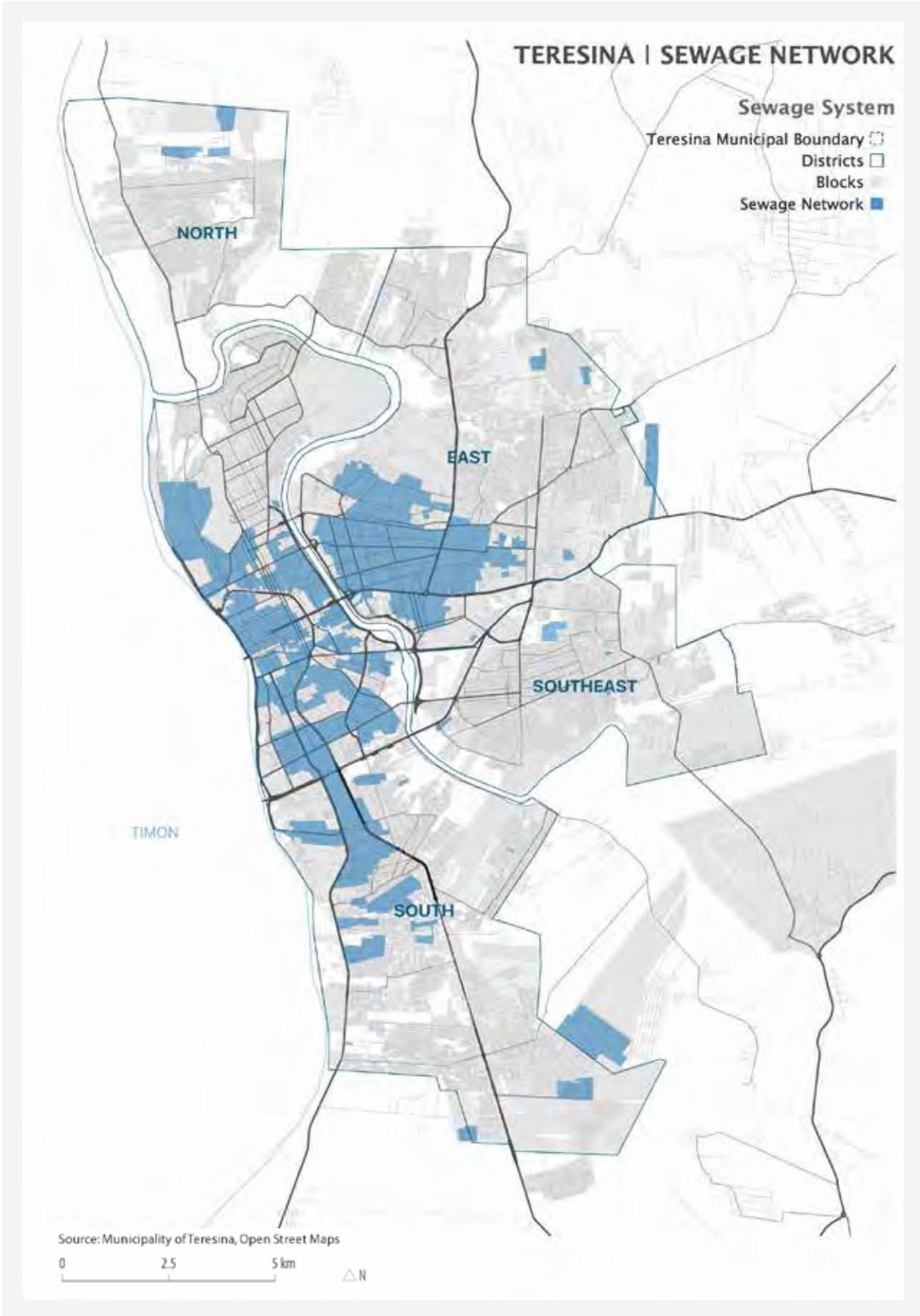


Figure 13: Coverage of the Sewerage Network. Source: CRGP, with data from the PMT and Open Street Maps (2019).

Waste Collection and Recycling

Teresina generates, on average, daily 1,200 tons of garbage (household waste, public waste, health waste, remains from open markets, tree pruning, etc.). When considering only household waste, this value is 543 tonnes/day. In 2018, the city's garbage services collected a total of 209 312.25 tons of waste.

Household, public, recyclable and hospital waste collection (from municipal health units) is carried out by two concessionaires hired via municipal public bidding processes: the Teresina Ambiental Consortium - CTA; and Sterlix Ambiental Piauí Tratamento de Resíduos Ltda. CTA carries out the conventional collection, and STERLIX carries out the collection and treatment of hospital waste produced by Municipality Health Units. Due to the weight of the health sector activities in Teresina, in 2018 the sector produced about 0.61 tonnes/per capita of special waste (Hospital), representing a total of 528.4 tons, from which 100% received adequate treatment.

The estimated population served by the garbage collection is 817,455 people. The service hires about 389 employees and uses 33 special vehicles (compacting trucks and other specific vehicles for hospital waste collection). All the households collected waste is sent to the city's controlled landfill.

In Teresina, there is also a waste recycling programme operating with the support of cooperatives and waste pickers. The program aims to promote the recycling of paper, plastic, glass and metals. The Municipality offers several recycling points with segregated bins spread in the city, where the local population can deposit separate waste. There is a service to collect this waste and take it to recycling cooperatives. At the recycling cooperatives and associations, the materials are screened and prepared for commercialisation. So far, there are 21 voluntary recycling collection points, with nine 10 m³ stations, and twelve 1.20 m³ stations. Door-to-door collection services to larger users (condominium, companies, institutions, bars, hotels, and bigger commercial establishments) are also in place to facilitate and promote recycling habits, requiring prior registration and scheduling.

According to statistical data from the Department of Urban Development and Housing - SEMDUH, 2.85 tons of recyclable waste are collected per day, which corresponds to 0.54% of total household collection waste. In 2018, the total recyclable waste collected was 829.96 tons

Waste Collection and Recycling	
Household Garbage Collection Coverage	94.52%
Daily Waste Generation	1.2 ton / day
Daily Residential Generation	543ton / day
Annual Waste Generation	312.25 ton / year
Hospital Waste Generation	528.4 ton / year
Recycling Collection Points	21 Voluntary Delivery Points
Recyclable Waste Collection	2.85 ton / day
Annual Recyclable Waste Collection	829.96 ton / year
Data SEMDUH, 2018	

Urban Area

The city of Teresina builds its urban spaces amid its two rivers, Parnaíba and Poty. The urbanized area of Teresina, by the time of its foundation, began on the right bank of the Parnaíba River. As the city developed it gradually expanded to the North, meeting the earlier established settlement of Vila Velha do Poty - located by the Rivers mouth, to the east - towards the River Poty, and further towards the south - filling the space between rivers.

The built area of the city remained stable during its first decades of existence. However, in the last decades of the 20th century, it faced a fast-paced low-density urban sprawl. The statutory urban perimeter underwent several amendments to comprise new developments until reaching the current 264km². Besides the sprawl, the urban area remains a modest share of 18.9% of the total municipal area of about 1392km². The remaining 81% forms the rural area, mainly formed by scattered occupation and scarce economic activities, implying in most of its territory in native vegetation. Since 2015 the urban perimeter has been frozen to favour density development and occupy vacant urban lands.

Despite the increment in land consumption, vacant lands inside the urban perimeter remain significant inside the city's urban perimeter. Considering the total urban boundary, the share of the territory under urbanised conditions (parcelled land connected to the road network) is about 75.7%. Notwithstanding, the occupation is significantly low; total buildings footprint is around 14.1%.

The local zoning code covers the urban perimeter entirely. It is a positive incentive to orderly development in compliance with the city's urban planning guidelines. The city is in the process of approving the new local master plan, which changes the current zoning map (shown below). It is going to replace the current instrument characterised by the strong segregation of urban activities - characteristic of modern Brazilian planning from preceding decades - with more flexible mixed-use systems with a focus on mitigating uncomfortable uses. The new master plan also prioritises enhancing urban density and protecting risky areas or demanding constrained urbanisation.

Urban Area	
Municipality Area	1391.99 km ²
Urban area	263.94 km ²
Urbanised Area	199.9 km ²
Buildings Area	37.20 km ²

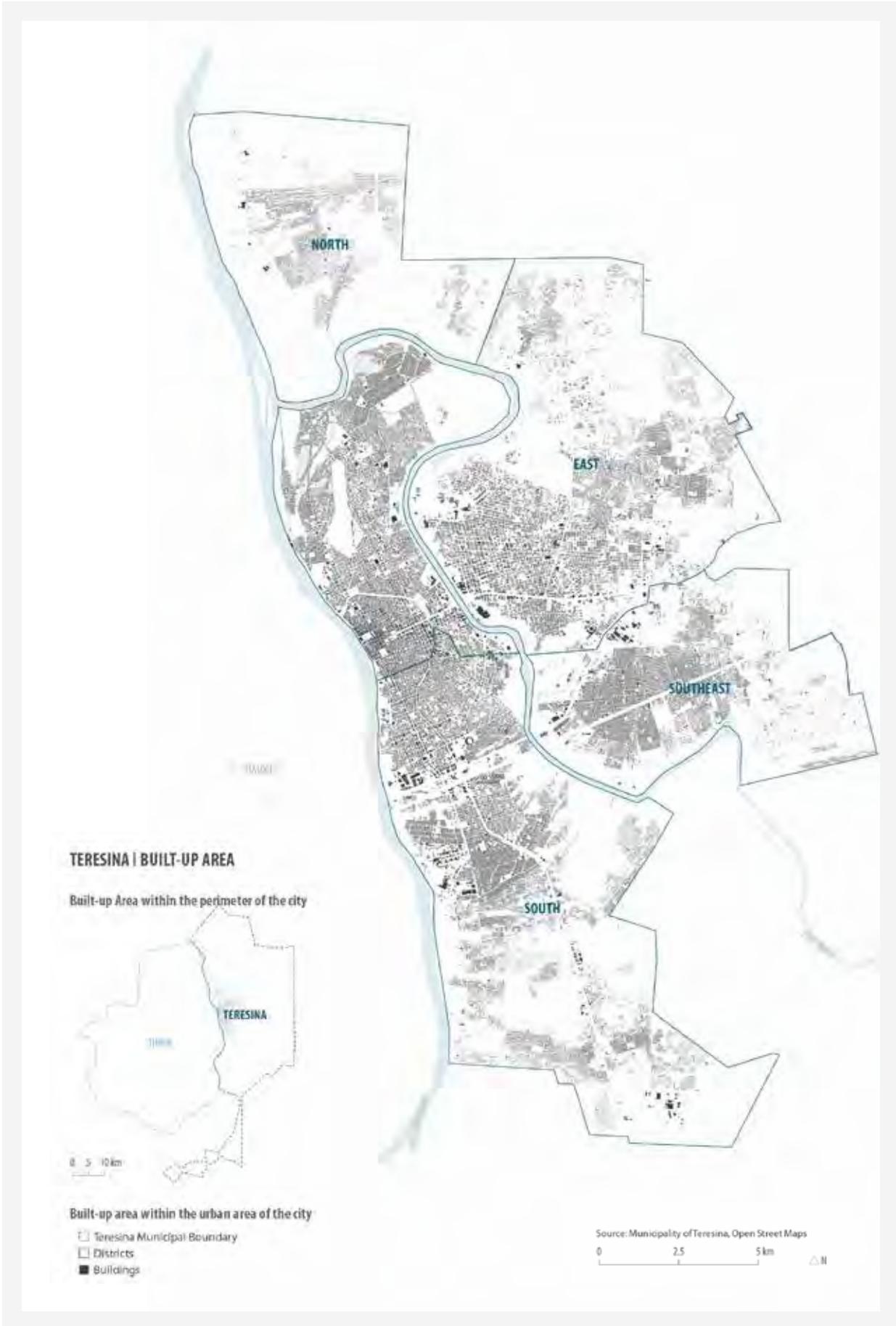


Figure 14: Teresina built area. Source: CRGP, with data from PMT and Open Street Maps (2020).

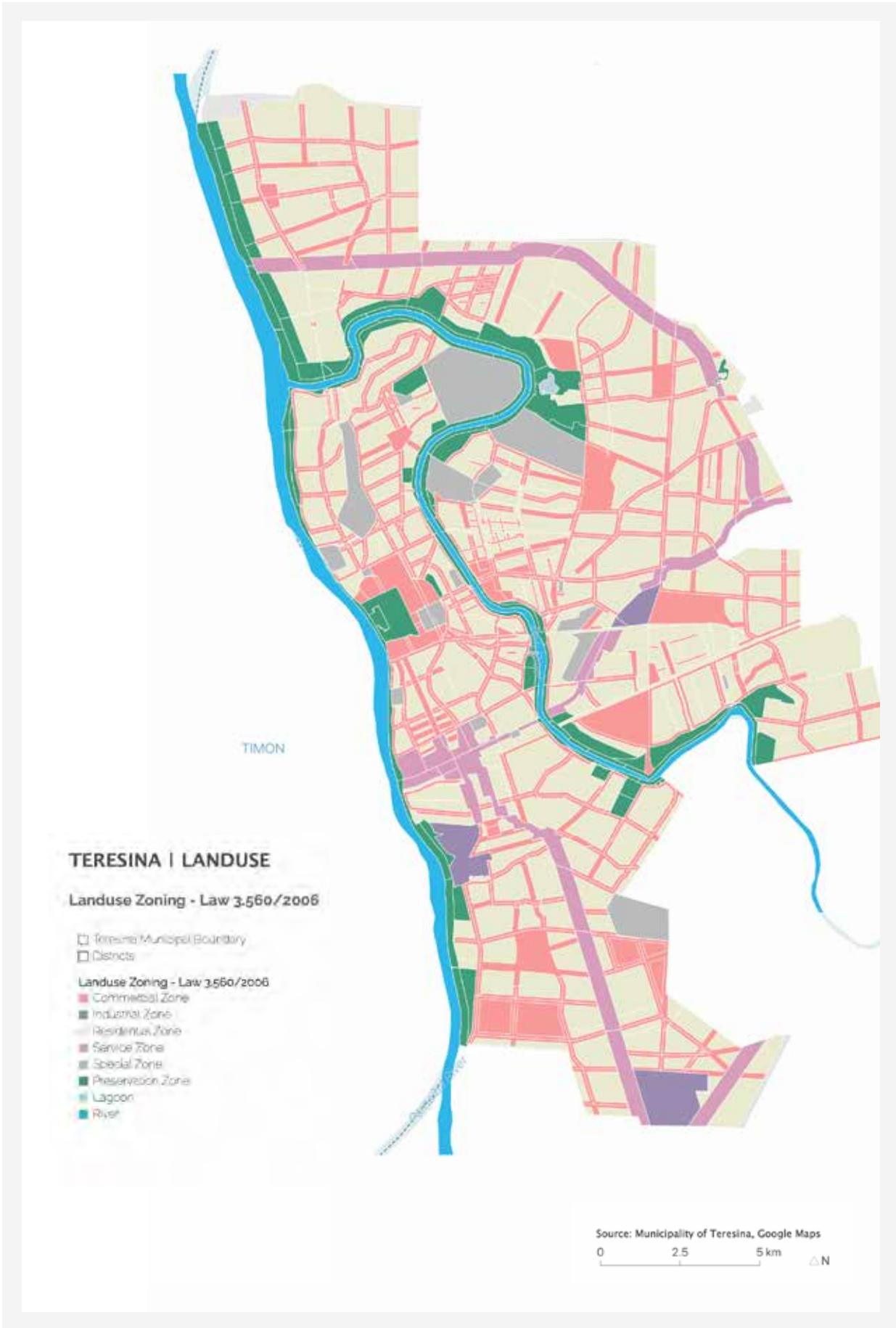


Figure 15: Teresina Zoning Map. Source: CRGP, with data from PMT and Google Maps (2020).

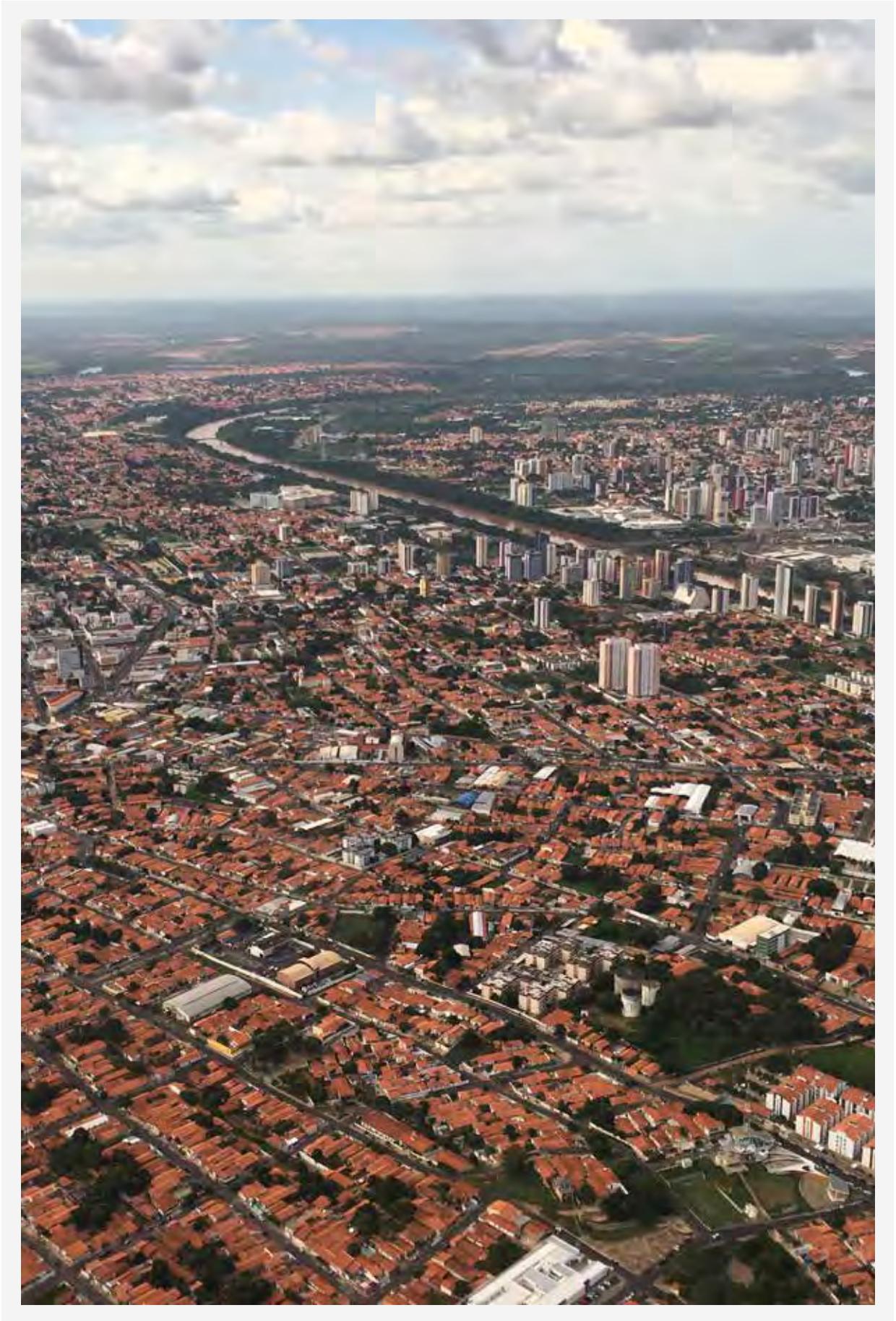


Image 7: Teresina, Brazil. Aerial view. Source: Gabriela Uchoa (2019).

Public Transportation

The public transportation systems are composed of individual and collective modal choices. The individual public modality offers the services of taxi and moto-taxi under licensed services regulated by the municipality. The total taxi licensed fleet in the city is 1,995 vehicles, which makes a ratio of 2.31 taxi/1000hab. The moto-taxi service offers 2,297 licensed bi-wheel vehicles, which makes a ratio of 2.66 moto-taxi/1000hab.

The collective public transportation offers regular bus, bus-rapid transit and tram services. Four private consortiums operate Regular Buses and BRT buses services under a municipal public concession scheme hired by a public bidding process. The municipal local transport authority is in charge of service planning and operation monitoring. In total there are 87 bus routes, organised in a feeder-trunk BRT system. The feeder lines connect the neighbourhoods of each city zone to main buses terminals (2 per zone, 8 in total). From the buses terminals depart the trunk services, operating in segregated bus lanes connecting zone terminals to 3 downtown terminals. The average number of daily bus journeys for weekdays is about 235,174.4 trips.

The State Government offers tram service that links the southeast zone to the city centre. Recent investments for the modernisation of the tram system included three new Light Rail Vehicles (LRVs) for 600 passengers each, improvements to the whole metro line and nine stations (Matinha, Ilhotas, Renascença, Itararé, Frei Serafim, Piçarra, Boa Esperança, Parque Ideal and Dirceu II), and the construction of an Operational Control Centre.

The Teresina urban mobility network also comprises a mixed-type set of cycle paths. In total, Teresina has 64.20 kilometers of cycle lanes. The Master Plan for the Cycle Network proposes the implementation of a structural network of more than 220 kilometers of cycle paths, however the city is still implementing the plan's first phase (minimum network).

Public Transportation	
Main Public Transport Modes	Bus, Taxi and Moto-Taxi
Number of Bus Routes	87 routes
Average Bus Journeys/Day	235,174.4 passenger trips
Licensed Taxi/Population	2.31/1000 inhab
Licensed Moto-Taxi/Population	2.66 moto-taxi/1000 inhabitants
Cycle Network	64.20 km

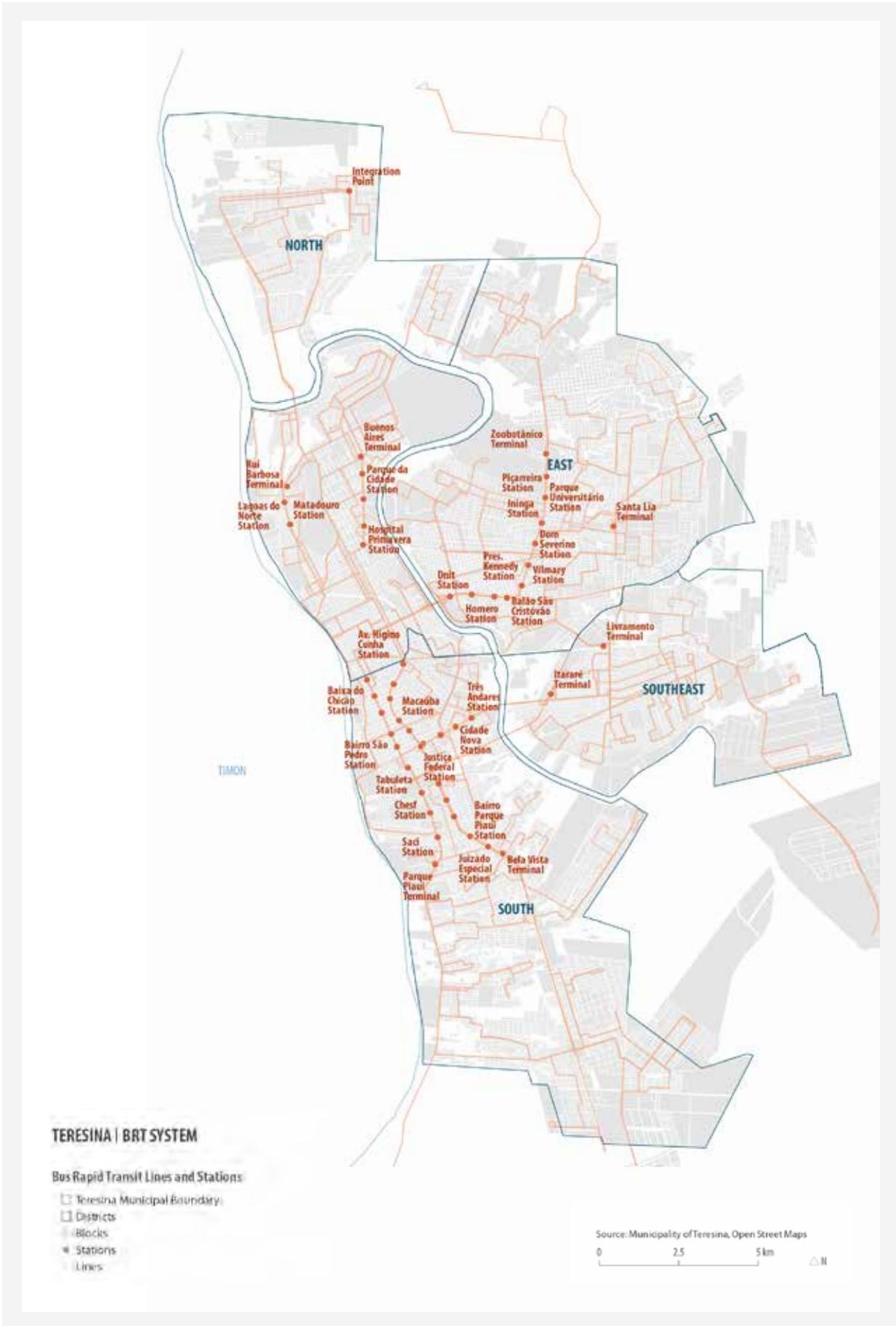


Figure 16: Public Transportation Map. Source: CRGP, with data from PMT and Open Street Maps (2020).

Physical Assets

The city of Teresina, due to its relevance as a capital of the State of Piauí, and functionality at the regional level in the provision of education and health services, has critical physical assets. It is essential to identify, locate and monitor exposure to risks in sites containing critical physical assets as its failure can provoke secondary shocks in crisis periods. The critical facilities in Teresina have importance at both local and regional levels. At the regional level, there are airports, transportation terminals, hospitals and healthcare services, universities, among others. At the local level, heritage sites, education and health facilities, logistics and supply chain routes, water and electricity distribution facilities, are examples.

Concerning intermunicipal transportation, a relevant entry point is the city's coach station "Terminal Petronio Portela". It connects the city to roughly 400 regional and national destinations. There are 19 bus operators, with more than 300 bus services/day. The total passenger flow is around 2,000 passengers on weekdays and approximately 5,000 on weekends. According to the last user's survey (Piauí, 2020), the main destinations were to the states of Maranhão, Ceará, Pernambuco, Federal District and Bahia.

Teresina is also home to Petronio Portela Airport, located near the city centre, which is the main airport in the State of Piauí. It primarily serves the Integrated Development Region of the Greater Teresina, as well as the State of Piauí, including also a noteworthy part of the State of Maranhão and a small portion of western Ceará. The airport operates national and regional domestic flights with a Passenger Terminal and a Cargo Logistics Terminal. According to the last published Infraero Statistics (2018), the airport had 13.823 flights that year, with 1,07% share in the national network. The total number of passengers/year was 1.073.570 (representing 1,27% of total national passengers), and through its cargo terminal, 5071 tons were handled (1,27% of national flight cargo).

Physical Assets	
Airport	Petronio Portela Airport (THE)
Annual Passengers	1.073.570 (2018)
Annual Cargo	5.071 ton (2018)
Bus Terminal	Terminal Lucídio Portela
Passenger Flow	2,000 pax / week 5,000 pax / weekend

In addition to logistics and supply chain assets, there are rail and road networks. The rail network connects Teresina to São Luis - Capital of the State of Maranhão, and Fortaleza -Capital of the State of Ceará; and thus to 3 ports in these cities - Port of Itaqui (Maranhão), Port of Pecém (Ceará), and Port of Mucuripe (Ceará). Ferrovia Transnordestina Logística (FTL) operates the rail services through a national public concession. FTL runs 105 locomotives and 1,377 wagons. In 2019, the company transported 2.2 million tons, of which 1.1 million tons of cellulose, 563,000 tons in fuels and 275,000 in cement. The railway is the primary network for fuel supply to the entire state of Piauí; it arrives by train to Teresina Rail Terminal from the Port of Itaqui. (REF).

Finally, the main transportation route is by road network. Teresina is traversed by 3 national highways, the BR-226, BR-343 and BR-316. The BR-343 connects the state coast to its hinterlands passing through Teresina. BR-316 is a vital highway that links Brazilian North and Northeast regions - linking Teresina to cities in the Amazonia, as Belém, in the state of Pará, to the east coast capitals, as Maceió, in Alagoas. It has a total length of 2,054 km. BR-226 is a 2,164.0 km long national road that connects Northeast Region to the Brazilian Midwest, passing through the states of Rio Grande do Norte, Ceará, Piauí, Maranhão and Tocantins. Other relevant entry routes are the state highways that connect the capital to other locations inside the state, namely PI-112 to the North, PI-113 to the east and PI-130 to the south.

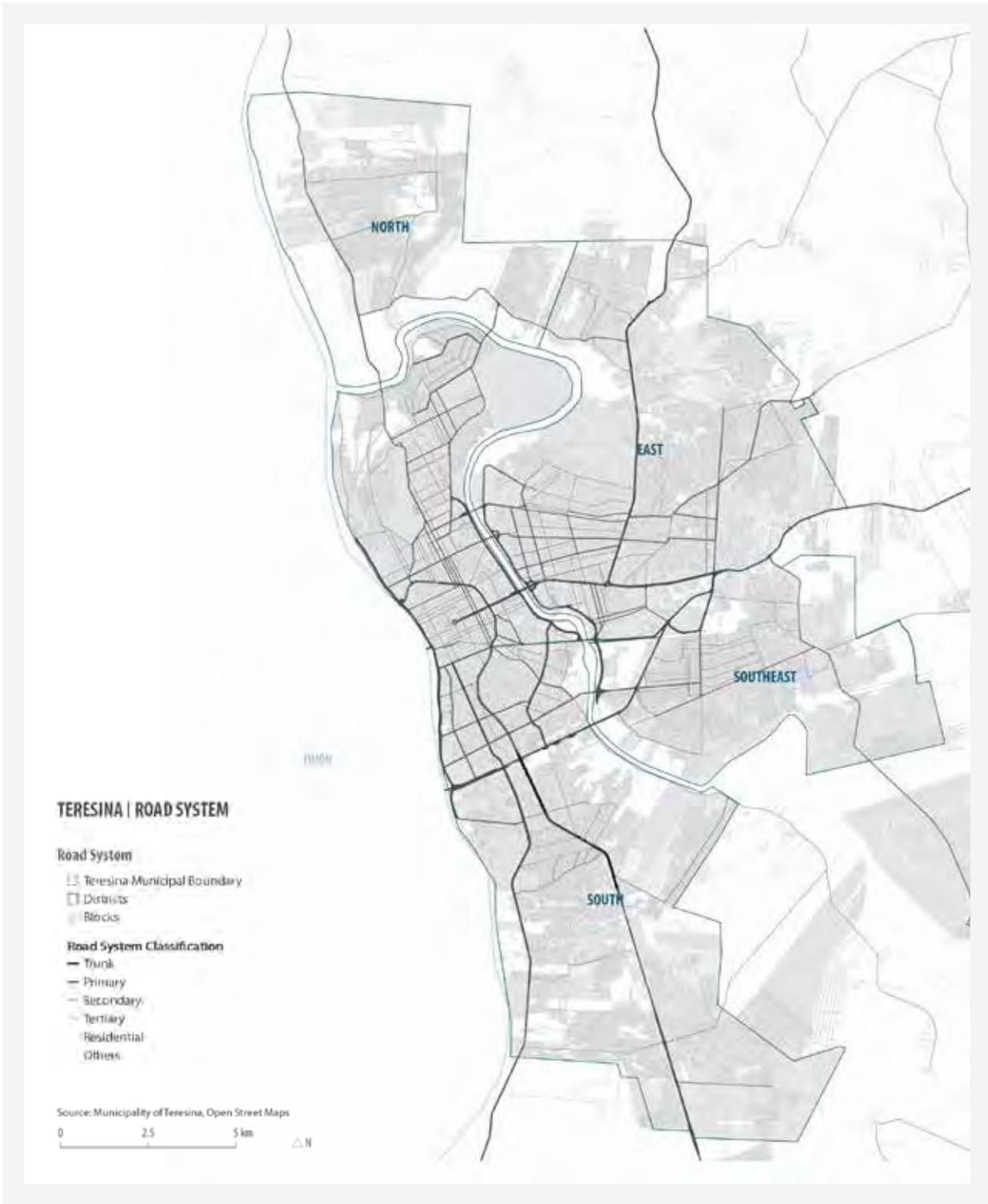


Figure 17: Road System Map. Source: CRGP, with data from PMT and Open Street Maps (2020).



TERESINA | ROAD JUNCTION

Municipal Location



Municipal boundary and neighboring municipalities

□ Teresina Municipal Boundary

Piauí State

■ Municipal Boundaries

Maranhão State

■ Municipal Boundaries

Source: Municipality of Teresina, IBGE Brazil, Open Street

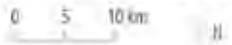


Figure 18: Road Joint Map. Source: CRGP, with data from PMT, IBGE and Open Street Maps (2020).

Urban Road	
Urban Road Network	4.731 km
Trunk Roads	281 km
Primary and Secondary Roads	662 km
Residential Roads	3144 km
Others	644 km
National Roads	BR-226; BR-343; BR-316; BR-343
State Roads	PI-112; PI-113; PI-130

Table 12: Urban Road. Source: CRGP, with data from IBGE.

Due to its functionality as a health and education hub on a regional scale, health and learning facilities are significant physical assets. Among relevant health facilities, it is worthy of mentioning the city centre medical hub as the home of several state-owned hospitals as the Hospital Getúlio Vargas; Hospital Infantil Lucidio Portela; Hospital de Doenças Infectocontagiosas; as also private run as Hospital São Marcos; Hospital Santa Maria; Hospital Med Imagem; Hospital ProntoMed; Hospital de Terapia Intensiva; and Hospital Unimed. Outside the central medical hub, the municipal public network offers several relevant hospitals such as the Hospital de Urgencias de Teresina - offering state coverage for trauma patients; Hospital do Monte Castelo; Hospital do Matadouro; Hospital da Primavera; Hospital do Parque Piauí; UPA Promorar; UPA Renascença; Hospital Alberto Neto - Dirceu Arcoverde; Hospital Mariano Gayoso Castelo Branco; Hospital-Maternidade do Buenos Aires; Hospital Maternidade do Satélite; and Maternidade Wall Ferraz. Other important public hospitals administered by other governmental spheres are the Hospital Universitário; Hospital da Polícia Militar; Hospital Areolino de Abreu; and Maternidade Evangelina Rosa.

In the educational sector, public administration critical facilities at the regional level are the university campuses of the Federal University of Piauí - Campus Petrônio Portella; of the State University of Piauí - Campus Torquato Neto and Campus Clovis Moura; Federal Institute of Piauí - Campus Teresina Central; Teresina Sul and Teresina Dirceu Arcoverde.

The built and natural heritage is also part of critical physical assets, and the mapping of relevant historical sites is essential for monitoring risks derived from shocks and stresses. In Teresina, the assets listed by the national heritage are the Parque da Floresta Fossil; São Benedito Church, Teresina Railway Heritage Site and the Ponte Metálica. In other levels of protection are several sites, mostly located in the urban centre, which make up the landscape of squares and streets that recover the city's historical image. Examples are the building of Museu do Piauí; Palácio da Cidade; Intendência de Teresina - now Fundação Wall Ferraz; Companhia Editorial do Piauí - now Fundação de Cultura do Piauí; Teatro 4 de Setembro; Cine Rex; Clube dos Diários; Casa do Barão de Gurguéia - Casa da Cultura; Palácio do Karnak - among others.

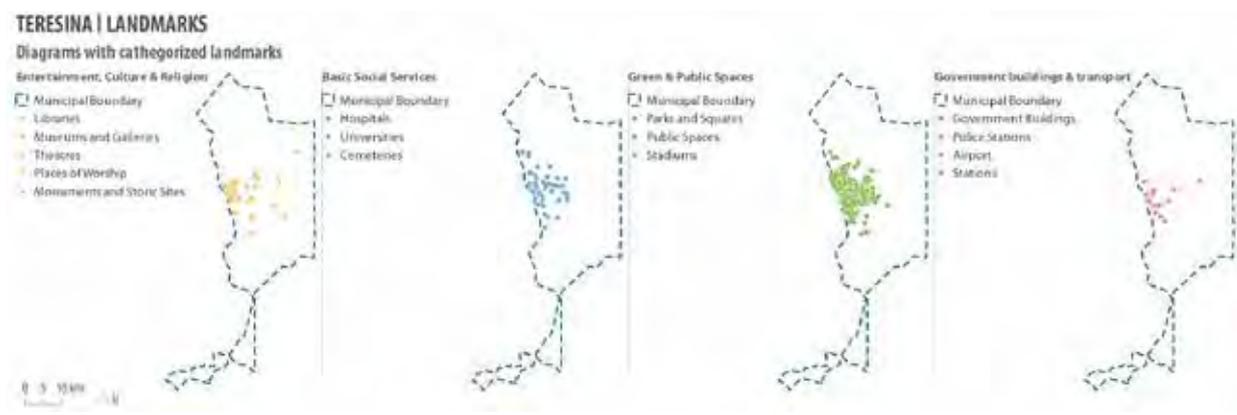
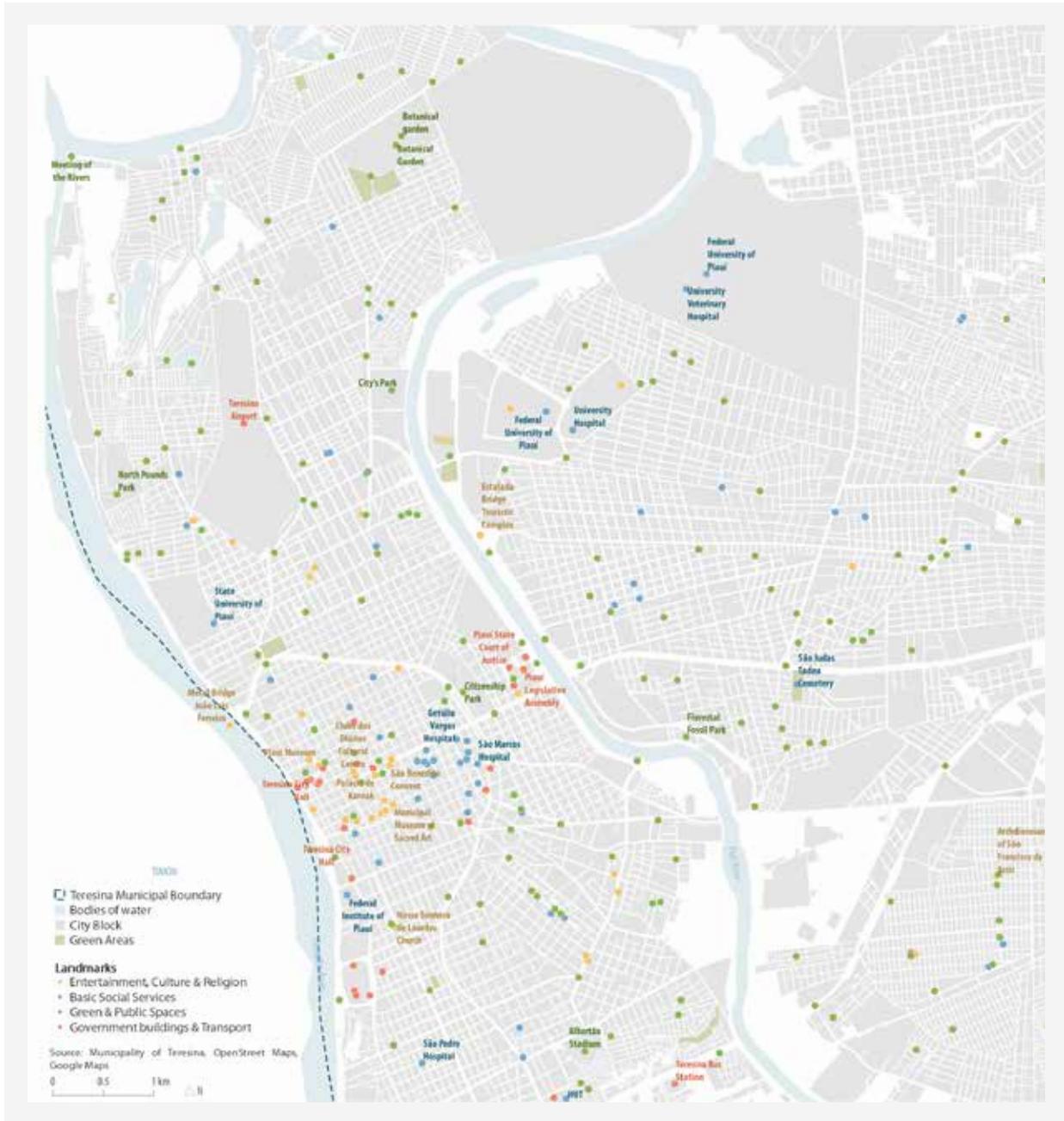


Figure 19: Map of Points of Interest. Source: CRGP, with data from PMT, Google Maps and Open Street Maps (2020).

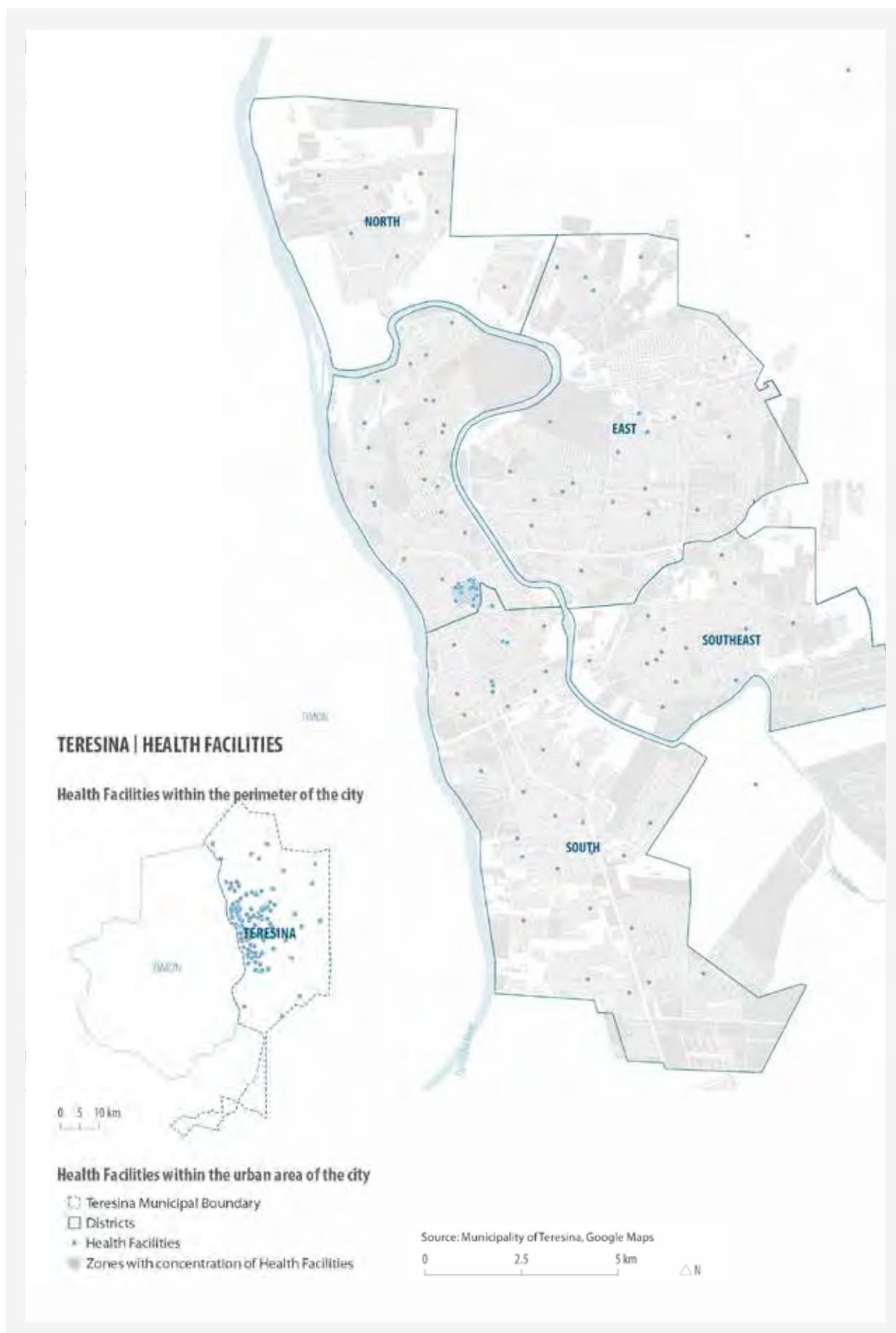


Figure 20: Health Equipment Map. Source: CRGP, with data from PMT and Google Maps (2020).



Figure 21: Map of Urban Gardens of the PMT. Source: CRGP, with data from the PMT, and Google Maps (2020).

1.4. Economy and Livelihoods

For a better understanding of economic context, data is also presented on a national and regional scale, since macro and microeconomic policies are mainly directed by national governments, and are closely interrelated with the fiscal and financial scenario at the higher levels.

National Economy

Brazil is the largest and most populous country in Latin America. With a nominal GDP of \$1.87 trillion (World Bank, 2018), Brazil is the 9th economy in the world. At the beginning of the 21st century, the country enjoyed growth and development by riding on the commodity wave. Lately, it has been suffering multiple hindrances with the end of the commodity supercycle, in addition to internal problems derived from political instability, which discouraged the investment and business environment. During 2006–2010, the country grew at an average of 4.5%, moderating to around 2.8% in 2011–2013. By 2014, it was hardly growing at 0.1%. In 2016, Brazil contracted by 3.5% before bouncing by 1% in 2017.

The national exports are about USD 240 Billion and are primarily related to natural products. Mineral products represent 22,3% of exports - crude petroleum and iron ore are the main ones. Agricultural goods are the second leading export sector with a share of 18% - with a predominance of soybeans. Asia and Europe are the main destinations of Brazilian products, corresponding for USD 108 Billion and USD 44 Billion respectively. The biggest export partner is China, that imports 26,8% of total Brazilian exports, followed by the United States with 12%, and Argentina with 6,2%.

The country imports a total of USD 181 Billion (2018). The main import sectors are Machines (22,5%) - especially Integrated Circuits, Telephones, and Broadcasting Accessories; Chemical Products (20,2%) - mainly medicaments, agricultural fertilizers and pesticides; Mineral Products (15,5%) - refined and crude petroleum, petroleum gas, coal briquettes, copper, and others; Transportation (13,95) - drilling platforms, vehicle parts, cars, trucks, aircraft; Metals (6,3%); and Plastic and Rubbers (5,7%). Concerning its origins, 19,2% of the goods come from China, the major Brazilian trade partner, followed by the United States (16%), Argentina (6,1%), and Germany (5,8%)

The relation of the country's imports and exports is given by the National Import and Export Ratio, that is 0.75, representing a surplus on the trade balance.

Regional Economy

The State of Piauí is the 21st economy among all 27 Brazilian federation units with a GDP of about USD 7Bi. The major economic sectors are, in order of importance, the retail and services, public administration and social security, administrative services, education, health, transformation industry, and construction.

The northeast of Brazil has a smaller export share among all the other regions, being responsible for about USD 17 Billion of the country's total exports. Considering only the State of Piauí, the share is only about USD 283 Million. The main export sectors of the state are related to Vegetable products (76,4%) and Animal and Vegetation bi-products (9,2%), and Foodstuffs (6,5%). The principal exportation product is soybeans, representing 76% of Piauí's exports, followed by vegetable waxes (9,2%) and soybean meal (6,5%).

The imports represent a total of USD 137 Million, and the main demanded sectors are Metals (42,5%) - Coated Flat-Rolled Iron Products, Cold-Rolled Iron Products, Copper Wire, etc.; Chemical Products (21%) - Fertilizers, Laboratory Reagents, and others; Mineral Products (10%) - refined petroleum, coal tar oil, calcium phosphates; Vegetable Products (8,2%) - wheat, coconuts, Brazil nuts, and cashews, Machines (7%) - electrical control boards electric motors, microphones and headphones, leather machinery, etc.; and Transportation (7,5%) - aircraft, bi-wheel vehicle parts. More than a third of the products come from China (38,8%). Other trade partners are the United States (14,6%), Ukraine (8,5%), Israel (5,7%), Spain (4,4%), and Russia (4,2%).

Urban Economy

The Teresina GDP is of R\$19.1 Billion(2017) - that represents about USD 3.3 Billion and is the most important economic unit of the State of Piauí. The GDP per capita of the city is around R\$ 22.5 thousand (USD 3.8 thousand), placing Teresina in 1944^o position among all 5570 Brazilian cities, and 13^o among 224 municipalities in Piauí. The services sector is the principal one, representing 61.95% of the city's GDP. It is followed by the public administration, including administration, defence, public education and health services, and social security, representing 22.19%. The industrial sector accounts for about 15.50% of the local GDP, while the Agro sector corresponds to 0,36%.

In comparison to other municipalities, the local administration revenues position the city in 21^o place among total 5570 Brazilian cities. In 2019 the total local government estimated revenues were about R\$ 3.47 Billion (USD 600 Million), following a continuous increasing trend in the last decade - municipal revenue has tripled in the past decade. It is important to note, bearing in mind the structure of the Brazilian federative pact, that these revenues are made up of more than 60% from external sources. The increase in revenue also demonstrates enhanced access to national and international resources to finance local projects. From the whole local revenue, relevant sources are 56,43% comes from transfers, 15,68% from local taxes and fees, and 7,98% from credit operations, among other incomes.

Notwithstanding, the current COVID-19 global crisis poses severe threats for local government's budget. Cities must strengthen public services and boost the local economy while suffering from sharp falls in revenues. Teresina is no exception in this scenario.

Concerning international trade activities at the local level, Teresina's total exports are about USD 1,29 Million, having humble significance in national and regional contexts. The city's exports matrix is mainly composed of Chemical Products(39%) - Mixed Mineral or Chemical Fertilizers, make-up and hair products; Metals (37,3%) - including scrap copper; vegetable products (23,1%) - mainly soybeans. Regarding trade partners, 59,3% of Teresina's exports go to Venezuela, and 37,3% to China. Regarding export logistics, a shift in the last decade swift the ports of Fortaleza and Pecém (both in Ceará), in the early 2000s; for the current 99% drained through the port of Santos (São Paulo).

The number of imports exceeds in the far distance the exports, totalling USD86,9Millions. This relation creates a negative trade balance deficit; the local import/export ratio is 67,37. Main imported goods are Metals (63%) - Coated Flat-Rolled Iron Products, Hot-Rolled & Cold Rolled Iron Products; Mineral Products (14,1%) - Refined Petroleum and Coal Tar Oil; Vegetable Products (7,6%) - Wheat; Machines (5,3%) - Electric Motors, Other Machinery, microphones and headphones; Transportation (4,8%) - Bi-Wheel Vehicle Parts; among others with reduced relevance. From the total, USD 52,5 Million comes from Asia, being China the leading import partner with 53% of market share; then North America with USD 20.2 Million in imported goods (United States - 15,6%; Canada - 7,6%); and finally Europe selling USD 12.6 Million to the city (Ukraine - 13,3%; Germany - 0,4%). During the last decade, the Port of Pecém was the main entry route for goods imported by the city. However, the Port of Maceió has been growing in relevance and nowadays receives 37,9% of the city's imports. The other shares are Port of Pecém with40,8%; Port of Fortaleza 7,7%; Rio de Janeiro Port of Sepetiba 7,1%; and Port of Santos 3,5%.

Economy	
National GDP	\$ 1.869 trillion (2018)
GDP / National Capital	\$ 8,920.76 (2018)
Imp./Exp. National Ration	\$ 181 million / \$ 240 million = 0.75
GDP Teresina	\$ 3.306 billion (2017)
GDP / Capita Teresina	USD 3,889.09 (2017)
Teresina Imports	\$ 86.9 million (2018)
Teresina Exports	\$ 1.29 million (2018)
Imp./Exp. Ratio	67.36

Jobs, Wages and Income

Despite a slight downward trend, the unemployment rate in Brazil is still significant, reaching around 10.6% (IBGE, 2019). In the Brazilian Northeast region, this figure is even higher, rising to 13.6%. The informality rate in the country reached 41% in the fourth quarter of 2019, a contingent of 38.4 million people. According to IBGE, the unemployment rate in Teresina increased from 13.8%, registered in the 3rd quarter of 2019, to 15.20%, in the 4th quarter. In Teresina, there were around 70 thousand unemployed people in the 4th quarter of 2019.

The most recent Sintesis of Social Indicators from IBGE (SIS/IBGE 2019, annual data from 2018), situated the unemployment situation of the city between national and regional ranges. Brazil had about 12% unemployment in 2018 while in the Northeast region it was about 14.5%. In Teresina, the indicator was 13.7%. The gender gap in unemployment is 0.2%, the male group faced 13.6% and female 13.8%. The gap is higher when considering data disaggregated by skin colour, White population 10.9%; Black and Mixed Race population 14.2%. The disaggregation for age groups displays a significant gap between younger and older occupied populations - Young <29 years 24%; 30-49 years 10.6%; above 50 years 7.2%. Among these workers, only 54.9% were under formal employment, considerably above state and regional figures (Piauí 35%; Northeast Region 41.4%). Regarding formal jobs in Teresina, 77.3% are employees, 21.2% are self-employed, and 1.5% are employers.

Among primary job sectors in the city, as a state capital, the most prominent is the Public Administration, accountable for 27,6% of the workers according to RAIS data from 2017. It is followed by the retail sector (17,8%); Administrative Activities (13,6%) - in especial call centres ; Human Healthcare and Social Services (7,9%) - mostly hospital services ; Education (6,3%); Processing Industries (5,7%); Construction (5,5%); Lodging and Food (3,6%); Transport and Postal Services (3,1%); and others.

According to the national households survey, for the first quarter of 2020, the average income in Teresina was BRL 1,999 (about USD 350). The results were lower than the national average of R\$ 2,398 (about USD 420), however considerably above regional and state-level figures, respectively BLR 1,648 (USD 288) and BRL 1,401 (USD 245). Notwithstanding, the wage gender gap is relevant. Disaggregated data reveals that the average income for men in Teresina was BRL 2888 9USD 505), while women received an average of BRL 2274 (USD 398). Regarding informal jobs, the 2018 national household survey estimated that average income for informal occupation was BRL 1140 (about USD 200), and gender gaps remained - women wages were 20% shorter than men. The differences also manifest in skin colour disaggregation, were white population had an average income about 1.4 times higher than black and mixed-race for formal jobs, and about 1.9 times higher for informal earnings.

Despite that, inequality in Teresina is below national and regional estimates. The local GINI coefficient is 0.511 (IBGE, 2018), while national and regional are both 0.545 - the closer to 1 the higher inequality. In the city, the 10% richer earned on average 10.3 times more than the 40% poorest. At the national level, the ratio is 13 times, and being higher in the Brazilian northeast were ratio is 14.1. Following this pattern, the number of people living under the world's extreme poverty line is less than national and considerably less than regional and state figures. In 2018, Teresina had 5,3% of its inhabitants living below the extreme poverty line (less than USD1,9/day PPP 2011) in comparison to 6,5% estimations for the whole country, 13.6% at regional level and 14.2% at state-level. Considering people living with less than USD 5,5/ day (PPP 2011), it was 29.3% of Teresina's population. For the same indicator, the country has 25,3%, the region 53,6%, and the state 41.9%.

Jobs, Wages and Income	
Unemployment rate (2018)	Brazil: 12%
	Northeast: 14.5%
	Teresina 13.7%
Employment Teresina (2018)	Freelancers 76,019
	Employers 5,317
	Employees 277,273
Average Income (2018)	Brazil: R \$ 2163
	Northeast: R \$ 1441
	Teresina: R \$ 1781
	Average Income Formal Occupation: R \$ 2282
	Average Income Informal occupation: R \$ 1140
Poverty and Inequality (2018)	Population living below the world extreme poverty line (below US \$ 1.9 PPP 2011)
	Brazil: 6.5%
	Northeast Region: 13.6%
	Piauí 14.2%
	Teresina: 5.3%
Population living below the world poverty line (below US \$ 5.5 PPP 2011)	Brazil: 25.3%
	Northeast Region: 43.6%
	Piauí: 41.9%
	Teresina: 29.3%
Gini coefficient	Brazil: 0.545
	Northeast Region: 0.545
	Teresina: 0.511
Income ratio between the richest 10% and the poorest 40%	Brazil: 13.0
	Northeast Region: 14.1
	Teresina: 10.5

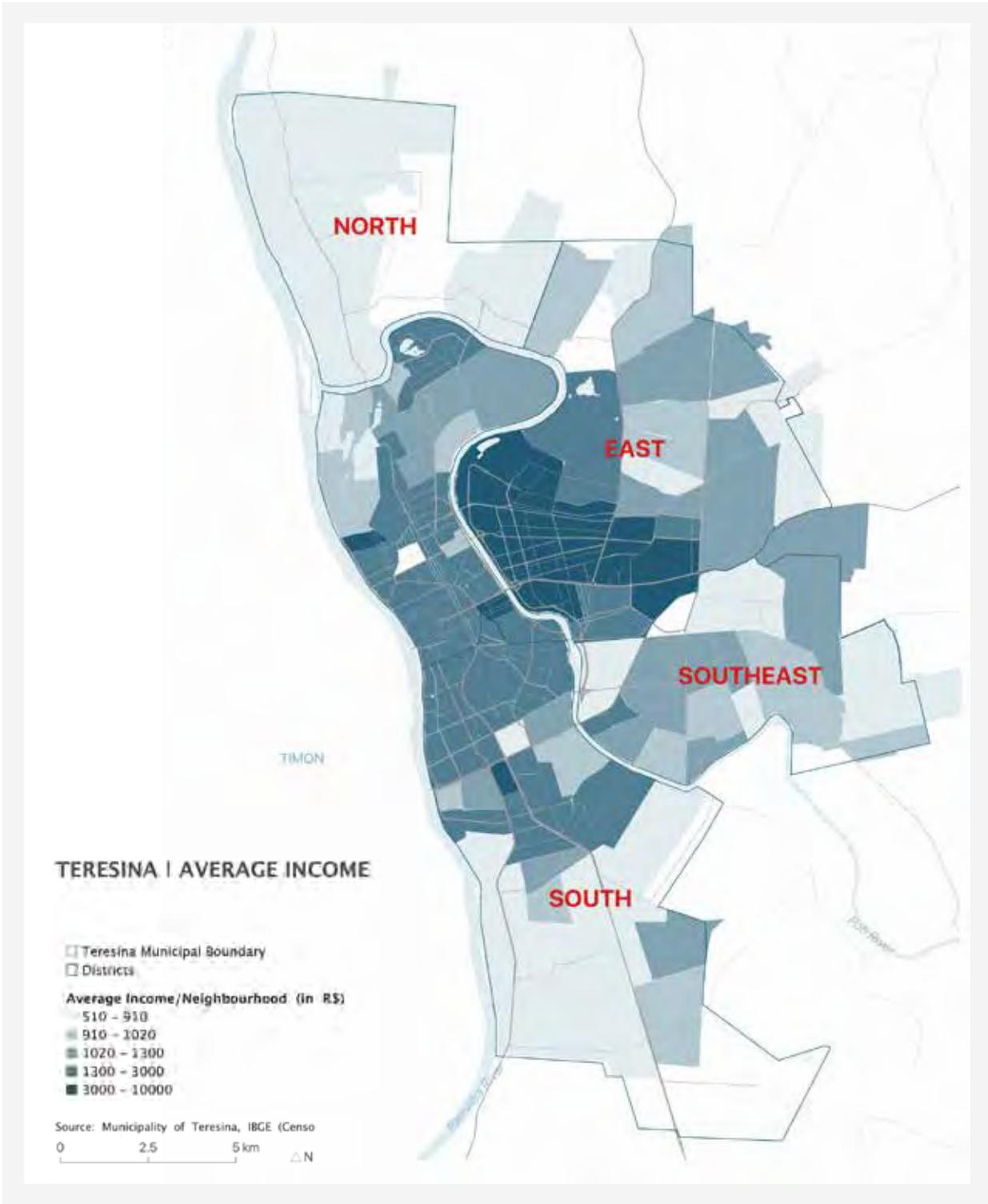


Figure 22: Map of Average Income by neighborhood. Source: CRGP, with data from PMT, and IBGE (2010 Census).

1.5. Local Government and Public Administration

Administrative Structure

Teresina's policy follows the model established in the federal constitution in the form of republican government, a system of local government composed of the mayor and vice mayor, representatives of the executive branch elected for four-year terms and may be reelected only once in a row, and councilors, representatives of the Legislative Power in the City Council, also elected for four-year terms, and can be re-elected for several consecutive terms, both through democratic elections with direct, secret and mandatory voting. At the municipal level, there are no representatives in the Judiciary Branch, which acts locally through the State and Federal Courts.

Although the councilors have no limits on the number of reelections they can run for, the Teresians are looking for a renewal of their councilors. In the last two elections, the renovation was approximately 50% of the house, with local community leaders, businessmen, religious and former politicians.

Local Government Organisational Structure and Characteristics

Teresina is governed by the Municipal Organic Law, approved by the Municipal Council, and which establishes the limits, competences, principles, objectives and rights, and individual and collective guarantees of the municipality and the citizens.

The Federal Constitution and the Municipal Organic Law assign the functions of legislating on matters of local interest to the Municipality; institute and collect taxes; grant licenses; prepare and execute urban development master plan; perform works or services directly or by concession; among others.

The Municipal Executive Power is exercised in the City Hall, which performs public services with the support of Secretaries, which are part of the direct administration of the municipality, for sectorized technical works. Public companies and foundations are part of the indirect administration and also perform services of their nature with greater autonomy conferred by law.

The city hall also has the Urban Development Superintendencies, which are like sub-prefectures, focused on the execution of works and provision of basic services to the community, such as paving, sweeping, housing. They are divided according to the administrative regions of the city: Center-North; South; Southeast and East. Urban Development Superintendents are freely appointed and dismissed by the Mayor for political office.

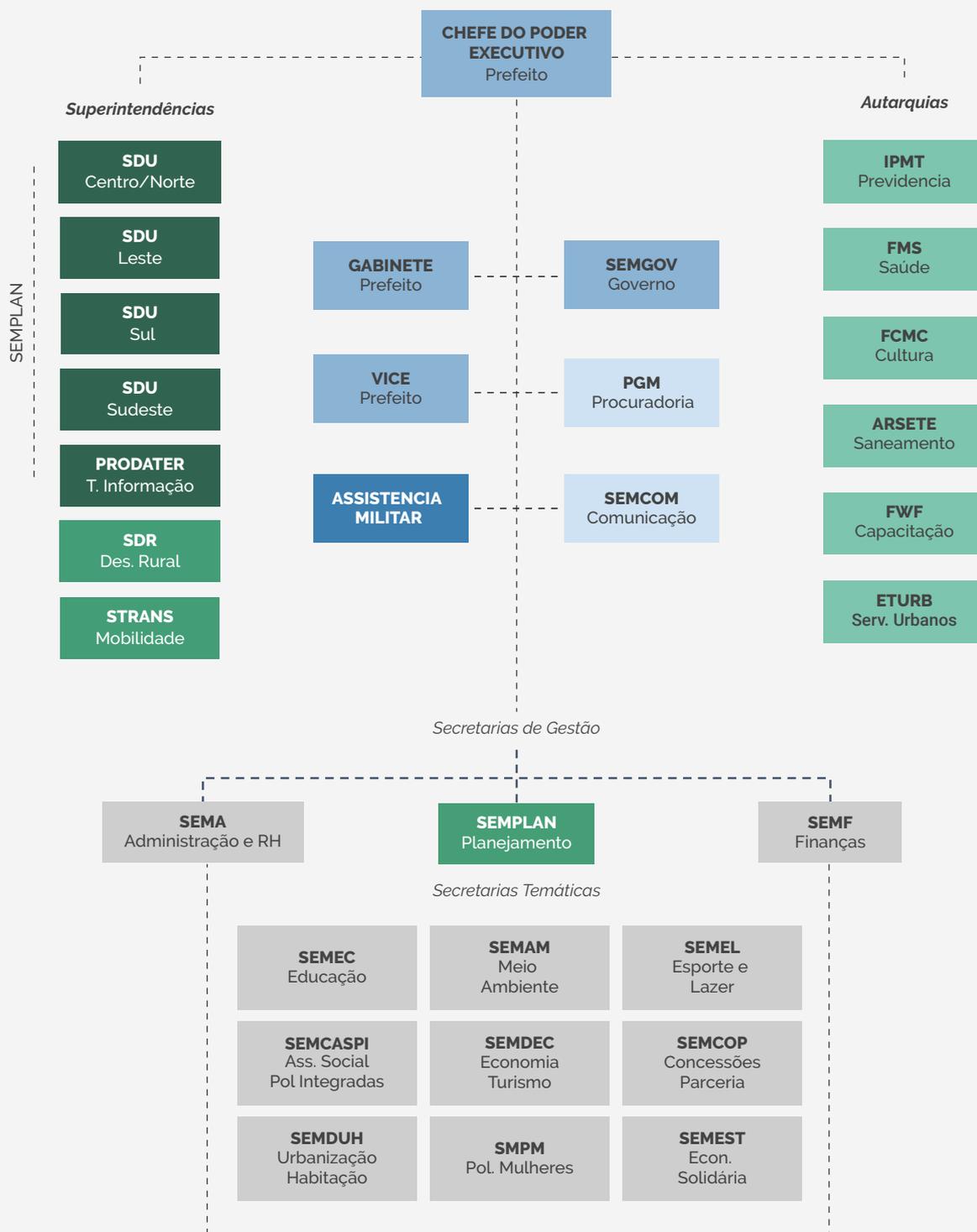


Figure 23: Organization chart of the Teresina City Hall. Source: CRGP, with data from the PMT (2020).

1.6. Challenges and Opportunities

Challenges refer to contextual or environmental conditions that have the potential to impact upon the ability and capacity of an urban system to address emerging risks and opportunities.² Challenges in Teresina can be classified into two major groups: those that Teresina has been facing since its formation and have become intrinsic characteristics of the city, referred to as 'enduring challenging', whereas 'emerging challenges' denote pressures extrinsic to the urban system brought forward due to changes occurring in this interconnected world. These identified challenges serve as overarching factors of which some require Teresina's continued adaptation in order to advance on its development targets.

Enduring Challenges



The Peripheral nature of the region

The colonisation process of the territory of Piauí is key to understanding the peripheral nature of the region's development, and its current economic and social structure. Piauí's colonisation was defined by the regime of large land properties called 'sesmarias'. The concession of 'sesmarias' benefited mainly Bahia and Pernambuco potentates, none of whom considered transferring their residences, or living and working in the hinterlands. This regime did not serve for cultivation and use for agriculture, but for territorial expansion, to increase the area available for the pasture (occupation of pastures by cattle ensured the appropriation of land by the owners) and consequently increased the power of the farmers. Instead of orienting production towards the foreign market, the main objective of the Brazilian colonial economy, the herds supplied the internal market.

Hence, the economic development of Piauí was based on extensive and extractive occupation, of a loose character, and influenced by the severe local droughts and weak central investment. With almost no slavery and capital investment, it developed economic activities of little expression in the colonial economy, differentiating itself from the coastal northeast, with its semi-bourgeois sugar economy directly linked with international capital. It was, instead, a supplier and subordinate to the mercantile capital of the coast in Salvador and Recife in the production, circulation of goods, and cattle. This subordinate link made the region more vulnerable during the sugar economic cycle decline. Only in the 19th century, the region took its goods on a world scale, with cotton, maniçoba rubber, and carnauba wax exports. However, the situation of foreign markets and the distance from consumer centres determined the low competitiveness of Piauí's products. The very primitive form of production that has been established since the colonial period, accompanied by the continuous degeneration of the productive structure, contributed significantly to the peripheral nature of the local economy. The reversal of this structural condition was the great challenge of modern Piauí.

² ISO 22370

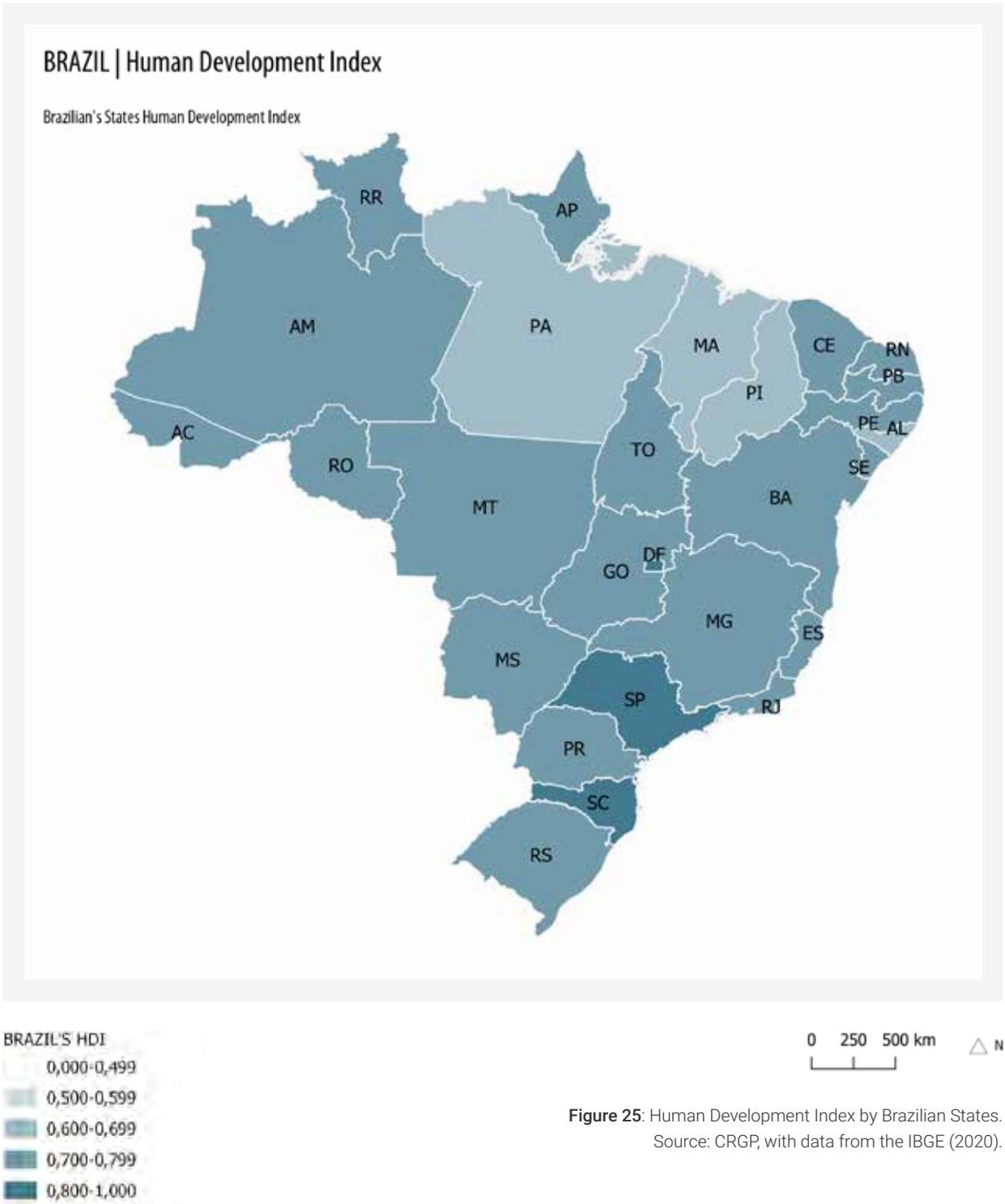


Figure 25: Human Development Index by Brazilian States.
Source: CRGP, with data from the IBGE (2020).

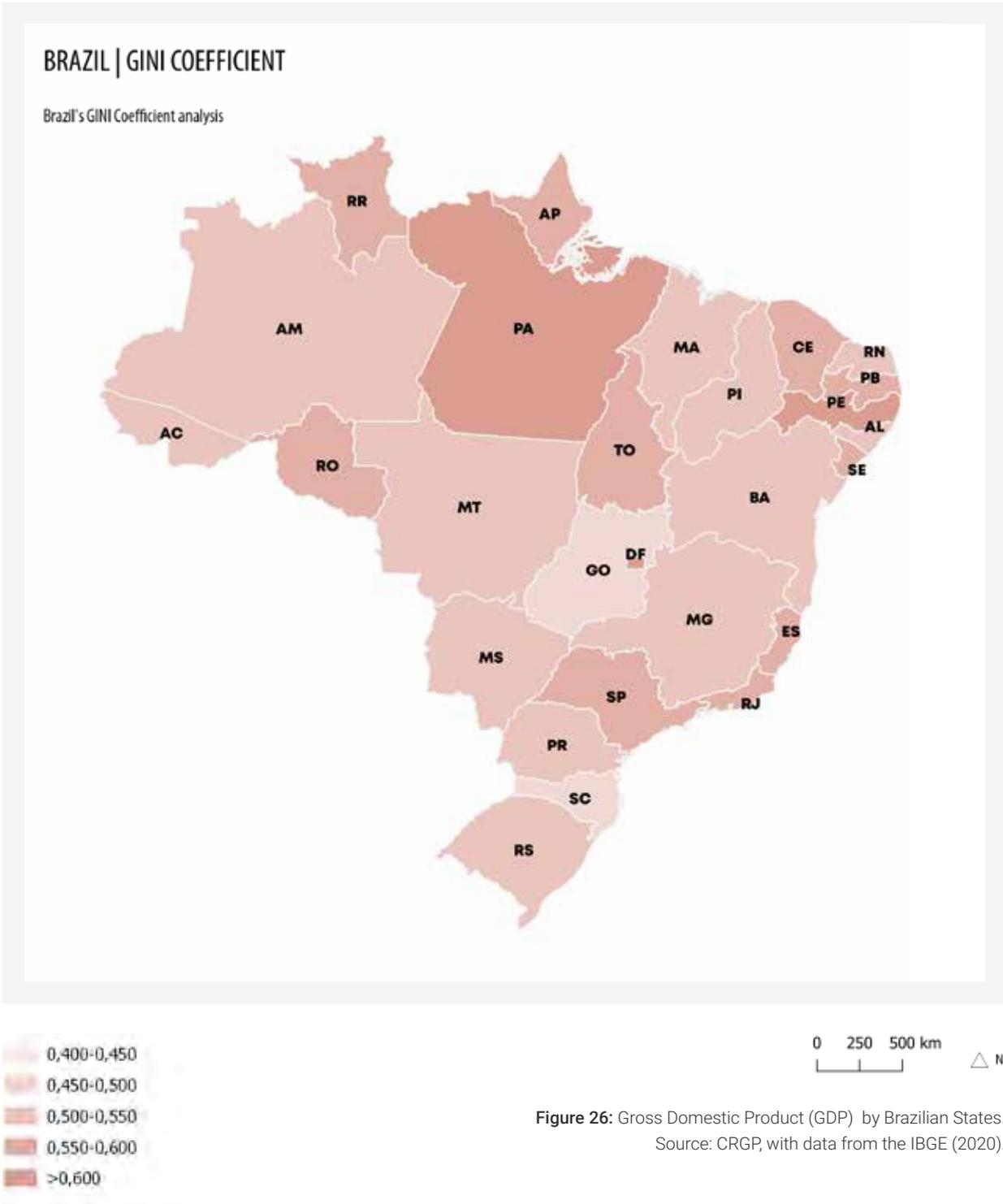


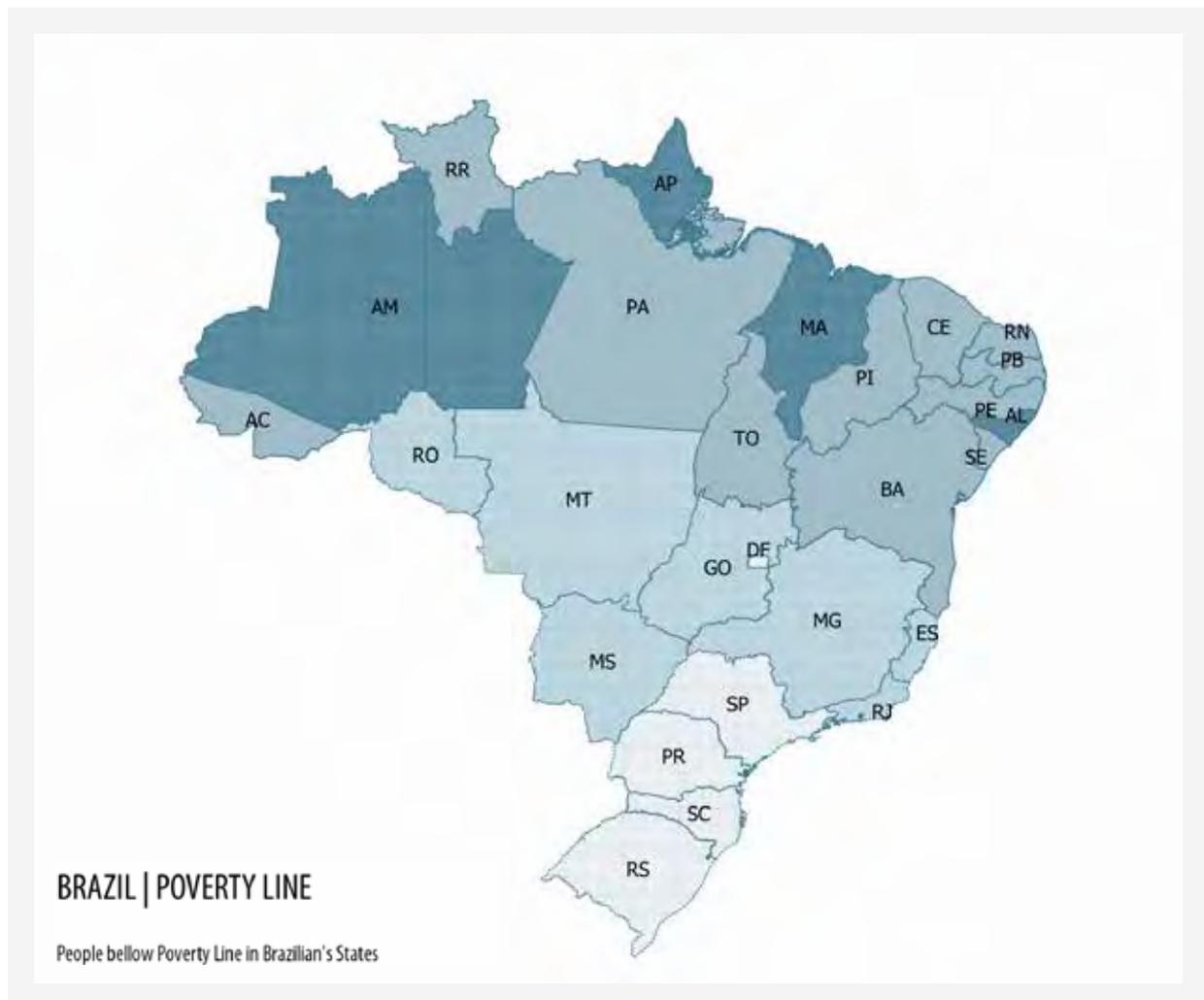
Figure 26: Gross Domestic Product (GDP) by Brazilian States.
 Source: CRGP, with data from the IBGE (2020).



Poverty and inequality

The structuring factors of the peripheral nature of the region also shaped inequalities and the impoverishment of the region. Far from being determinants, these were practices resulting from the domestic centre-periphery link, which led, reinforced and allowed the region to enter the 20th century without an established economy supported by domestic consumption and a consolidated middle class. As a result of the colonial process, Piauí housed, in the middle of its development, a fractured and unequal society, composed of a proprietary elite representing the government and, on the opposite side, a large group without assets, composed of displaced populations, refugees, fugitives, and herdsmen and settlers without salary/property rights working in vassal-like regimes.

In the Piauí of the 20th century, these conditions are reflected in high levels of social inequality, poverty, low levels of education, and deficient public investment in the provision of satisfactory basic services. The labour market is uneven and poorly developed, with low dynamism in several territories and with little capacity to generate sufficient wealth to provide a minimum level of quality of life for the majority of its population. Teresina, as the capital city, has gradually moved away from the State level poverty and inequality indicators over the past few decades. However, due to the structural nature of these conditions, this is a persistent challenge that will require decades of investment to transform society and reach satisfactory levels of development and equality.



People bellow Poverty Line

- Less than 15%
- From 15 to 30%
- From 30 to 45%
- More than 60%

0 250 500 km

Figure 27: People below the poverty line in Brazilian States.
Source: CRGP, with data from the IBGE (2020).



Figure 28: GINI Coefficient by Brazilian States. Source: CRGP, with data from the PNAD (2020).



Weak intergovernmental coordination

The administration of financial resources in large countries tends to be a challenge for its public managers. In Brazil, the constitution establishes an organisational arrangement with three levels of government (federal, state and municipal government) in an attempt to overcome unequal income distribution and lack of resources to finance the welfare state. This design in practice has several inefficiencies, particularly for small and medium-sized municipalities, whose actions are limited by own resources scarcity and hence the dependence of state and federal governments for budgetary support. In cases like Teresina, the local resources are essentially limited to the fulfilment of its minimum constitutional obligations. The dependence on external sources curbs its actions to state and/or federal public policies that not always are aligned with the municipal administration. The policy implementation, then, depends not only on the quality of the city capacity to develop projects and programme but that is generalised for all federal or state entities, neglecting the participation of local stakeholders in policy design. Far from their reality or needs, this process often exacerbates difficulties to the execution of most suitable solutions, adapted to the local realities, and feasible in its implementation, particularly in the long-term. Therefore, the municipality has to adapt to these proposals in a creative/alternative way and to increase its range of financing to be more resilient on project implementation.

In addition to the unequal income distribution, intermediary and small Brazilian cities also strive with the inefficiency of institutions. Teresina, in particular, has the distinct case of being one of the three metropolitan areas in Brazil in a conurbation with more than one state. This situation, in the federal arrangement, creates the need for national oversight to implement a functioning metropolitan administration. Called RIDE Great Teresina (RIDE Grande Teresina - Integrated Administrative Development Region of the Great Teresina), the local metropolitan administration is ineffective in practice due to the distancing of the federal government from the local reality. This institutional framework design has power imbalances that are not compatible with the stakeholder's interests since national governments have few incentives to act at the local level. Consequently, it deters municipalities to seek solutions for urban planning for the region collectively, acting independently and dispersed, and so reducing the effectiveness of their actions.

Emerging challenges



Climate Change Effects

One of the main challenges in the city of Teresina is the current trend of climate warming above the global average. In the last century, the region's temperature warming was between 2-4°C, while the average global warming has been around 1-2°C. Climate change, for beyond increasing temperatures and causing more extensive and more frequent heat waves, exacerbates extreme climatic phenomena, such as storm intensity and duration of the rain season. It can change the occurrence of the already frequent fluvial, pluvial and flash floods. It can also exacerbate droughts, migratory phenomena of the affected population in areas of regional influence, thereby causing economic crises, urban conflicts and failures in the provision of infrastructure and services.

The following image shows the change in average surface air temperature during the Teresina drought season period (October-December) for the last 50 years. Teresina is in a red area, which reinforces the exceptionality of the average temperature rise of the city compared to latinamerican situation, and other parts of the globe.

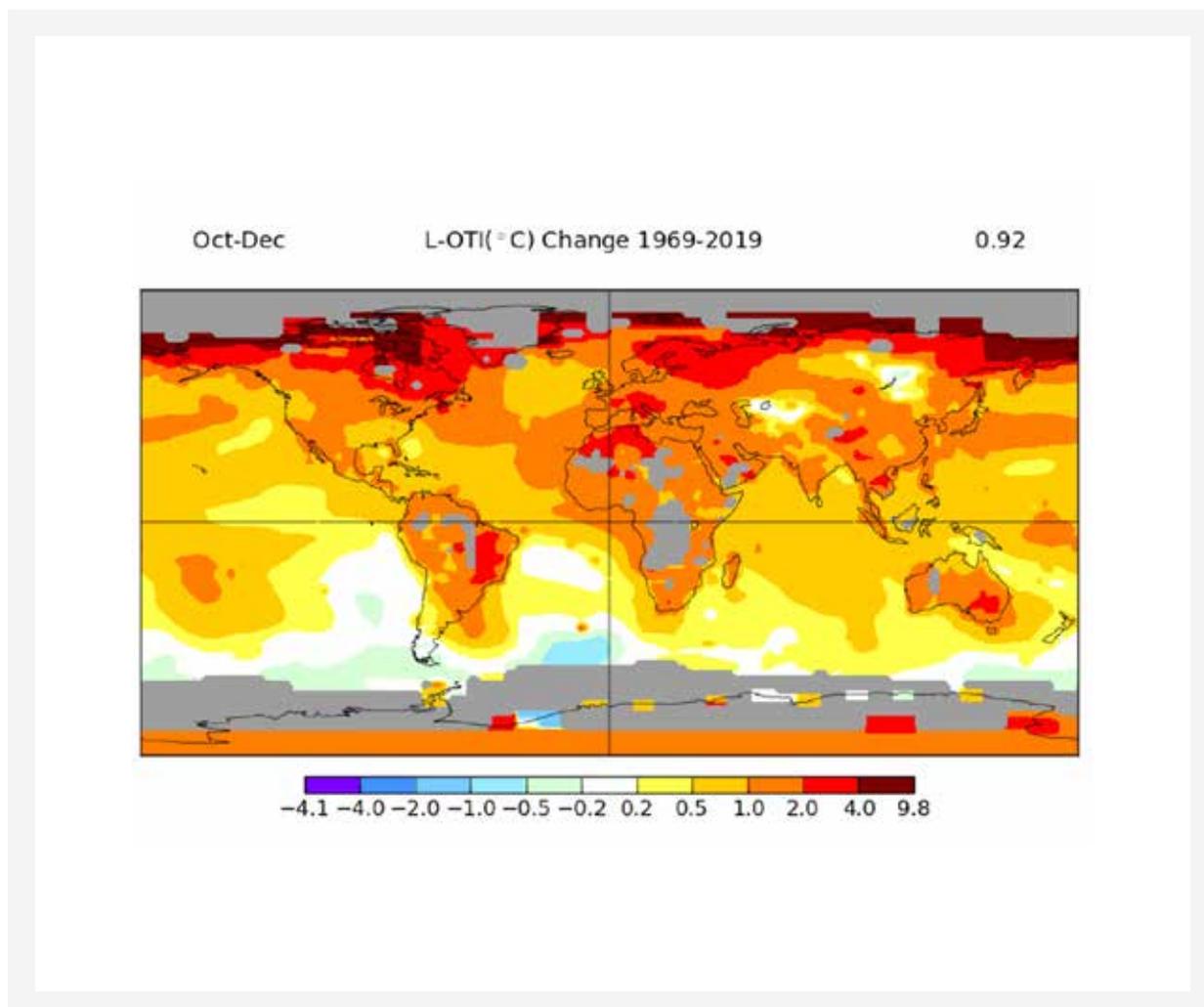


Figure 29: Global average surface air temperature for Oct-Dec from 1969 to 2019. Source: NASA GISS..Note: Gray areas signify missing data. (2019).



Safety and Crime

Problems related to the rise in crime rates, the increased sense of insecurity, especially in large urban centres, the degradation of public space, ineffective criminal justice institutions, police violence, the weak preventive capacity of organisations and precariousness of the prison system, among many others, represent conjunctural challenges for Brazilian society. For two decades, from the 1980s, the national homicide rate increased sharply. It presented relative stability in the early 2000s, but then the rates started to grow again in 2008. Today, with 27 more homicides for every 100,000 inhabitants,³ Brazil is considered one of the most violent countries in the world. The death rate among the black population (black and mixed-race, as defined by the IBGE -Brazil Statistics and Geography Institute) is 37.8 per 100 thousand inhabitants, while that of non-blacks is 13.9 (2020).

While the growth of urban violence is a problem that afflicts Brazilian municipal governments, consolidated instruments and competences in the matter, such as the criminal sphere and police operation, are stated in the constitution as functions of the state and national governments. However, in recent years, municipalities have emerged as important actors in the design, implementation and monitoring of public security policies to restrain the escalation of urban violence and crime. In Teresina, urban violence increased sharply in the first decade of the 21st century. In 1996, the homicide rate per 100,000 inhabitants was 11.29. This indicator rose to 28.80 in 2006 and increased again reaching 44.13 ten years later (2016)⁴. However, the most recent report by the Piauí Public Security Secretariat (SSP-PI) shows that, in the last five years, this value has decreased by -45.74%⁵. Among the neighbourhoods in the city that most registered intentional lethal violent crimes in the city (SSP-PI, 2019) are Poty Velho, São Joaquim, Alegre, Pedra Mole, Verde Lar, Centro, Beira Rio, Santo Antonio, Promorar and Esplanada.

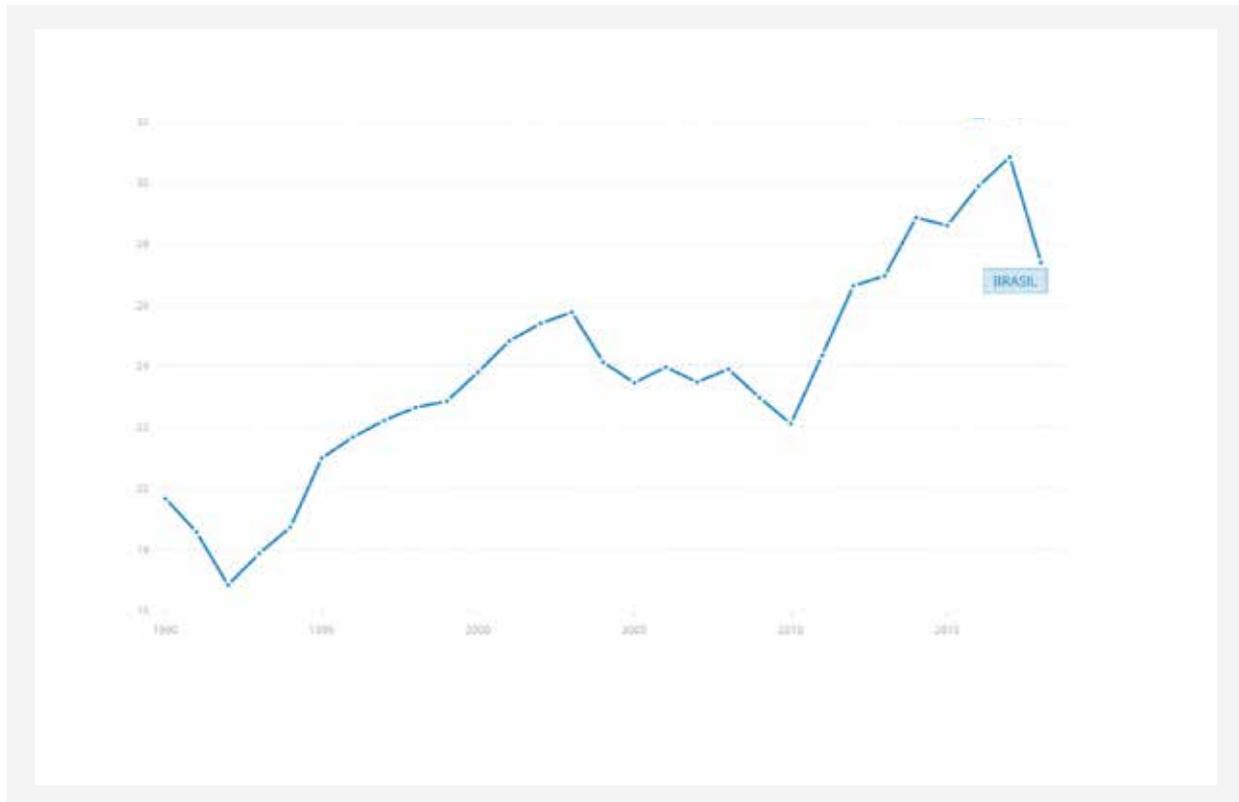


Figure 30: Violent Deaths Rate in Brazil per Year. Source: World Bank Data.

³ Cerqueira et al., 2020

⁴ IPEA.n.d.

⁵ SSP-PI, 2020

TERESINA | CRIMINALITY

Comparison of criminality rates in 1980 and 2017 in Brazil

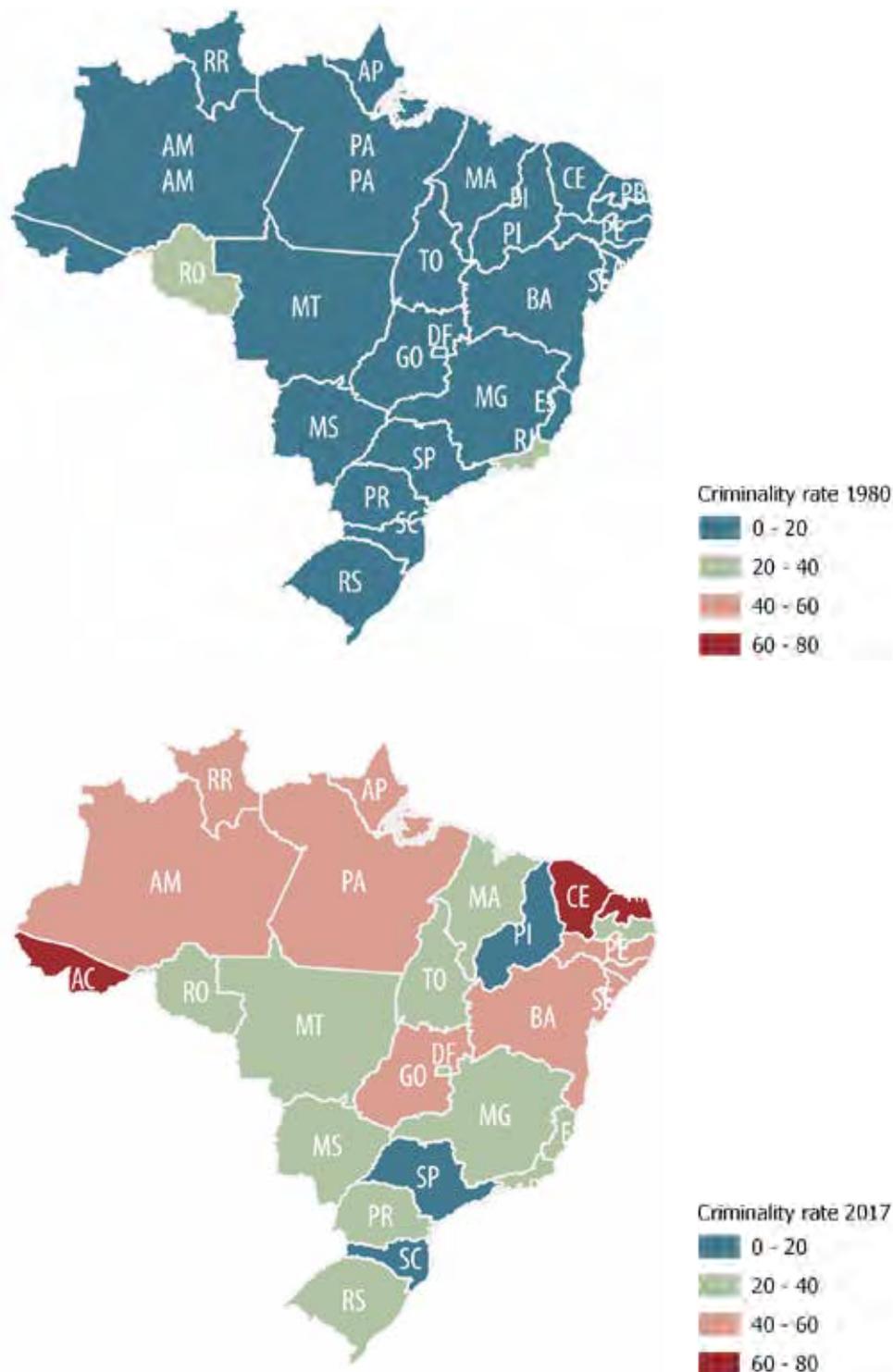
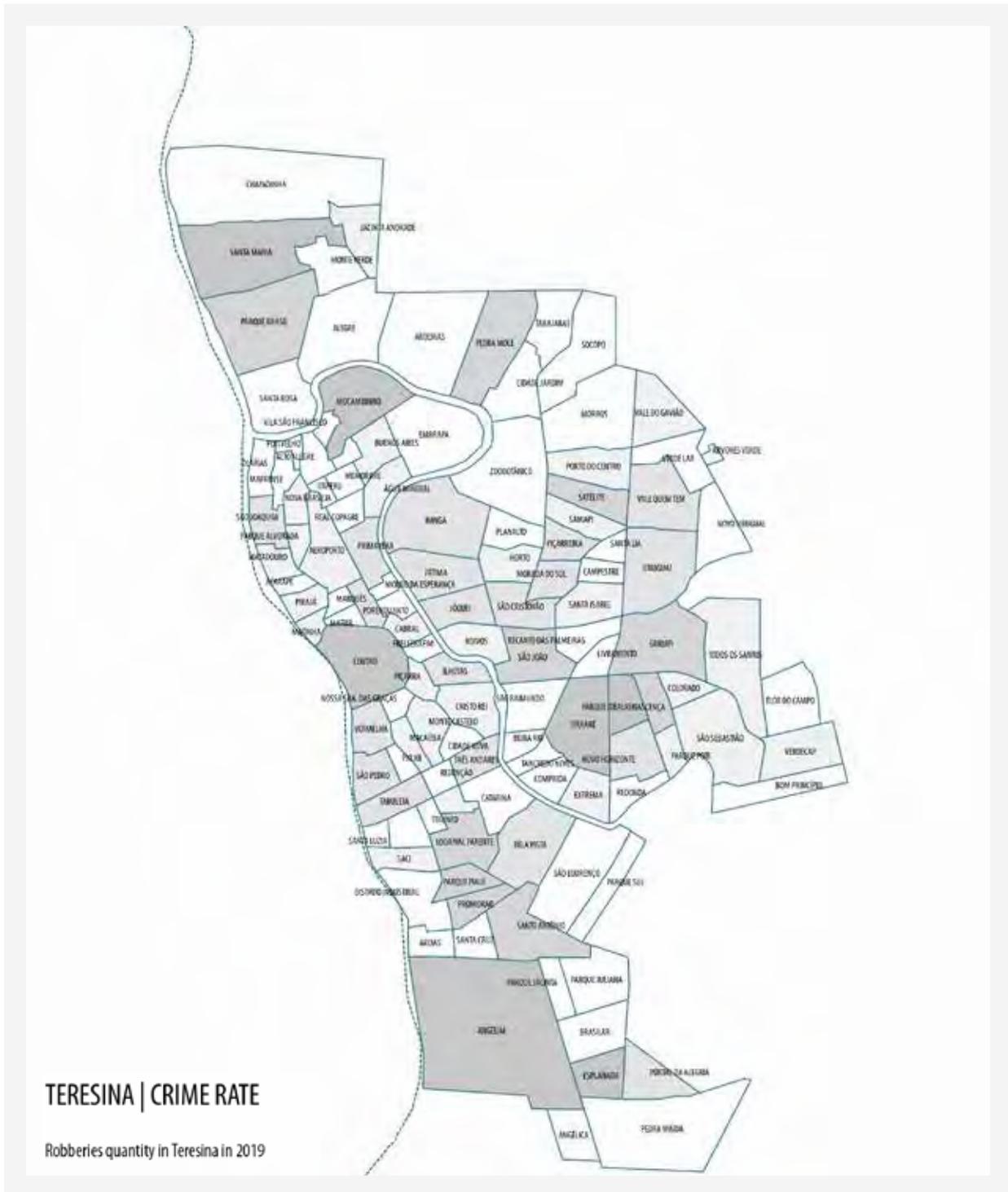


Figure 31: Crime Rate per Brazilian States in 1980 and in 2017. Source: CRGP, with data from the IPEA.

0 250500 km
N



- Robberies in 2019
- 0 - 100
 - 100 - 200
 - 200 - 350
 - 350 - 500
 - 500 - 1787
 - Teresina's Perimeter

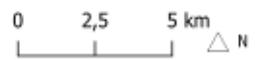


Figure 32: Crime Rate, Robberies in Teresina per Neighbourhood, in 2019.
 Source: CRGP, with data from SSP-PI.

Opportunities

Despite the aforementioned numerous challenges in Teresina, a number of structural, organizational as well as administrative change and arrangements are emerging in the city, resulting in opportunities that have the potential to alleviate the effects of risks and challenges encountered by the city as a whole. These opportunities are highlighted below:



Growing coverage and provision of basic infrastructure and social services

Latin American cities faced extraordinary challenges of accelerated urbanization after the massive rural-urban migration from the second half of the last century, becoming the most urbanized region in the world. Urban planning frameworks and policies at the time did not reflect and accommodate these issues satisfactorily. The provision of public services did not keep up with the demand for urban transformations, leading Brazilian cities to arrive in the 21st century with significant challenges even from the last centuries, such as the weak access to basic sanitation services. However, in the last two decades, the population growth rate stabilized, which has reduced the pressure on the supply of services. The freezing of the urban perimeter in the last decade has also contributed positively to reducing the rate of consumption of urban land and spreading the city, favouring population density and thus greater efficiency in the provision of services.

In 2020, Teresina achieved universal access to clean water with 100% of the population receiving safely managed water services. The coverage of the electricity supply is 99,7%, and the garbage collection reaches 99% of the city's urban population. The coverage of sewage networks remains remarkably low, but figures increased from 6% to 35% in the last decade. The city still faces the challenge of increasing its stormwater solutions to guarantee more safe and resilient urbanization, especially among the most vulnerable population. Regarding the provision of basic social services, the city of Teresina has the highest investment/capita in public health among the Brazilian capitals, being the most comprehensive regional hub for high complexity health services according to the IBGE. Finally, the municipal public education in Teresina is considered the best among all Brazilian capitals, being recurrently in the highest ranking in all national indicators that measure the performance of basic education in the country.

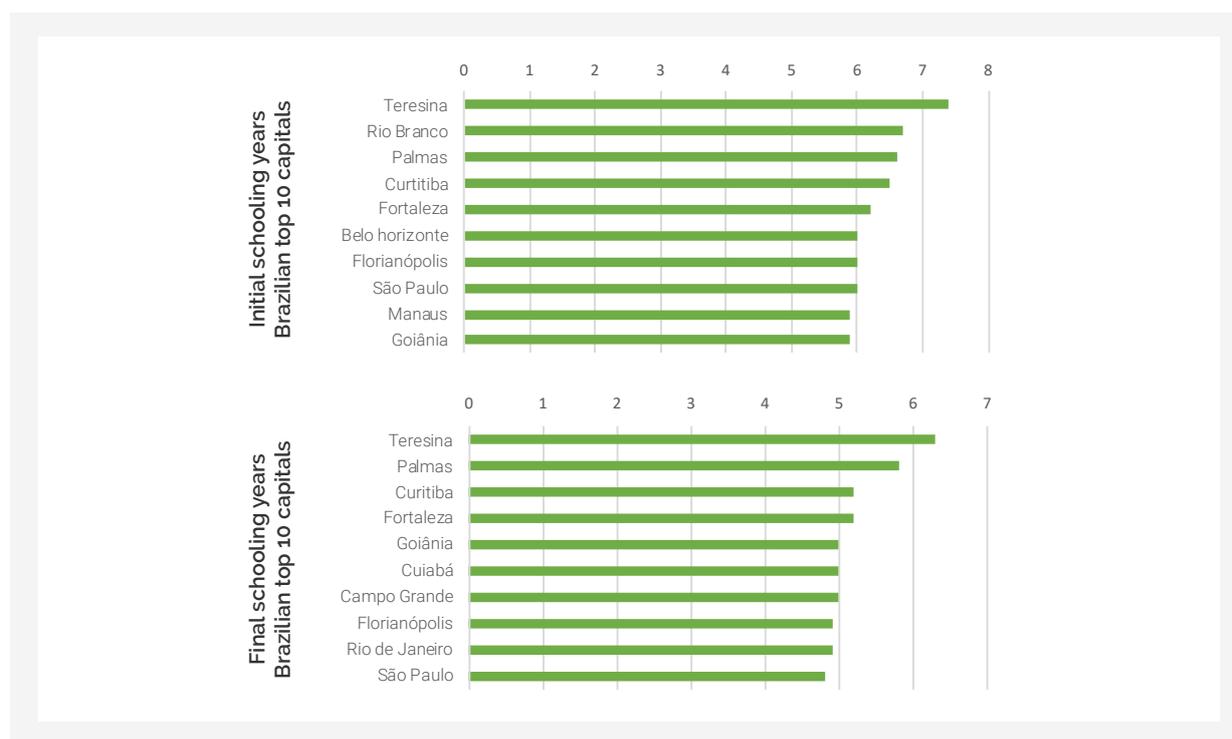


Figure 33: Top 10 capitals according to national basic education index for initial and final years.

Source: Ministry of Education/Brazil (2020).



Municipal revenue growth

Another strength to be considered in Teresina is the current trend of economic growth, reflected both in the growth of local GDP and in the municipality's own revenues. During the last decade, local GDP (at current prices), as well as GDP/capita, has been on a growth trend. The exception is during the 2015 national economic crisis, which affected Brazilian municipalities in general. Even so, the economy experienced a rapid recovery, currently remaining at stable levels. The most recent IBGE survey estimates the GDP at around R\$ 19 billion in 2017, while GDP/capita was estimated at R\$ 22,481.67. With these figures, Teresina was ranked 46th among Brazilian cities, a significant jump compared to the 64th position occupied in 2005 when a GDP of around R\$ 13 billion (R\$ 13.049/capita) was recorded, in current values. The municipal revenue collection followed these economic trends in the second half of the decade, including their fluctuations. While in the first years the value of own resources remained stable, as of 2016 these values started to rise, only to decrease severely as a result of the impact of the national crisis on public finances. After a period of local budgetary reforms, municipal revenues resumed growing sharply until the early 2020s, when it was again impacted this time by the Covid-19 health crisis.

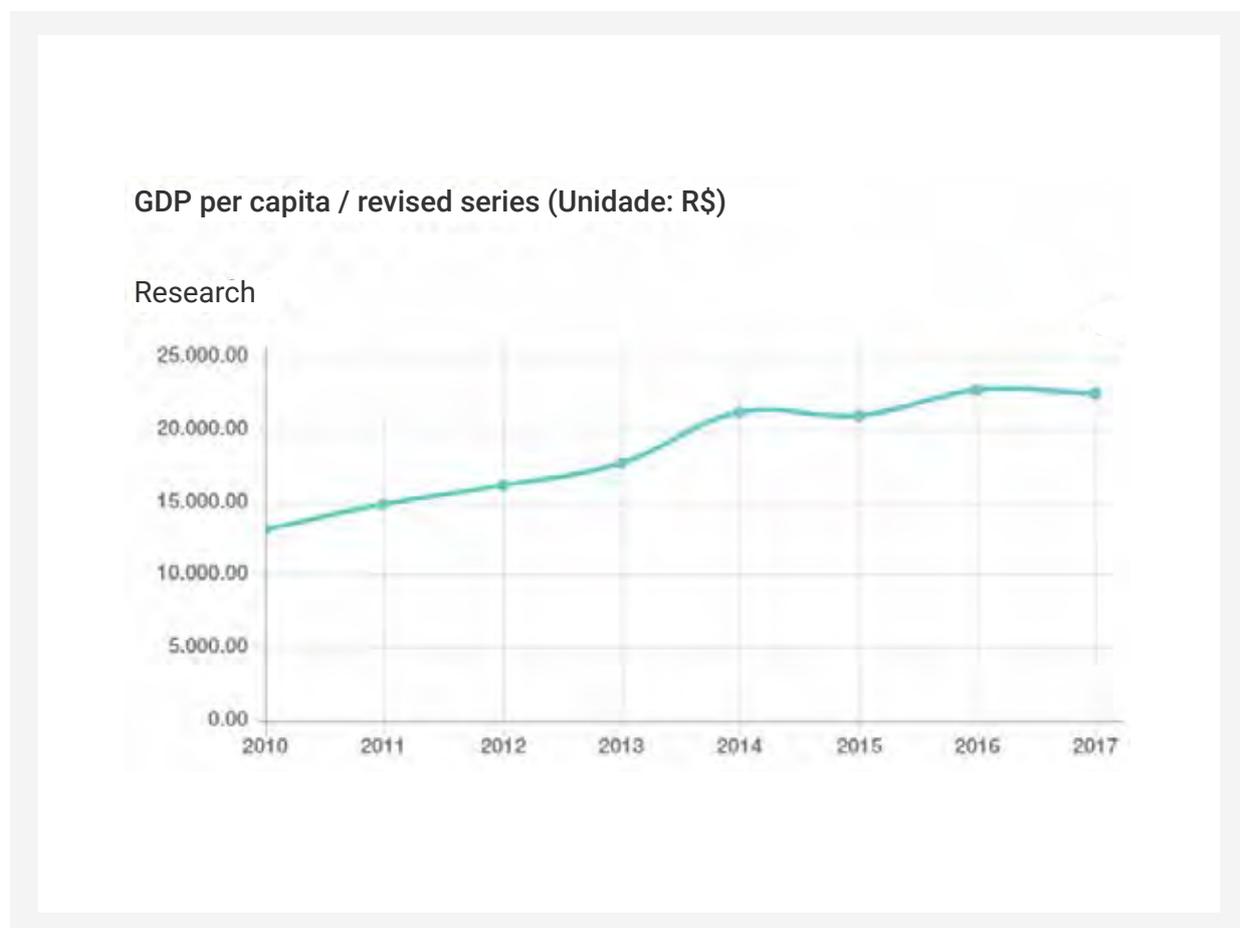


Figure 34: Evolution on Teresina GDP/capita. Source: IBGE (2020).

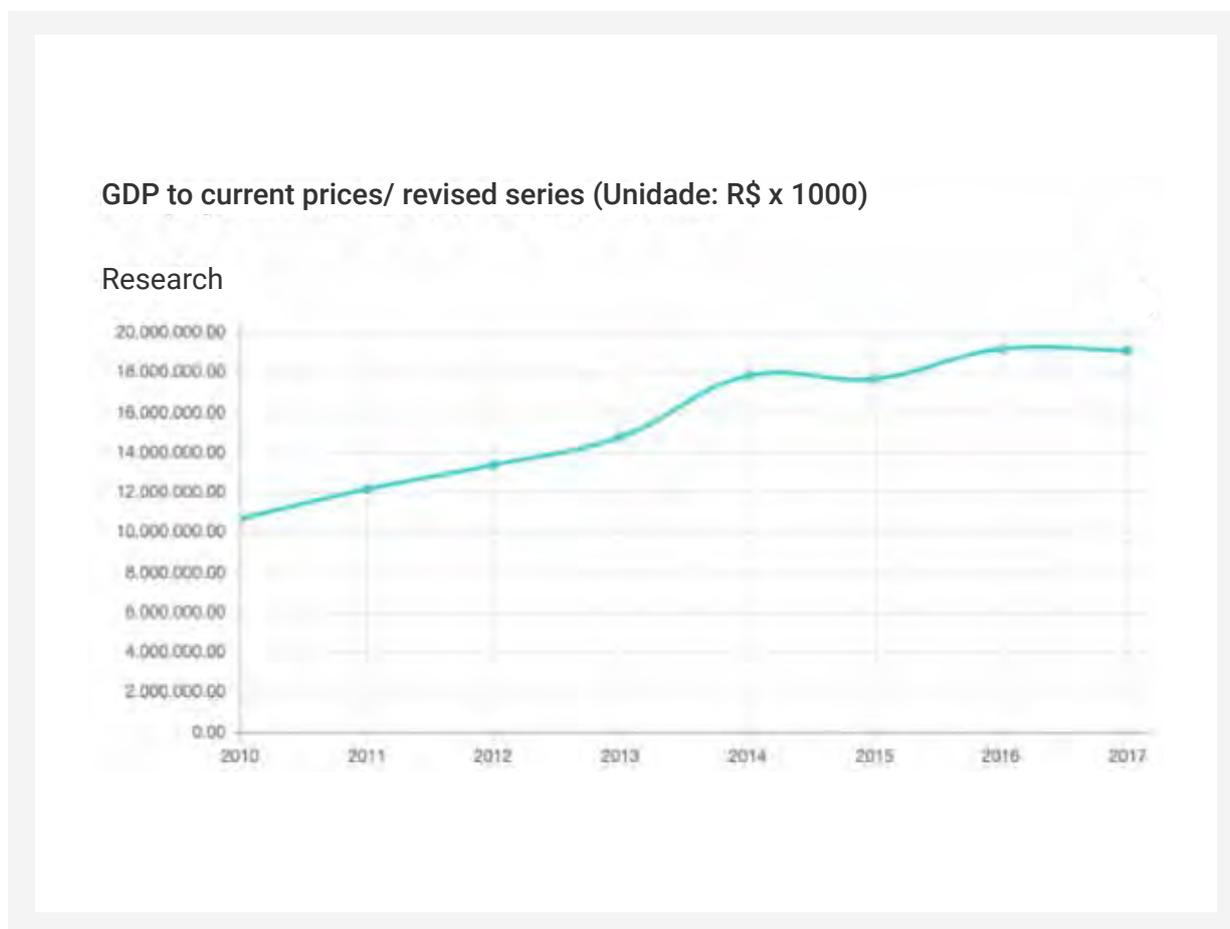


Figure 35: Evolution on Teresina GDP in current prices. Source: IBGE (2020).

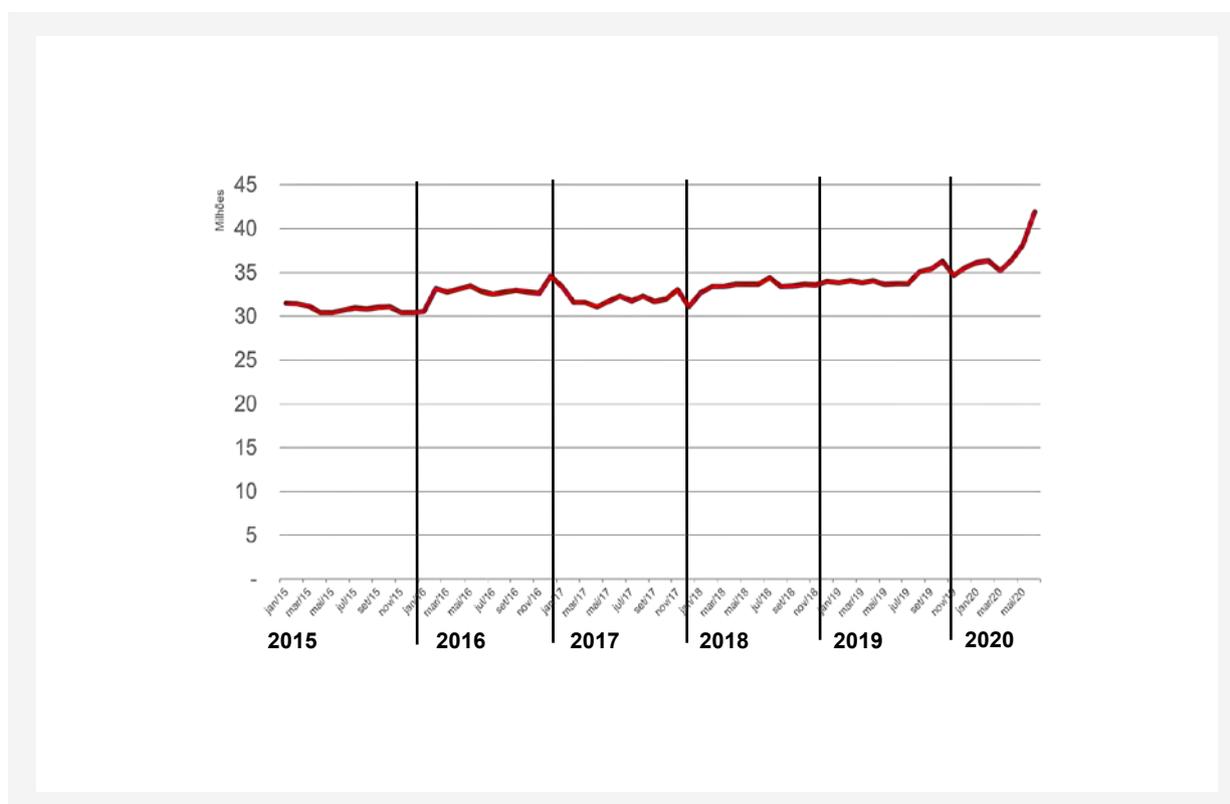


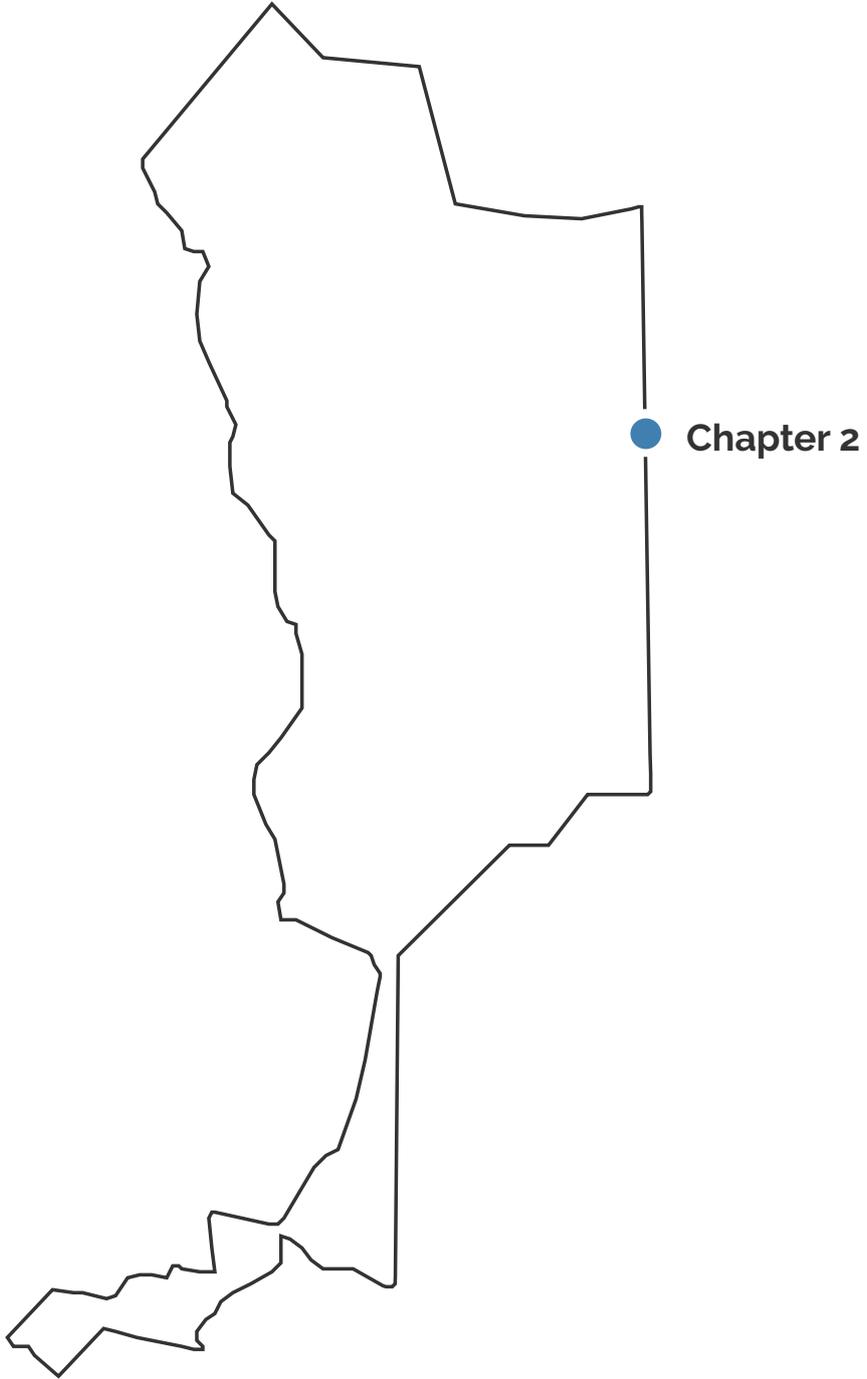
Figure 36: Evolution on Teresina Own Revenues. Source: PMT (2020).



Partnerships from local, to regional and international levels for increased technical and financial capacity

As a response to the challenge of weak intergovernmental coordination and the peripheral nature of its development, the city of Teresina had to seek alternative solutions, partnerships and networks in different levels (local, provincial, national and international) to build greater technical, financial and institutional capacities. As an example, in the area of education, the Municipal Department of Education has partnerships with relevant national NGOs in the field, such as Instituto Ayrton Senna and Comunitas, in addition to being part of the Juntos Program. Also in this area, a recent partnership with the Novo Banco de Desenvolvimento provides financing for the Teresina Educational Infrastructure Program which will also invest in improving urbanization in the municipal schools neighbouring areas. In the mitigation and adaptation to flood risks in the north, the municipality has a long partnership with the World Bank, which finances the implementation of the Lagoas do Norte Project.

Towards sustainable urban development, the municipality signed a cooperation agreement with the UN-Habitat City Resilience Global Programme to build technical capacities for a resilient and sustainable future. In its efforts for a more sustainable city that responds to the call of the 2030 Agenda, the city has signed a cooperation agreement with the French Development Agency to fund a comprehensive program to meet the SDG targets. In the transport sector, a partnership financed by the European Union, with support from ITDP Brasil, is analyzing the modernization and transparency of the municipal public transport service, and it is also part of the Mobilize Your City network. The municipality is also a member of different networks for climate action as the ICLEI Covenant of Mayors, and ICLEI's TAP - Transformative Action Programme. As an example of a partnership at the local level, there is a shared strategy for recovering from COVID-19 impacts. The municipality coordinates the Teresina Activa strategy, with the support of local actors such as the Federal University of Piauí, CDL, representatives of retail/industries (restaurants, hostelry, municipal markets, construction, etc.); and local actors from national entities such as SEBRAE, FIEPI, CAIXA, Banco do Brasil, Banco do Nordeste, among others. These partnerships allow data and information sharing to build a diagnosis of the crisis and to advance on recovery alternatives.



Chapter 2
The Current State of
Urban Resilience in Teresina

Chapter 2

The Current State of Urban Resilience in Teresina

As described in the introduction, the methodology which guided the CRGP implementation in Teresina relies upon a series of interconnected and overlapping processes to form a resilience analysis and diagnosis in order to recommend actions to build resilience in the city. This chapter presents the city's Current State of Urban Resilience, a combination of information derived from statistical, documentary and qualitative analysis of various municipal data, documents, combined with the outcomes of stakeholders consultations. This part of the report displays the main priority matters for urban resilience in Teresina that were co-prioritized through consultation workshops, validated and further characterised through indicators-based urban performance assessment. Particularly, this analytical chapter illustrates the different combinations of shocks and stresses that are shaped by present urban challenges (see chapter 1, Section 1.6: Challenges and opportunities) leading to the emergence of each priority matter. It further presents the characterisation of each priority matter through urban performance assessment which rely on CRPT indicators for evaluating the strengths and weaknesses of different urban elements interlinked to these priority issues.

2.1. Priority Matters

Priority matters are where the majority of risks to the urban system converge and concentrate in the presence of certain challenges or constraints, but are also where opportunities for maximizing the outcome of targeted actions lie.

The determination of priority matters in Teresina was the outcome of a series of workshops held by CRGP together with the Teresina Resilience Commission which is composed of representatives from 14 municipal departments. Taking stock of local knowledge and expertise, these workshops served as spaces to discuss the multiplicity of risks including shocks and stresses in Teresina and their interdependencies, and how these are shaped by present challenges and constraints leading to the emergence of certain issues seen as priority matters crucial to be addressed for building and strengthening urban resilience in Teresina (See Annex 01 for more detail on these workshops).

The findings of these workshops were corroborated by an evidence-based analysis using CRPT urban performance indicators with the purpose of carrying out an in depth investigation into the underlying drivers of each priority matter identified during the aforementioned workshops (See annex 02 for more detail on CRPT urban performance indicators and their findings in Teresina).

The following sections will provide detailed descriptions of the three priority matters, data collection and analysis findings. For each priority matter, a brief introduction is provided. This introduction is followed by a display of the driving factors behind each matter, and the risks associated including both shocks and stresses.

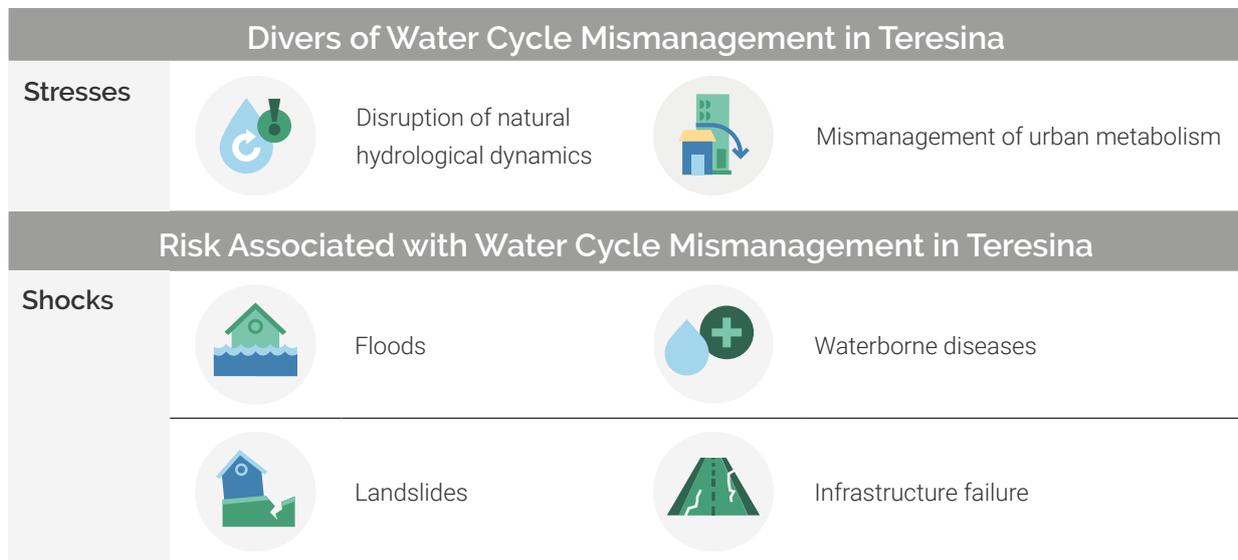
2.1.1. Priority Matter 1: Water Cycle Mismanagement

This priority matter is concerned with the management of both the natural and urban water cycle in Teresina, which in the light of unfolding climate change impacts, trigger different types of shocks and chronic stresses in the urban system. Moreover, water cycle mismanagement is strongly interrelated with the issue of Ecosystem Imbalance (Priority Matter 2).

Water cycle, also known as hydrological cycle, is the phenomena of the circulation of water between the biosphere, atmosphere, lithosphere and hydrosphere. In cities, this natural cycle of water is affected and modified by urbanisation, industrialisation and population growth. Its management becomes a highly complex process when considering water supply, drainage and wastewater collection⁶. This is known as the urban water cycle, which is essential for urban planning. Water cycle mismanagement refers to the lack of conditions and means for the effective protection and conservation of water resources, poor assessment and planning of both water resources and water demands, and inadequate monitoring⁷. A good water cycle management would ensure long-term water availability in both quantity and quality in all locations and have a low environmental impact.

The following subsections illustrate how processes of urbanisation, framed by poverty and inequality, have altered the natural water flows leading to an increase in the frequency of multiple shocks with severe socio-economic impacts. Concurrently, the lack of sustainable methods for managing urban metabolism, particularly solid waste, wastewater and storm water systems undermine further the urban water cycle management with serious implications for the city's ecological balance, increasing the potentials of more risks to emerge.

The next subsections describe and explain two different aspects related to water cycle mismanagement in Teresina: The 'drivers' which refer to varieties of factors including urban processes and risks which jointly lead to the emergence of water cycle mismanagement; and 'associated risks' which touch on both shocks and stresses happening as consequences of this priority matter.

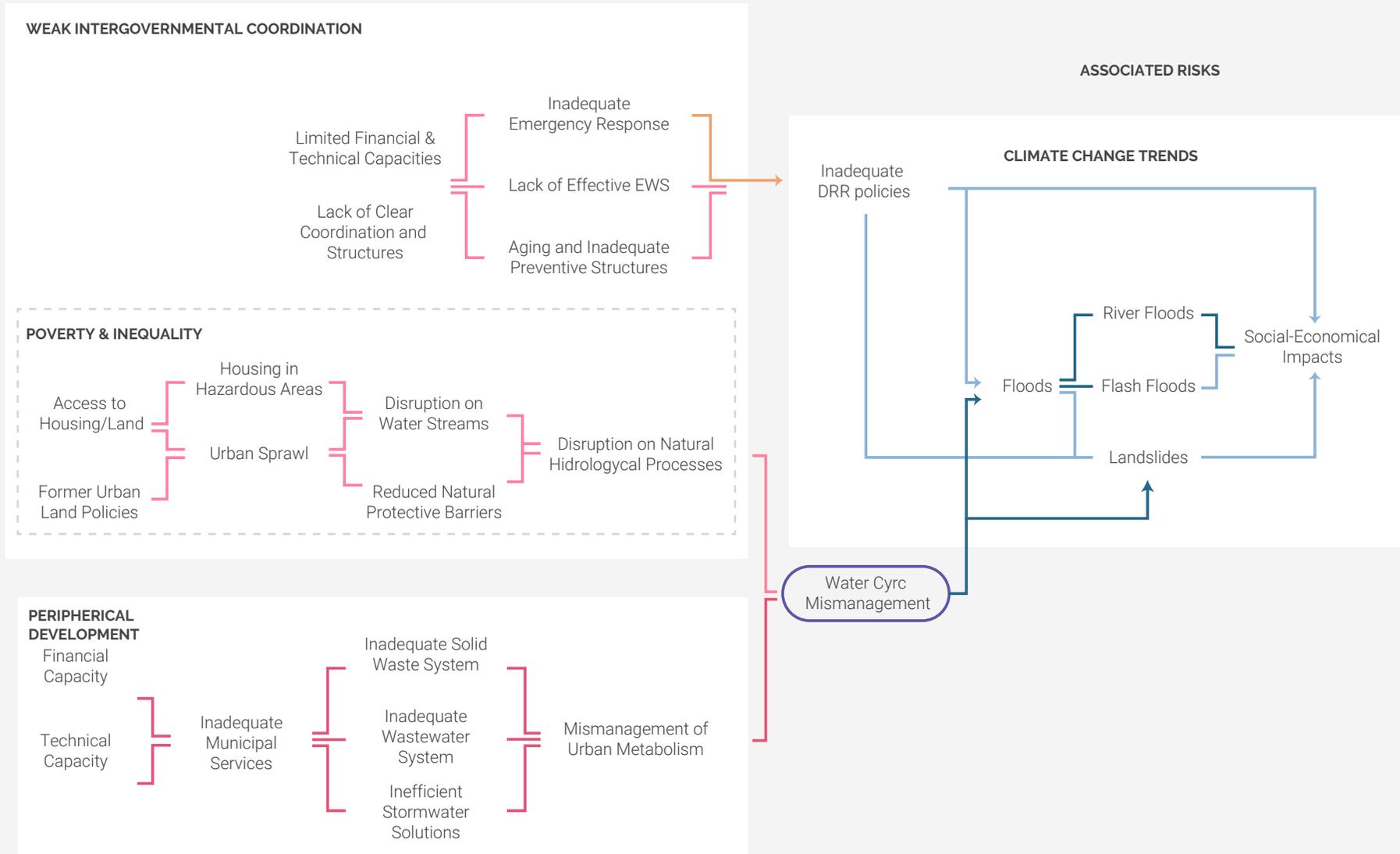


Insights from CRPT Urban Performance Indicators		
1.1.1	(Net) Urban population density	3.091 hab/km ²
1.1.1.1	Land consumption to population growth rate	1.05
1.3.1.1	Percentage of city area considered informal:	2%

⁶ Marsalek et al., 2007

⁷ Dyck, 1990

Figure 37: Cause and effects of Urban Water Cycle Management. Source: CRGP (2020).



Divers of Water Cycle Mismanagement in Teresina



Disruption of natural hydrological dynamics

Stressors: Urban sprawl and housing in hazardous areas

Between 1996 and 2000, Teresina's population grew at a rate of about 2.5% annually, higher than the average growth rate in Brazil, that was about 1.6% per year. In that same period, there was also a trend characterised by population declining in urban central zones, with -3.1% decrease, and an intense growth in the peripheral zones, mostly the southeast in neighbourhoods such as Gurupi, with an annual increase of over 10%.⁸

Teresina's rapid spatial growth is attributed to a number of factors, namely the general tendency by urban planning authorities at the time (Teresina Structural Plan I and II) which favoured horizontal spatial growth and low density developments inspired by urban planning trends in the US. In addition, lack of access to land and housing for many socio-economically disadvantaged populations meant moving to peripheral zones where land and housing was more affordable. The construction of various low-income housing developments, financed by BNH (Banco Nacional da Habitação) took place during this period. At first, these new neighbourhoods were totally disconnected from the urban area, built up in remote locations and acting as satellite cities. Nowadays, these neighbourhoods are already incorporated into the urban fabric of the city.⁹ Moreover, for those who couldn't afford any of these options, informal settlements in floodplains and peripheral zones, where risks of pluvial floods are high or access to basic urban services is minimal, were the only option.

The implications of this rapid growth and expansion for natural and urban water cycles are summarised below:

- Alteration of natural terrains.
- Disruption to water streams and their micro basins, hence alteration of water flow and circulation.
- Removal of natural vegetative barriers and increasing the risks of soil erosion, floods and landslides.
- Surface sealing through the use of impermeable materials for buildings and pavements which undermine natural drainage processes.
- As the new developments lacked services, the necessary basic infrastructure for solid waste and wastewater, unsustainable methods of disposing solid waste and wastewater have caused environmental damage.
- The spread of informal settlements in floodplains and peripheral zones has led to soil degradation and increasing the danger of flooding, posing additional risks on the residences of these settlements. In some instances, such as the Olarias area, building along constructed flood barriers is endangering the existing structures while putting the life of residence, their livelihood and properties into acute risks.

In the light of weak inter-governmental coordination, addressing some of the above mentioned issues has been very challenging. Particularly, As both Parnaíba and Poti rivers are considered preservation areas falling within the federal jurisdictions, the economic and environmental development of preservation areas requires prior authorization from the Federal Executive Branch, something proved to be challenging and very time consuming.

⁸ Secretaria Municipal de Planejamento e Coordenação, 2012, p.16

⁹ Carvalho & Collet, 2009



Mismanagement of urban metabolism

Stressors: Solid waste mismanagement, wastewater mismanagement and inefficient stormwater solutions

Urban metabolism as a concept focuses on the potential of sustainable patterns of consumption and production in an urban system by connecting material and non-material flows with ecological and social processes.¹⁰ The degrading natural and urban water cycle in Teresina is strongly linked with the management of such processes of flows and circulation, particularly the unsustainable management of solid waste, wastewater and stormwater.

Inadequate solid waste management

The way solid waste is managed can have a direct impact on water quality. In many developing countries, solid waste is dumped without adequate sanitary landfilling practices. During rainfalls, water can get mixed with waste, and this mixtures can eventually infiltrate into the soil and change its composition, and often contaminate groundwater¹¹.

In the case of Teresina, the city is trying to solve this issue by improving its solid waste management. The administration of conventional solid waste collection is carried out by a municipal concession, through the Secretariat for Urban Development and Housing (SEMUDH), that is also responsible for all the outsourced contracted companies. Most of the households have garbage collection and in most part, collection is 3 times a week. In rural areas, the responsibility of waste collection is of the Rural Development Secretariat (SDR), with a frequency of once a week¹².

Teresina generates, on average, daily 1,200 tons of garbage including household waste, public waste, health waste, tree pruning, etc. When considering only household waste, this value is 543 tonnes/day. In 2018, the city's garbage services collected a total of 209 312.25 tons of waste. The estimated population served by the garbage collection is 817,455 people (which counts to 99% of the urban population).

Waste management in Teresina is seen inadequate with considerable environmental impacts. The capital of Piauí has a poor performance compared to other Brazilian capitals regarding the adequate disposal of solid waste¹³. There is also a lack of public awareness programs about sustainable methods for waste disposal, especially for those residues that are not to be managed by household collection¹⁴. But, the city is improving its recycling system, with selective waste collection in Voluntary Delivery Points, that are exclusively within the urban area of the city.

Moreover, reports point out to the significant amount of construction solid waste generated by Construction which outsource the disposal of their produced waste to different private service providers, which in turn dump waste in a number of landfills without being subjected to any treatment processes. The current Civil Construction Waste management RCD framework in Teresina shows indiscriminate waste collection that does not follow any materials separation or segregation procedures.

Despite the existence of a number of regulations for the landfills management, such as CONAMA Resolution No. 307/2002 and the PNRS on Civil Construction Waste management (RCD) in Teresina, companies still do not comply with the established guidelines due to the absence of enforcement mechanisms and regular inspection by any of the environmental agencies present in the state be it a municipal, a state level or a federal body.¹⁵ This raises the danger of such practices on the environment given that these landfill sites are in areas with visible damage to the local natural system.

¹⁰ Broto et. al., 2012

¹¹ Vasanthi et al., 2008

¹² Latus Consultoria, 2017

¹³ Macedo, Samya & Malheiros, 2019

¹⁴ Cardoso de Sousa et.al., 2019

¹⁵ alves & Santos, 2018

Insights from CRPT Urban Performance Indicators

3.3.1.1	Proportion of solid waste collected out of total solid waste generated by the city.	Total solid waste generated (all types of waste)= 449.148,10 ton
3.3.1.1.2	If informal solid waste collection exists, please characterise the amount collected	116.434,71 ton
3.3.2.1	Percentage of population with regular municipal solid waste collection service (at least once a week)	99%
3.3.3.2	Main method(s) used for solid waste pre-treatment	No pre-treatment methods exist
3.3.7.1	For collection and for treatment, what maintenance and monitoring measures are applied?	Asset databases for solid waste, operations and maintenance plan for waste management, regular cleaning of collection points and drop of facilities (incl. within treatment sites), regular maintenance of vehicles and machineries of solid waste systems, regular monitoring and replacing of ageing infrastructure.
3.3.7.2	Remaining useful life of the site where the landfill is located (in years, based on capacity and municipal solid waste generation projections)	5

Inadequate wastewater management

Only 35% of the total population has access to a proper wastewater network through the 505.14 km of collection system. For the rest of the city's residents, the available options for the disposal of wastewater are individual sewage systems such as septic tanks, sinks and infiltration ditches. According to IBGE (2010), there were about 210,000 urban permanent private households; of which 41% have a septic tank system and 31% have a rudimentary cesspool system. Data show significant disparities between different neighbourhoods in the city in terms of access to an adequate sewage system suggesting marked levels of environmental injustices.

It is estimated that, in the urban area of Teresina, a total volume of 22,712,000 cubic meters of sewage is produced per year, which is equivalent to approximately 76.42 litres per inhabitant / day. Considering the limited coverage of households covered by a proper network of sewage, the vast majority of produced wastewater is being disposed off with only on-site treatment processes. Wastewater, produced by the parts of the city covered by sewerage network, is treated in three Sewage Treatment Plants (Estações de Tratamento de Esgoto, ETE), ETE Leste, ETE Pirajá and ETE Alegria. The ETEs have the purpose of reducing pollution present in sewage before launching the water again into the rivers, and in the case of Teresina, stabilisation ponds are used. This process follows a sequence of preliminary treatment, aerated pond, optional pond, maturation pond and effluent discharge. ETE Pirajá, the oldest and located on the right bank of the Parnaíba River, serves the population of the North and part of the Central area of the city. ETE Alegria, located on the left bank of the Poti River, is in an area prone to flooding, and ETE Leste is located on the right bank of the River Poti. Then, 5 independent subsystems integrate the sewage collection network, with seventeen sewage pumping stations¹⁶.

¹⁶ Latus Consultoria, 2017

Notwithstanding, since only 35% of the city population is covered by wastewater network, many of those who lack access to the network resort to clandestine connections where wastewater produced by households and businesses is channeled into the drainage network which in turn end up in the rivers. According to a study in 2012 by a number of environmental experts, due to the disproportionate concentration of Cu, Ni and Cr, Poty river water was neither suitable for recreational activities, nor for agricultural uses¹⁷.

Furthermore, the study findings showed high molar conductivity in all tested samples, which meant that treatments by AGESPISA for dissolving inorganic substances were not effective at the time. "PCA statistical analysis of the results obtained in this study showed the effects of seasonality, as the metal concentrations were higher in the period of heaviest rainfall due to diffuse sources of pollution displaced by the floods discharged into the Poty River¹⁸."

The effects of the existence of diffuse sources of pollutants, without any type of treatment, which end up in the rivers through the drainage of rainwater can be seen in episodes with high level of nutrients in rivers, leading to decreasing oxygen levels in the water and increasing the incidence of algae and plants, resulting in ecosystem imbalance with environmental impacts like the death of fish and unpleasant odors.

Insights from CRPT Urban Performance Indicators

3.2.2.2.1	Percentage of households connected to a wastewater network	35%
3.2.2.2.1.1	If percentage is considered inadequate (or less than 60%), please indicate reason(s)	Normative and institutional frameworks
3.2.2.3.1	Proportion of wastewater that is safely treated	34%
3.2.2.5.2	Is regular sampling of wastewater discharge for compliance with water quality standards	Yes, regular sampling

¹⁷ Damasceno et al., 2017

¹⁸ Ibid

Inefficient stormwater solutions

As indicated previously, rapid urban spatial expansion from the 1960s through the nineties and the beginning of the century resulted in enacting major alteration to land terrains and disruptions in water streams. Moreover construction methods and impermeable pavement materials have led to surface sealing. consequently, natural water flows are altered and stormwater is created. However, Teresina does not have a proper drainage system for collecting and reusing stormwater.

Stormwater gets contaminated when it comes in contact with urban surfaces such as roofs, roads and footpaths, due to the existence of oil, metals, litter and other pollutants, which means pollutants are carried directly into waterways, rivers and streams.

This has been already highlighted by studies testing the level of pollutants in Poti river. August to December, garbage accumulation in the margins, sand of banks, exposed soils, ciliary forest degradation, minerals dredge operation, erosion and sanded area, in several spaces were observed. It was verified that values of sodium carbonate were higher than the recommended limits by legislation for DO, NH₃ and thermo tolerant coliform, suggesting serious concern for the aquatic balance¹⁹ and the overall ecological balance.

Insights from CRPT Urban Performance Indicators

3.2.3.1.1	Percentage of urban area covered by stormwater collection system	Not Covered: 24,5% Street network with curb/gutter system connected to wastewater system: 75,5%
3.2.3.1.2	Is the city's drainage system currently able to cope with seasonal increase in rain/stormwater?	Yes, for a 25-year recurrence interval (Note: only limited parts of the city are covered by the network)
3.2.3.1.3	Is the city reusing rainwater collected stormwater and/or reclaimed water	No
3.2.3.4.1	What monitoring and maintenance measures are applied?	Regular clearing of storm drains and street sweeping; Regular monitoring of illicit sewer connections and elimination; Regular monitoring and replacing of ageing infrastructure.
3.2.3.2.3	Do zoning rules, building codes and standards that address water sensitive urban design and/or onsite stormwater solutions exist, are widely applied, properly enforced and verified?	Yes Drainage Act / Lei de Drenagem 4724 de 03/06/2015 Master plan/Plano Diretor (PDOT), Building law/ Código de Obras, Sidewalk Law/ Lei de Calçadas

¹⁹ Damasceno et al., 2017

Inadequate Risk Reduction Policies

Risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and, therefore, to the achievement of sustainable development.

Most of the risks (floods, landslides, disease outbreaks) associated with water cycle mismanagement in Teresina are not entirely of natural origin (as it will be seen through the following next subsections), but are rather the result of unsustainable urbanisation processes, generating exposure to risk conditions and pervasive vulnerabilities which render the effects of a natural event extremely dangerous. Thus, while acting on such exposure and vulnerabilities require long-term urban planning and development strategies, disaster risk reduction policies and measures are essential to ensure the risk of hazards are minimised and their effects are mitigated and responded to adequately and timely.

Although the city has initiated a number of plans and programmes over the past several years to address vulnerability drivers in particular zones of the city (such as “The Lagos do Norte Project - PLN - explained in detail in Chapter 3), a meaningful mainstreaming of DRR into urban planning and policy, such as into local land use plans, building codes and regulations and urban services provision, is still lacking. One of the major factors constraining Teresina’s efforts to legislate and adopt useful DRR measures, specifically prevention and mitigation, is the challenging context of intergovernmental coordination, particularly on the vertical dimensions. In Teresina’s context, this is very relevant and crucial for DRR as many of the zones within the city’s boundaries, characterised as of high risk areas are subject to multiple jurisdictions ranging from local, to state and federal level. Meaning that for a DRR related policy to become approved in such areas, extensive negotiations efforts and resources are necessary. Moreover, as legislating meaningful DRR policies and measures involves a great deal of environmental protection policies against deforestation and vegetation loss, orchestrated coordination efforts across the different levels of the government become crucial.

Nonetheless, a number of initiatives in place prove that such a task could be attainable. For instance, the National Civil Defense System which was approved in 2010 provided support to local and regional authorities by conducting risk assessment and studies. As part of this legislation, the national government financed and conducted the Teresina’s risk-prone areas cadastre. Moreover, it created a national early warning system that informs municipalities when a risk is imminent. Citizens could also register using their postal codes to receive push alerts via phone in the case of an event in their areas. The establishment of the S2iD (Integrated Disaster Information System) was an important initiative by the national government in cooperation with local authorities across Brazil which aims at gathering and providing real-time information and data regarding on-going threatening events in the country per city. These services are provided through the S2iD platform publicly accessible for everyone.

Apart from coordination challenges, financial and Human Resources on the local level are seen as insufficient for the adoption and enforcement of integrated DRR policies, plans and measures. Teresina still lacks adequate civil protection units with the right skills and capacity for emergency response and preparedness to hazardous events. In several cases of flooding and disease outbreaks, for instance during the Zika epidemic in 2016 the city had to rely on Piauí’s state civil protection units and in some cases on national military forces.

Risks Associated with Water Cycle Mismanagement



Floods

Sub-type: fluvial, pluvial and flash floods

Triggered secondary shocks: infrastructure failure, water borne diseases

Owing to its tropical climate with intense seasonal rainfall and its geographic location that is crossed by Poti and Parnaíba, Teresina has been historically prone to the risk of floods. Riverine floods of the Poti and Parnaíba rivers were already an issue in the 19th and 20th centuries due to natural and cyclical phenomenon related to water flow regime and rivers dynamics²⁰. Starting from the 1960s, the city experienced rapid population growth and spatial expansion towards areas beyond the bed of the Poti River. In the 1990s, its urban area started to cover floodplains to the north, east and south through both private and public housing programs.²¹

While this rapid expansion did not take into account the relief and the rivers, grounding lagoons and fluvial plains as the city grew, construction practices caused major alterations to natural terrains and water streams alongside the destruction of natural flood barriers and the erosion of riversides, affecting directly the natural water cycle. Moreover, The new neighborhoods were not properly planned, with inadequate drainage and sewage systems. Consequently, risks of pluvial and flash floods increased significantly.²²

While floods happen throughout the year especially during the rainy seasons, the incidences of flooding and their impacts are not homogeneous in all areas of the city. Some areas experience higher environmental risks resulting in marked social vulnerability. This is the case of neighborhoods like Poti Velho, Olarias, Alto Alegre or São Francisco. In the North, center and eastern parts of the city, the neighborhoods of Cidade Industrial, Chapadinha, Mafrense, São Joaquim, Mocambinho, Primavera, Cabral, Ilhotas, Ininga, Fátima, Noivos, and São João are especially vulnerable to flooding and its effects. Areas in the northern part, in the riverbed of the Poti River, have a type of soil that is favorable to flooding²³. In the South and Southeast neighbourhoods, São Pedro, Vila da Paz, Torquato Neto, Itararé, Extrema, São Sebastião and Recanto da Palmeira, are areas that recently has been seriously affected by floods.

Relevant recent Flooding events include the Fluvial Flood of March 20, 2020, that affected Conj SãoPaulo, Novo Milênio and São Sebastião, a marginal area to the Poti River, subject to flooding with a return period of approximately 10 years. Those affected are mainly informal settlers. Concurrently, the areas in Parque Dagma Mazza experienced major flooding along drainage lines. While these flooding events have not caused major life loss, they have caused significant economic material loss and displacement movements.

In terms of socio environmental vulnerability, the North, South and Southeast areas of Teresina are most at risk to both social and environmental issues, including high risk of flooding. Research suggests that the areas vulnerable to floods are also characterised by being low-income, with low levels of education and having low sewage coverage. These areas of high environmental risk, often having informal settlements, present precarious urban services and economic deprivation. In the northern area, 64.9% of the sectors are in a situation of high vulnerability in the income indicator and 48.2% in a situation of high social vulnerability in the education indicator, and with the high probability of floods due to geographical reasons, makes it the area most socio-environmentally vulnerable of all ²⁴.

²⁰ Lima, 2002

²¹ Lima, 2016

²² Ibid

²³ Feitosa, Nobrega & Junior, 2016

²⁴ Vieira and Gomes, 2011

Insights from CRPT Urban Performance Indicators

3.2.3.3.1	Percentage of dwellings damaged by intense flooding (10 years)	No data
3.2.3.3.2	What level of disruptions on road traffic due to waterlogging does the service face?	Recurrent/ Seasonal disruptions (First half of the year)
3.2.3.3.3	What level of disruption of access to public services due to waterlogging does the service face?	No major disruptions



Water-borne diseases

Sub-types: Dengue and Zika

Triggered secondary shocks: Health emergency

Floods not only cause landslides, they can also provoke a rise in infectious diseases when combined with the effects of inadequate solid waste and waste water management. It is reported that there are “zoonosis diseases” outbreaks as secondary shocks in the city, both of viral and bacterial nature. Mosquito-borne viral diseases like Zika and Dengue have been an important issue in Teresina.

In 2012, there was a significant dengue epidemic, being the year with the highest number of dengue cases reported among the population of Teresina in the historical series from 2007 to 2019. This epidemic directly affected 7142 people, with 4 fatalities, and also had marked economic impacts as a result of halting work for 15 working days in the city. In 2016, there was an epidemic increase in the occurrence and notification of Zika cases in Teresina, directly affecting 333 people with 42 falling seriously ill.

The occurrence of most diseases normally reflect inequality and is linked to poor social and economic conditions, especially in terms of frequency and distribution, the case of dengue is an exception, and the distribution of cases in the city is quite heterogeneous in terms of social class and purchasing power, but for different reasons. While dengue cases in poorer areas is more related to water storage in containers and inadequate sanitation, infrastructure and water supply, in high income areas the main factors linked to the cases of vectors are the storage places without a proper covering and with the presence of plant pots and other objects that are used in ornamentation²⁵.

²⁵ Gonçalves da Silva and Silva, 2019

Insights from CRPT Urban Performance Indicators			
5.2.2.3	Presence of notification mechanism on communicable disease occurrence or outbreaks	Yes	
5.2.2.4	Existence of early warning and rapid alert systems in case of diseases outbreak	Yes, general public	
5.2.2.5	Existence of awareness-raising activities as means of prevention and control of communicable diseases	Yes, general public	
5.2.2.5.1	Please specify the five most relevant emergency events occurred in the last five year	2020 - COVID-19 2019 - Dengue, Zika, chikungunya, Leishmaniose	
6.3.2.1.1	Physical Capacity of Health Facilities	Number of Hospitals:	0,14/1000hab
		Hospital beds:	3,73/1000hab
		Physicians:	70,65/1000hab
		Nursing Personnel:	71,65/1000hab
6.3.2.1.3	Do local or national early warning systems for disease control exist (e.g. Ebola outbreak)?	Yes	
6.3.2.1.4	Are there protocols in place for monitoring infectious diseases	Yes	
6.3.2.3.1	What level of disruption is faced in the healthcare system?	Significant	
6.3.2.3.1.2	If disruptions in provision of health service are significant, please describe the cause(s) of the disruption(s)	Fiscal/Budgetary Constraints or Mismanagement Administrative/Health Provider Disruption	



Landslides

Sub-type: mass movement

Triggered secondary shocks: infrastructure failure

Landslides and mass movement are recurrent in Teresina. Their triggers are multiple. Some are triggered by intense rainfalls and pluvial floods, whereas other events have happened as indirect results of urban spatial expansion and the consequent alteration to land terrains, disruption of water stream and the removal of vegetative barriers leading to soil erosion, thus reducing soil cohesion and render it highly vulnerable for mass movements.

Such events have caused severe damage to properties and mass displacement. In 2000, at Parque Afonso Gil, intense rain triggered a series of mass movements, sliding and flooding of buildings in embankments in a drainage line subject to flooding.

On April 6, 2020, a landslide was induced by pluvial floods at Vila Nova Esperança, an area with irregular occupation on a land with great unevenness. These soil characteristics make it vulnerable to landslides due to intense rainfall. 5 people were directly affected, 15 indirectly. Bem Viver has also been subject to landslides, that also resulted in soil degradation, with such events recorded in March 20, 2019 and March 15, 2016, affecting 1600 and 30 people, respectively.



Infrastructure Failure

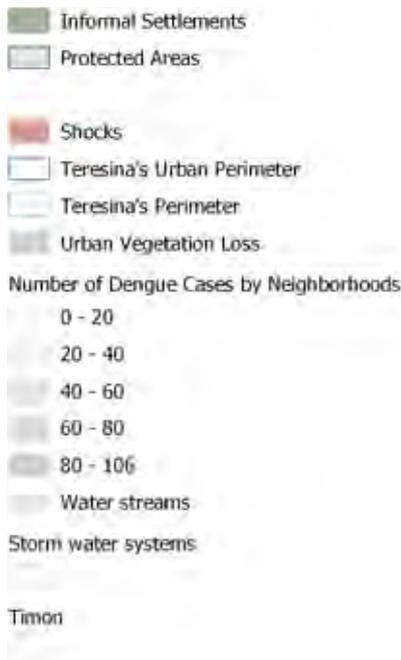
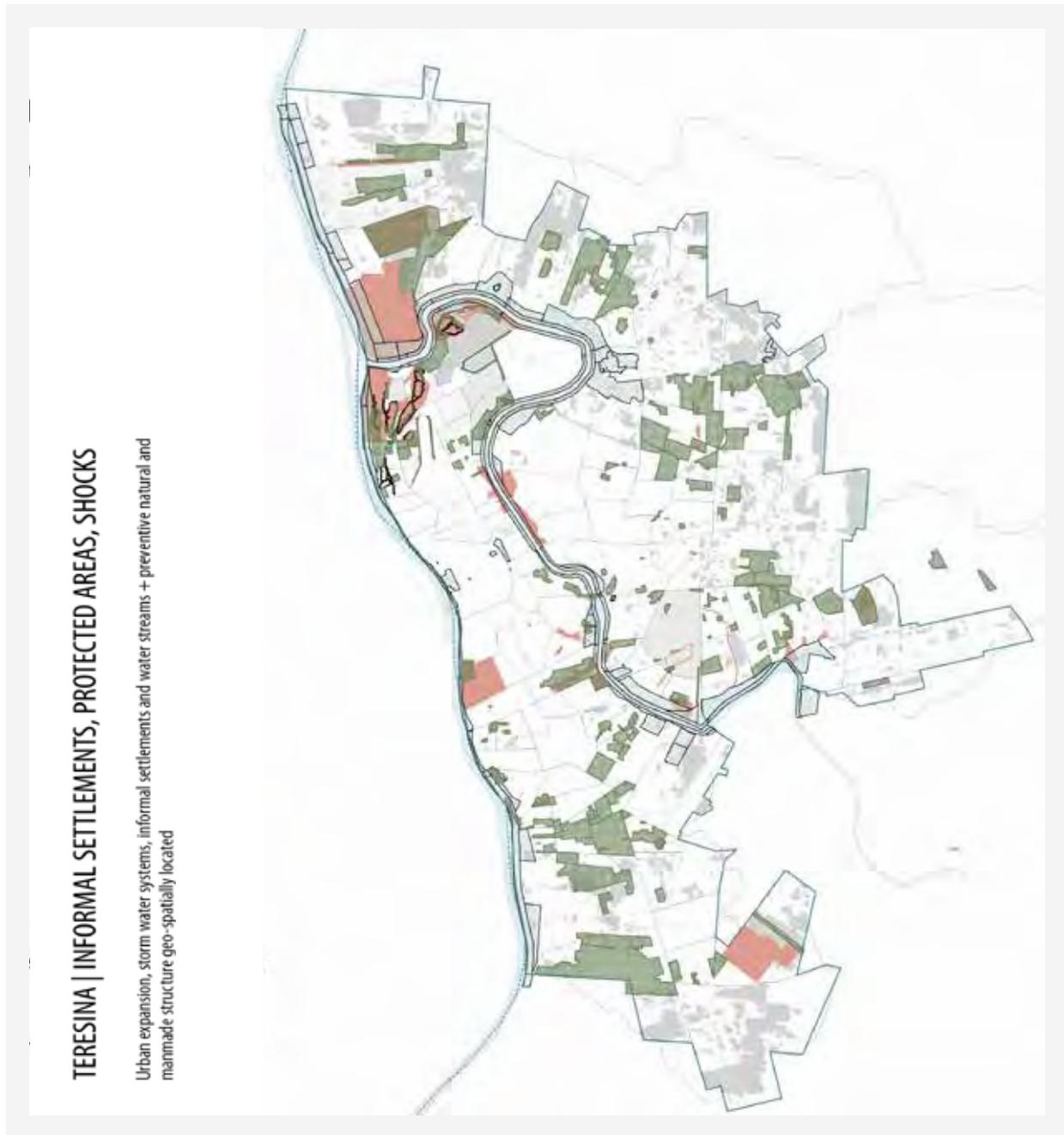
Historically, the infrastructure of the city of Teresina has also experienced a series of issues and failures due to floods.

In 1985, the waters of the Poti River, after invading the northern zone of Teresina and joining with the existing lagoons, were able to cross the Boa Esperança dyke, also with a breakdown of its structure around the current pumphouse. This event directly affected over 50,000 people and more than 70,000 were indirectly affected, with important damage in infrastructure, households, commerce, industry and agricultural activities. After this incident, the lagoons were connected and the Poti Dyke was built, in addition to the installation of a rainwater pumping station. There is also an urban and environmental requalification project for the Boa Esperança Dam under preparation.

However, despite effort to prevent these types of episodes, infrastructure failure in Teresina associated with floods is still a recurrent problem. On March 30, 2018, a section of BR343 highway yielded as a consequence of the heavy rain. A drainpipe below the highway broke due to 12h of continued rain, with the consequent mobility system breakdown associated with it. 4 people were injured during this incident.

Insights from CRPT Urban Performance Indicators

1.2.2.1	Percentage of homes with inadequate structure	Greater than 20%
1.2.2.2	Percentage of critical infrastructures with inadequate structure	Less than 10%
1.2.1.1	Percentage of urban footprint located in hazardous areas	7,745%
1.2.1.1.1	Percentage of built assets located in hazardous areas	3,81% of Built Assets (Including close to 1% of the Critical Infrastructure)



Source: CRGP with SEMPLAN, 2020



Figure 38: Combined factors related to the mismanagement of the water cycle. Source: CRGP with SEMPLAN (2020).

2.1.2. Priority Matter 2: Ecosystem Imbalance

Ecosystem/ ecological imbalance refers to disruptions to the balance of a natural ecosystem due to natural or anthropogenic causes. For an ecosystem to maintain its ecological balance, a number of processes are crucial²⁶:

1. The cyclic flow of materials from abiotic²⁷ environment to the biosphere and then back to the abiotic environment.
2. Upholding the equilibrium of interaction inside food webs.

Numerous factors can contribute to the disruption of these processes, which consequently undermine the balance of the ecosystem, namely: the global warming and greenhouse effects, and pollution. Locally, some of the major causes are rapid urbanisation, disposal of toxic waste in water bodies, soil erosion, deforestation, agricultural practices among others.

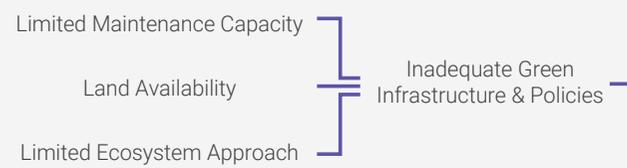
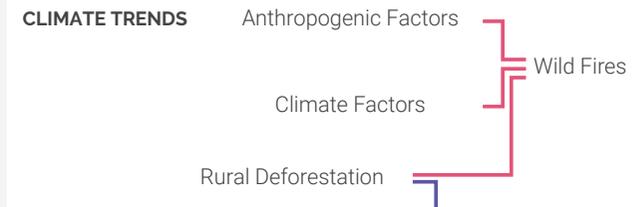
The effects of this issue are becoming quite evident in Teresina through various events, mainly biodiversity loss, and insects, animals and plants infestation which in turn caused both marked public health problems and considerable socio-economic impacts. In what comes next, a detailed explanation of associated risks and drivers of ecological imbalance in Teresina is provided.

Drivers of Ecosystem Imbalance in Teresina	
Stresses	 Environmental pollution
	 Vegetation Loss
Shocks	 Wildfires
Risk associated with Ecosystem Imbalance in Teresina	
Stresses	 Urban Heat Islands
Shocks	 Insects, animals and plants infestation

²⁶ Agudo, 2017

²⁷ Abiotic parts such as the soil, air, water etc

DRIVERS OF ECOSYSTEM IMBALANCE



Vegetation Loss

Ecosystem Imbalance

ASSOCIATED RISKS

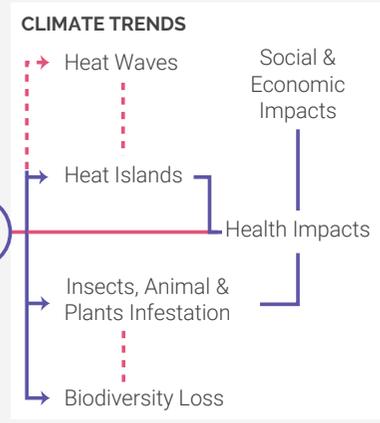
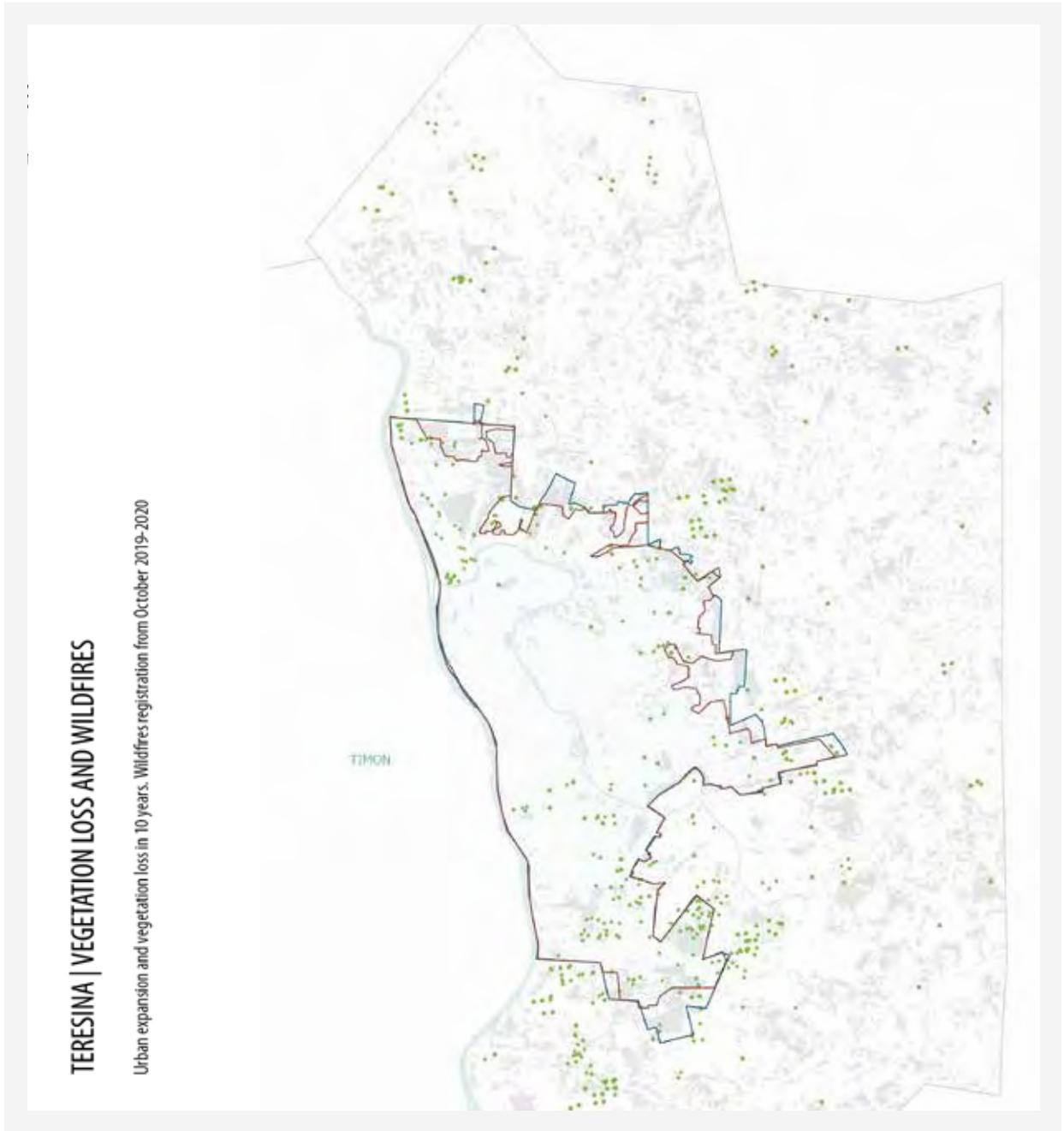


Figure 39: Drivers and associated risks of Ecosystem Degradation. Source: CRGP (2020).



-  Urban Perimeter 2010
-  Urban Perimeter 2019
-  Wildfires
-  Vegetation Loss
-  Water streams

0 2,5 5 km  N

Figure 40: Vegetation Loss and Wildfires.
Source: Global Forest Watch (2020).

Drivers of Ecosystem Imbalance in Teresina



Environmental pollution

Stressors: Water contamination and Soil degradation

During the years of rapid urban growth, unregulated occupation of the riverbanks of the Poti and Parnaíba Rivers took place in the absence of adequate planning and building regulations. This Brought about many clandestine connections with raw sewage in rainwater drainage pipes which have been causing serious health and environmental consequences, most noted in deprived areas without basic infrastructure²⁸. Apart from the effects of the unregulated spatial expansion in these areas, the inadequate management of wastewater in the city has greatly affected the quality of the water resources, leading to serious levels of soil and water contamination in the basins. With almost 70% of Teresina's population not having access to proper waste water networks, individual sewage systems such as septic tanks, sinks and infiltration ditches are the only options available for the majority of the city's residents, raising concerns regarding soil and groundwater contamination.

Poty River in Teresina receives in its bed several stormwater lines without any pretreatment measures leading to water contamination through illegal sewage connections, as also debris and sediments carried out by water runoff leading to river sedimentation. The ecological damage caused by erosion and sedimentation due to anthropological factors is visible in the Parnaíba river, as during the dry season the free passage of vessels is almost not feasible²⁹. The soil of the Parnaíba river banks is composed predominantly of sand and clay. Its original vegetation consists of riparian forests. These types of forests work as ecological corridors between other forests while guarding biodiversity. They also act as filters, protecting the soil against erosion and the water contamination, retaining pesticides and sediments that otherwise would end up in the water courses, hence affecting the flora, fauna, and human populations.

Although there exists many laws and legislations aimed at protecting the riparian forest, in reality the river banks have already been affected by the urban development from the previous decades. The river suffers from the disposal of illegal sewage connections, and from man-made fires that happen frequently and damage the vegetation. Further, urbanisation processes and the construction of roads and hydroelectric plants in upstream areas also put additional pressure on the riparian forest, raising the risks of riverside erosion and water contamination.

²⁸ Alves & Lima, 2017

²⁹ Clímaco de Lima, N. et al., 2008



Vegetation Loss

Stressors: Deforestation, urban vegetation loss, and inadequate green infrastructures and nature based solutions

Urban vegetation contributes to improving environmental qualities, leisure, recreation, and wellbeing in cities, while it also helps to reduce temperature levels and energy consumption.

Rapid urban expansion in Teresina meant significant loss of vegetation cover over the past 2 decades as a result of deforestation. While marked cover of vegetation still exists in the city as part of backyards, private gardens and sidewalks within private residential complexes, these are mostly private disconnected green areas with no access for the public. Also, the city lacks adequate coverage of green areas which can form connected green networks that provide integrated habitats for urban wildlife apart from their role in improving living qualities in the city.

The main causes of vegetation loss in Teresina are:

- Rapid urbanisation and urban sprawl at the expense of green fields.
- Lack of effective enforcement mechanisms for environmental protection.
- Safety and crime: residents tend to remove sidewalk trees that have the potential to be used for trespassing into properties for robbery, or create darker spots on sidewalks at night.

The major implications of vegetation loss in Teresina are higher surface temperature due to high concentration of built-up areas. These temperatures tend to get milder in the outskirts of the city, where more green areas exist.

Insights from CRPT Urban Performance Indicators

8.3.1.3	Proportion of natural areas and urban green spaces in the city as a percentage of the urban area	Natural areas	1,26
		Urban green space	44,19%
8.3.1.4	Specify the urban green space per capita and disaggregate, if possible, by sex, age and groups in vulnerable situation	13,43 ha/1000pop	
8.3.1.5	Proportion of urban green space cover (including vegetation canopy cover and blue areas), as percentage of the size of the functional area.	76,88%	
8.3.2.1	Please, specify the proportion of natural urban areas in the region that is protected	21,4%	
8.3.2.3	Please specify the total size of the number of areas (in ha) that connect protected natural areas and urban green spaces in the city, using the Green Infrastructure Index as measure.	No data	



Wildfires

Causes: natural, manmade, and rural deforestation

Triggered secondary shocks: Sudden air pollution, health emergency (respiratory diseases)

Teresina's climate and its environmental conditions have the potential to increase the incidence of wildfires due to both natural and man-made causes. While fires happen throughout the year in Teresina, it is between July and December when the occurrence of these fires intensifies, while decreasing from January onwards. The regions in the far north and the far south of the city seem to be most affected, but the fires are increasing yearly in the municipality as a whole. These fires also result in sudden air pollution and in the formation of sudden heat islands in the urban perimeter, increasing the already high temperatures, affecting urban living conditions and triggering health issues such as respiratory problems.

There seems to be a lack of effective preventive and mitigating actions by the public sector, and inadequate environmental policies for regulating land use in rural and peripheral areas conducive to reduce the risks of wildfires, and protect biomes³⁰. In addition, the city still lacks civil protection units that could support emergency response in such events.

Important wildfire events registered in the city include the incident of the 12th of October 2016, when a large-scale fire hit the Palmares National Forest, located between the municipalities of Teresina and Altos, and lasted for 7 days. Fires were recorded at the outskirts of the city, especially on the BR 342, between Teresina and Altos, and on the PI-112 and PI 113 highways that connect the capital to the municipalities of União and José de Freitas. The incident affected 300 people directly and 1000 indirectly, mostly vulnerable groups in informal settlements, with important impacts on the environment and infrastructure. As a consequence of this fire, there was a sudden air pollution event. Teresina was covered by a smoke screen and humidity reached 13%. This caused serious health issues affecting approximately 40000 people.

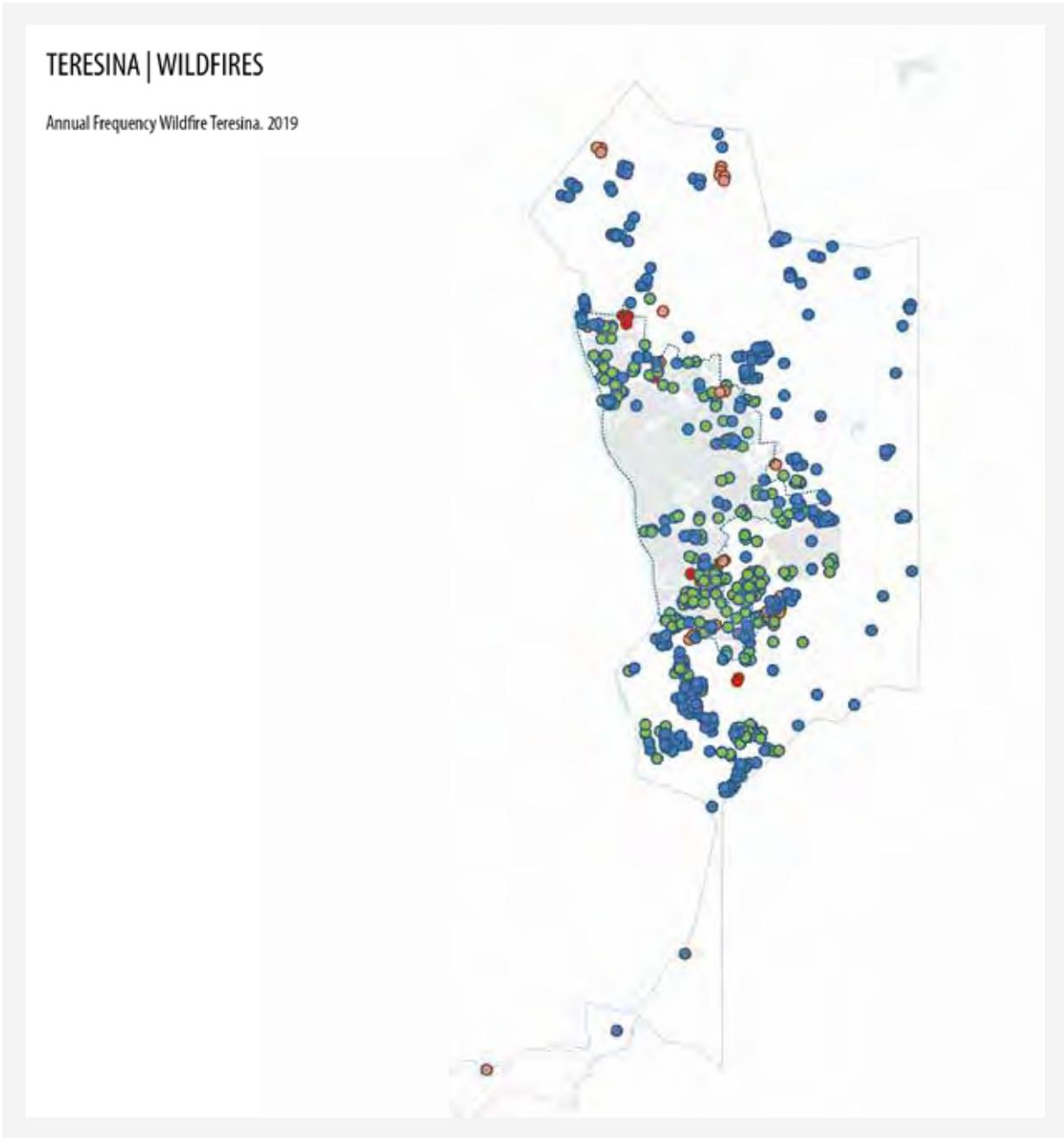
On the 15th of October 2017, a fire devastated shacks in the 8 de Março settlement in Teresina, destroying multiple homes, affecting 800 people and killing a child. Likewise, this caused a sudden air pollution incident and subsequent health issues.

While many fires are from natural origin, others can be man-made and clandestine. In informal settlements where access to proper services and public awareness is lacking, the population still sets fire for getting rid of domestic waste³¹. Apart from that, fires in Teresina are mostly found in the regions of the extreme north and the south of the city, outside the urban perimeter, in areas characterised by the presence of agricultural crops, suggesting there is a relation between agriculture and some of these fires. The fires also intensify in the period from June to December, that coincides with the with the drought season.

Insights from CRPT Urban Performance Indicators

5.5.1.1	Fire emergency services operating in the city, with respective capacities	Defesa Civil (Civil Defense) e Corpo de Bombeiros (Firefighters)
5.5.1.3	Emergency services available in the city, with respective staffing and equipment capacities	No data

³⁰ Gomes et al., 2019



Urban Perimeter

City Blocks

Wildfire

● October - December 2019

● January - March 2020

● April - June 2020

● July - September 2020

● October 2020

Vegetation Loss

Natural streams

0 2,5 5 km



Figure 41: Wildfire frequency annually.
Source: Global Forest Watch (2020).

Risk associated with Ecosystem Imbalance in Teresina



Urban Heat Islands

Stressors: Inadequate green cover, impermeable surfaces, thermal mass

Urban heat islands in the city are difficult to measure, since the environmental departments lacks the proper environmental sensors to track reliable data for comparison. According to research studies, the formation of heat islands is visible in the centre-north neighbourhoods such as Poti Velho and Aeroporto, especially around the Centenário avenue, a space of great density of houses and with no afforestation. This avenue has high traffic and acts as an important link between the north and downtown areas of Teresina. Maranhão Avenue is another point where heat islands form, with an air temperature of 1.7°C hotter than the surrounding points and 2.7°C on the smallest measure among the transects³¹.

The impact of vegetation can be seen in the areas after the Mariano Castelo Branco bridge. The areas with native vegetation have lower temperature levels than the areas that consist of open fields. At the same time, the hottest and coldest areas coincide, respectively, with the areas of urban density and demographic voids. While urban vegetation is mostly beneficial, not all trees function the same way to prevent the formation of heat islands: Avenida Santos Dumont, that borders the neighborhoods of Pirajá and Vila Operária, has trees with closed canopies. These trees provide shade during the early hours of the morning, preventing solar radiation from reaching the ground. However, closed canopies also prevent the release of heat to the upper layers of the atmosphere, and the trees of Avenida Santos Dumont hinder the dispersion of heat. This justifies the higher air temperatures on this avenue during the afternoon measurements.

Insights from CRPT Urban Performance Indicators

1.1.2	Percentage of open areas within the urban footprint	46%
1.1.2.2	Public open space per 100 000 population	57 ha/pop

³¹ Araujo & Andrade, 2017



Insects, animals and plants infestation

Triggered secondary shocks: biodiversity loss and socio-economic crisis

The impacts of ecosystem imbalance and the consequent ecosystem degradation are becoming evident through recurrent incidents of animals and plants infestation in Teresina. Water hyacinths (*Eichhornia crassipes*), locally known as aguapés, are an example of plant infestation in Teresina. Water hyacinth is a free-floating and flowering invasive aquatic plant originating from the Amazon Basin³². While the plant is beneficial when existing in moderate numbers, its infestation suppresses local aquatic biodiversity in rivers and waterbodies. In Fact, Its excessive infestation is an indicator of the river's water quality. The release of effluents of organic residues from sewages to this rivers without undergoing adequate treatment, increases the concentration of organic matter and nitrite content that is linked to the increase of aguapés³³.

This plant feeds on the residues that are suspended in the water, that are more abundant with reduced rainfall and lower river water levels, fostering aguapés proliferation. Its infestation has caused over the years significant sudden and long-term environmental and socioeconomic impacts in Teresina. In recent years, there has been an increase in the proliferation of Water hyacinths in the Poti river, mostly during the dry season. Forming a plant mate, aguapés covers the surface of the river blocking other aquatic plants from sunlight, causing their decay and death leading oxygen in water to dissolve. The low levels of oxygen then endanger the life of many types of fish and aquatic important species translating into socioeconomic impacts for the fishermen³⁴. "Water hyacinth has significant negative impacts on ecosystem services limiting cultural service that people obtain from an ecosystem. It significantly affects the lake hydrology by increasing the evapotranspiration of lake water. It creates a favorable environment for the production of snails and mosquito that cause diseases like Bilharzia and malaria"³⁵

Moreover, local reports indicate an increase in insect infestation such as crickets in the urban area during the dry season, owing this to the deforestation process and vegetation loss which destroy the natural habitat of such insects' predators.

Insights from CRPT Urban Performance Indicators

8.3.2.4	Does the city take the biodiversity in these corridors [green corridors], and in their green spaces and blue areas in general, into consideration?	Yes (Master Plan for Urban Afforestation for Teresina)
8.3.1.1	Change in number of native species over the past ten years (please disaggregate by species on the Red List of the threatened species, if available)	586 species on the Red List of Threatened Species, which 2 are classified as Endangered and 8 as Vulnerable. The others are classified as Near Threatened (12), Least Concern (554) and Data Deficient (10)
8.3.1.2	Percentage of invasive alien species as percentage of all species	No data
8.3.2.2	Does the local government take measures (regulation, monitoring, enforcement) to prevent or control invasive alien species.	Yes (partially)

³² Dersseh et al., 2019

³³ Sousa et al., 2008

³⁴ G1, 2018

³⁵ Dersseh et al., 2019

2.1.3. Priority Issue 3: Economic Underperformance

Being the capital city of one of the least developed regions of Brazil, Teresina also has historically suffered the consequences of the peripheral nature of its location which has been most of time far away or at the fringes of major national economic hubs and their sphere of influence. It therefore never has never had any major strategic industries and relevant infrastructure. This also left the region and the city under-served by well connected national and interregional networks of transportation and supply chains, which in turn have undermined the city's economic development and growth.

The symptoms of this issue are manifesting through the relatively less attractiveness of the city for businesses, high rates of unemployment and undermined municipal revenue, which combined lead to exacerbate existing poverty and socio-economic inequalities, increasing crime levels, and reduced safety, posing considerable risks of social unrest.

The Brazilian financial Crisis of 2015 exacerbated economic performance further in Teresina, with effects mostly evident in commercial and industrial activities. This led to an increased unemployment rate, especially among the youth, and resulted in spikes in informal commerce and subsistence economy.

The crisis affected the city's budget severely. Teresina had to participate in a programme in an attempt to increase the efficiency of recurrent costs, conducting a strong adjustment in the recurrent expenditure in the years 2017 and 2018, and lowering most of the contracts. All expenses were analysed and lowered in order to face the decrease in revenues. In the period between 2018 and 2020, the city was on a relative recovery, but the COVID-19 crisis is expected to reverse this progress.

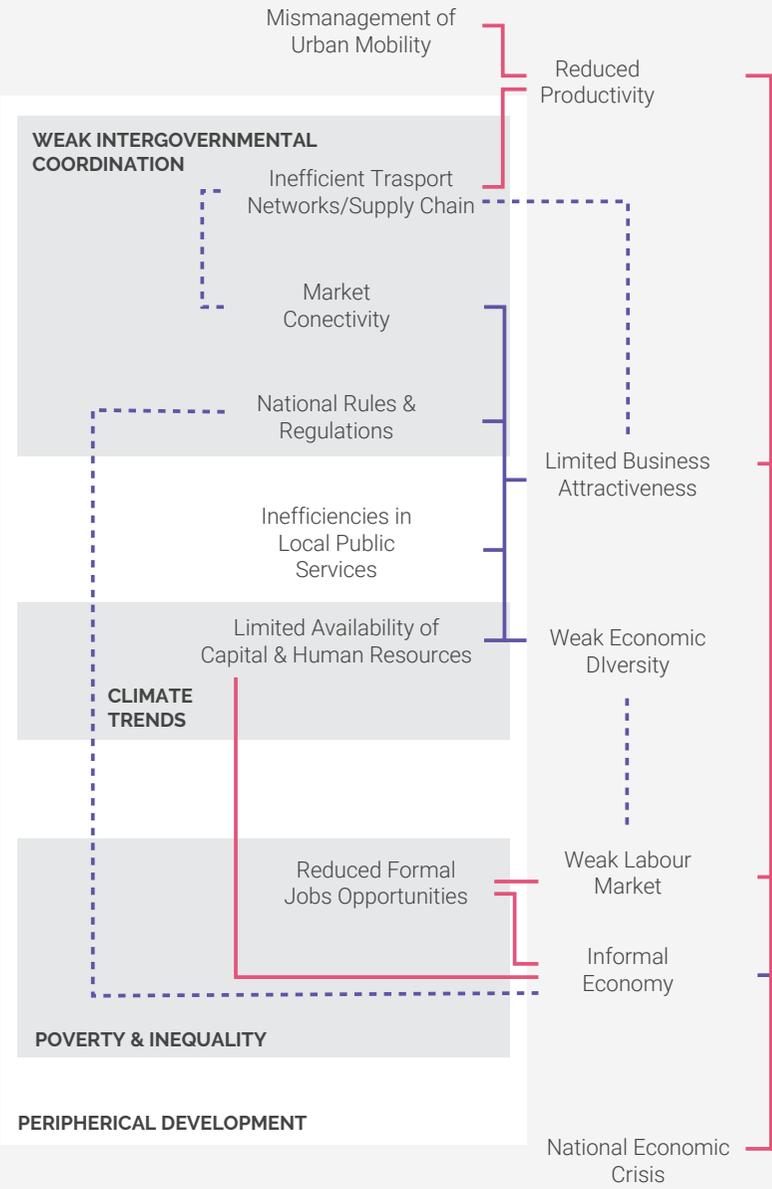
The following subsections will provide a thorough explanation for the major driving factors for economic underperformance in Teresina and the implications arising from this priority matter.



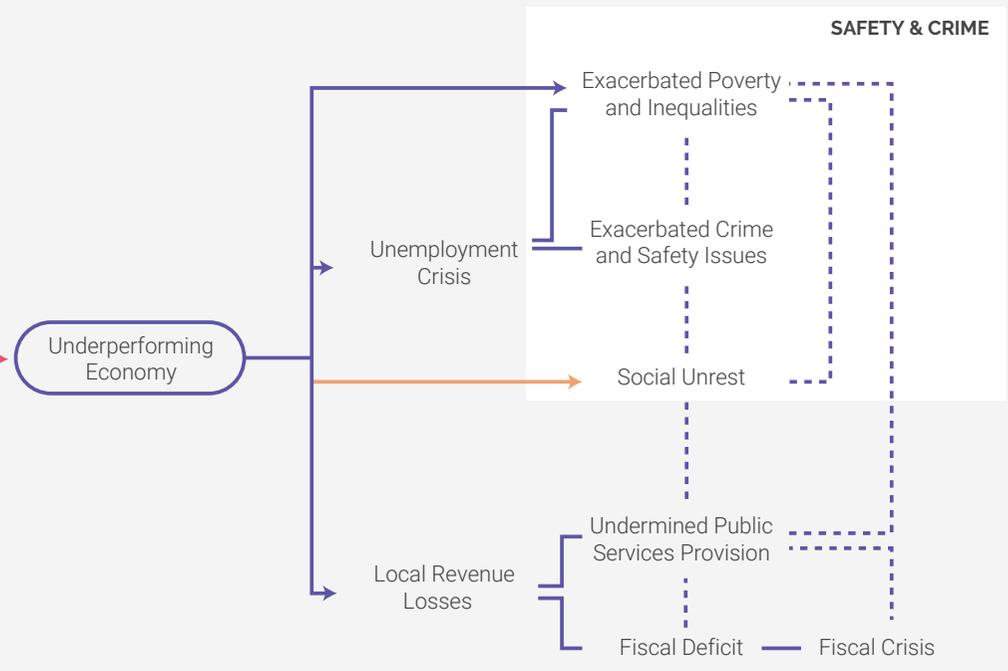
Insights from CRPT Urban Performance Indicators			
7.1.1.2	Gross City Product (GCP) and GCP per capita for the past 10 years	Average Growth Rate GCP (current US\$)	0,00%
		Average Growth Rate GCP per Capita (current US\$)	-0,64%
		Average Growth Rate GCP (R\$)	7,73%
		Average Growth Rate GCP per Capita (R\$)	7,04%
7.1.4.2	Proportion of the households below the poverty line		29,3%
7.1.4.3	Provide GINI Coefficient at local level the last year available		0,511
7.3.2.3	Currency volatility over the past decade	Total 2011-2020	68,71%

Figure 42: Drivers and Associated risks of Underperforming Economy. CRGP (2020).

DRIVERS OF ECONOMIC UNDERPERFORMANCE



ASSOCIATED RISKS



Drivers of Economic Underperformance



Limited Business Attractiveness

Limited business attractiveness

Stressors: market disconnectivity, national rules and regulations, inefficiency of local public services, and limited availability of capital and human resources.

Teresina has been struggling with establishing an environment that is attractive for businesses due to a combination of multiple factors. Historically, the northeast of Brazil as a region has been always poorer than the south-east as a result of uneven distribution of national development policies and opportunities, the availability of relatively less resources and the peripheral nature of Teresina's location. These historical, geographic and developmental conditions have had major implications for the city's connectivity and economic integration on the national and regional level. The city lacks adequate infrastructure for enabling intra-national and international mobility, namely roads, highways and an active airport essential to attract businesses despite its relative proximity to Maranhão and the Amazon forest.

Concurrently, Local development policies and local bureaucratic mechanisms still lag behind in terms of providing a competitive business environment. Moreover, despite the recent progress in local basic service provision, inadequate distribution of electricity and sanitation in Teresina also play marked roles in making the city less alluring.

In addition to the aforementioned factors, lack of industries, skilled labour and higher levels of illiteracy make the city under-developed in terms of economic knowledge.

Insights from CRPT Urban Performance Indicators

7.1.1.1.1	Manufacturing share of Local City Product		5,7
7.1.2.2	Total number of business establishments per square kilometre		77,61
7.3.1.2	Market Connectivity - Commercial banks per 100000 inhabitants		6,13
7.3.2.1	National Business Freedom measure according to the Index of Economic Freedom		63.8
7.3.2.1.1	Trade Freedom measure		73.9
7.3.2.4	Largest cities located between 200 and 500 km that have greater than 150,000 inhabitants	Parnaíba-PI	153.482hab under 340km
		Sobral-CE	210.711hab under 360km
		São Luís-MA	958.545hab under 439km
7.1.3.6	Are worker training and retraining programs available for city inhabitants?		Yes



Weak economic diversity

Stressors: Market disconnectivity, and Limited availability of capital and human resources

Economic diversity measures the degree to which a region utilises a broad mix of economic activities, transforming the economy by using multiple sources of income from primary, secondary and tertiary sectors and involving large sections of the population, as opposed to using just a single source or relying too much on one sector ³⁶. Diversified economies are correlated with higher economic growth thanks to the lower output volatility. On the local level, increased city's productivity can be achieved through greater professional diversity ³⁷.

In terms of resilience, "Economically diverse cities provide residents some insurance against major economic downturns, globalisation, changing legislation, and natural technological progress, each of which is likely to have a differential effect on various industries and occupations," says Andrew J. Hussey, associate professor of economics at the University of Memphis.

The weak economic diversity is ascribed to multiple issues, namely weak regional connectivity, weak business attraction, lack of skilled human capital, weak development and growth management strategies, and lack of loans and entrepreneurs. The interest rate in Brazil now is high in comparison to other countries despite the recent reductions considering inflations rates. According to many observers, both the state and municipality have been unsuccessful when designing economic development strategies.

³⁶ CHMURA, n.d. UNFCCC, 2016

³⁷ Bettencourt, Samaniego & Youn, 2014

Insights from CRPT Urban Performance Indicators

7.1.1.1	Industrial diversity using composition by city product sector shares	Public administration:	36%
		Retail sector:	11%
		Administrative activities:	8%
		Human healthcare and social services	7%
		Education:	8%
		Processing industries:	5%
		Construction:	3%
		Lodging and food:	3%
		Transport and postal services:	3%
		Others	7%
		Specialized services:	2%
		Agriculture:	0%
		Electricity and gas:	2%
		Domestic Services:	0%
		Extractive industry:	0%
		Information and communication:	0%
		Arts, entertainment and recreation:	3%
Real estate activities:	0%		
Financial activities:	2%		
7.1.2.2	Total number of business establishments per square kilometre		77,61/km ²



Informal economy

Stressors: Reduced formal jobs opportunities, and national rules and regulations

Informal economy refers to parts of “any economy that is neither taxed nor monitored by any form of government”³⁸.

Informality in Brazil is a national issue, for which the Federal Government has been unsuccessful in bringing people into formality due to lack of incentives in the formal market. In Teresina particularly, informality is higher than the national average which is around 40%. It is partially attributed to the absence of legal, regulatory and policy frameworks essential for organising and regulating businesses and labour markets. In addition, low education levels, poverty, lack of access to resources, financial services and markets are micro levels factors leading many into the informal economy in Teresina.

The implications of Teresina’s informal economy are complex and are becoming quite challenging in the light of the current crisis of Covid-19. The significant size of the informal sector means that many workers are exposed to exploitation and lack the rights to decent working conditions as most businesses within the sector are not monitored by any regulatory authorities. Moreover, most informal businesses are neither taxed nor monitored resulting in reduced municipal public revenues which in turn undermine the municipality’s capacity in terms of service provision. This is becoming a major challenge for local and federal authorities during the current Covid-19 crisis in setting and providing any social support schemes and financial stimulus as the majority of the sector is not even recognised, pushing many into poverty while increasing inequalities.

Despite the recent efforts by the federal state as well as the municipality of Teresina through initiatives by local departments such as “Economia Solidaria” for addressing the issue of informality and promoting the formalisation of businesses and jobs, evidence show that more is needed, and the fact that getting into formal sectors requires high education levels while being financially less rewarding is disincentivizing formalisation efforts.

Insights from CRPT Urban Performance Indicators

7.1.2.3	Proportion of total businesses that can be classified as informal	58,80% of informal workers in Piauí, in the 1st semester of 2020
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7.1.3.3	Informal employment rate (please desagregate by sex and vulnerable groups, if possible)	Total	44,7
		Male	50,1
		Female	49,9

³⁸ The Economist, 2004



Reduced productivity

Stressors: Labour market dynamics, mismanagement of urban mobility, and inefficient transport networks and supply chains

While reduced productivity is normally driven by diverse economic and social factors shaped by existing fiscal and regulatory policies, on the local level additional factors namely urban mobility and inadequate provision of public services have the potential to exacerbate low productivity. This is particularly relevant in Teresina.

The city centre of Teresina is where major busy avenues such as Avenidas Maranhão, Frei Serafim, Miguel Rosa and Joaquim Ribeiro intersect owing to the monocentric feature of the city's development. Despite the attempts of the Structural Plan II of Teresina to modify the urban roads network towards an orthogonal grid and poly centric distribution of activities, the city remains hugely mono-centric³⁹. Most bus lines pass through the city centre, undermining the efficiency and effectiveness of public transport systems including Teresina's BRT leading to longer commuting times for those reliant on public transport.. These dynamics have consequently impacted the economic activities of the area leading to major daily economic losses as a result of reduced productivity.

Teresina is considered the Northeast capital city with largest rural area⁴⁰. Yet, connectivity and coordination between Teresina and the municipalities that form the Teresina metropolitan area are poor. The creation of RIDE Grande Teresina, intended to serve as a tool for economic integration, collaboration and inclusive policies, has so far had limited progress, as there is a lack of clear management strategies and wide political and economic differences among municipalities, creating a centre-periphery dichotomy that culminates in divergent interests and prevents a fructiferous integration. However, the management of RIDE, as well as the review of governing instruments, are under the competences of the federal administration.

Insights from CRPT Urban Performance Indicators

4.1.1.1	Percentage of commuting trips using each one of the following modes.	Private modes	28
		Public modes	26
		Sustainable modes	46
4.1.1.2	Percentage of population using paratransit modes of transportation		9,23
4.1.3.5	Average commuting time using various modes of transport.		No updated data
4.1.4.4	What is the average travel speed on major thoroughfares during peak hours?		35 km/h

³⁹ SouBranco de Vasconcelos Filho, 2019

⁴⁰ Carcará & Leal Junior, 2016

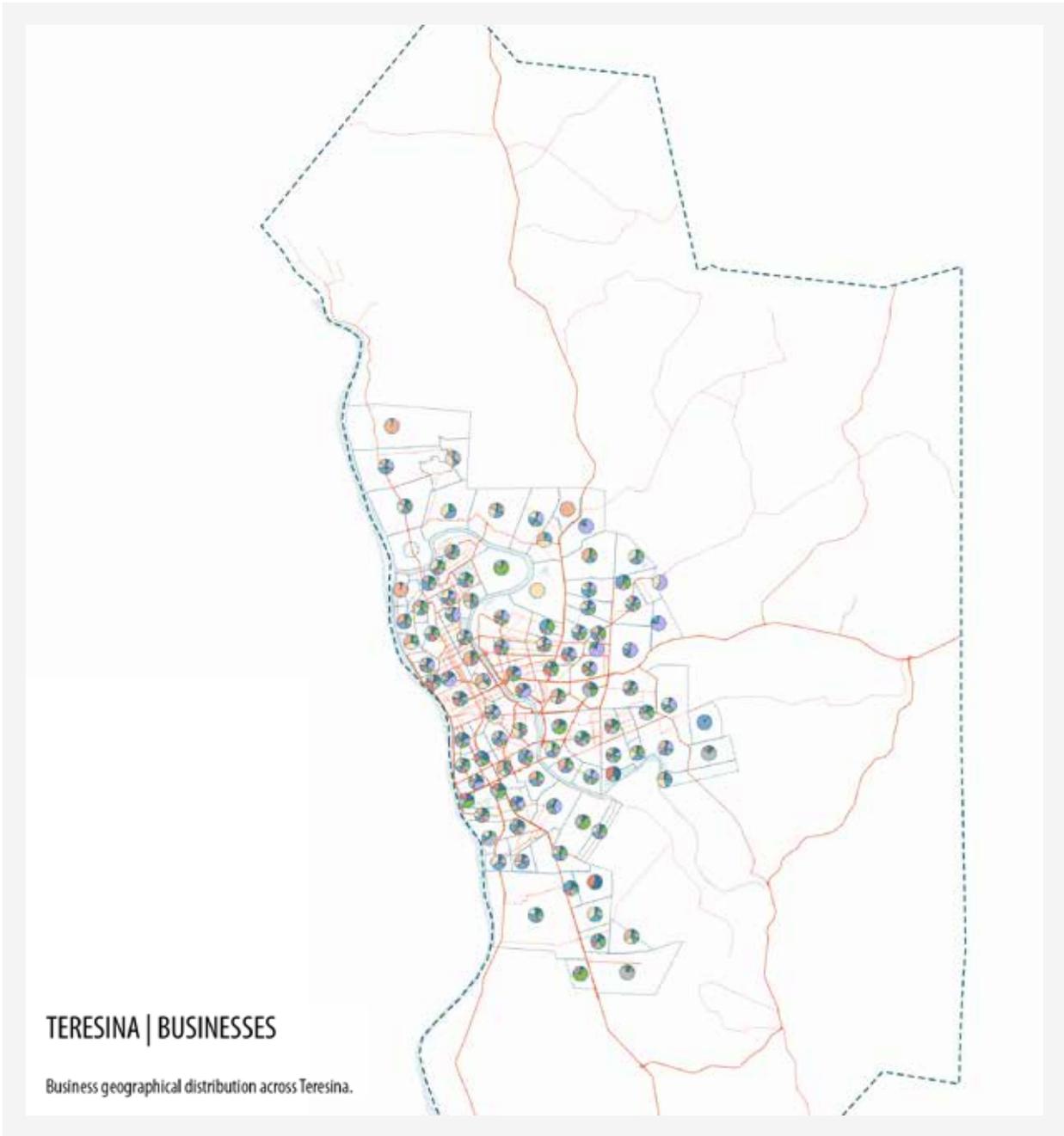
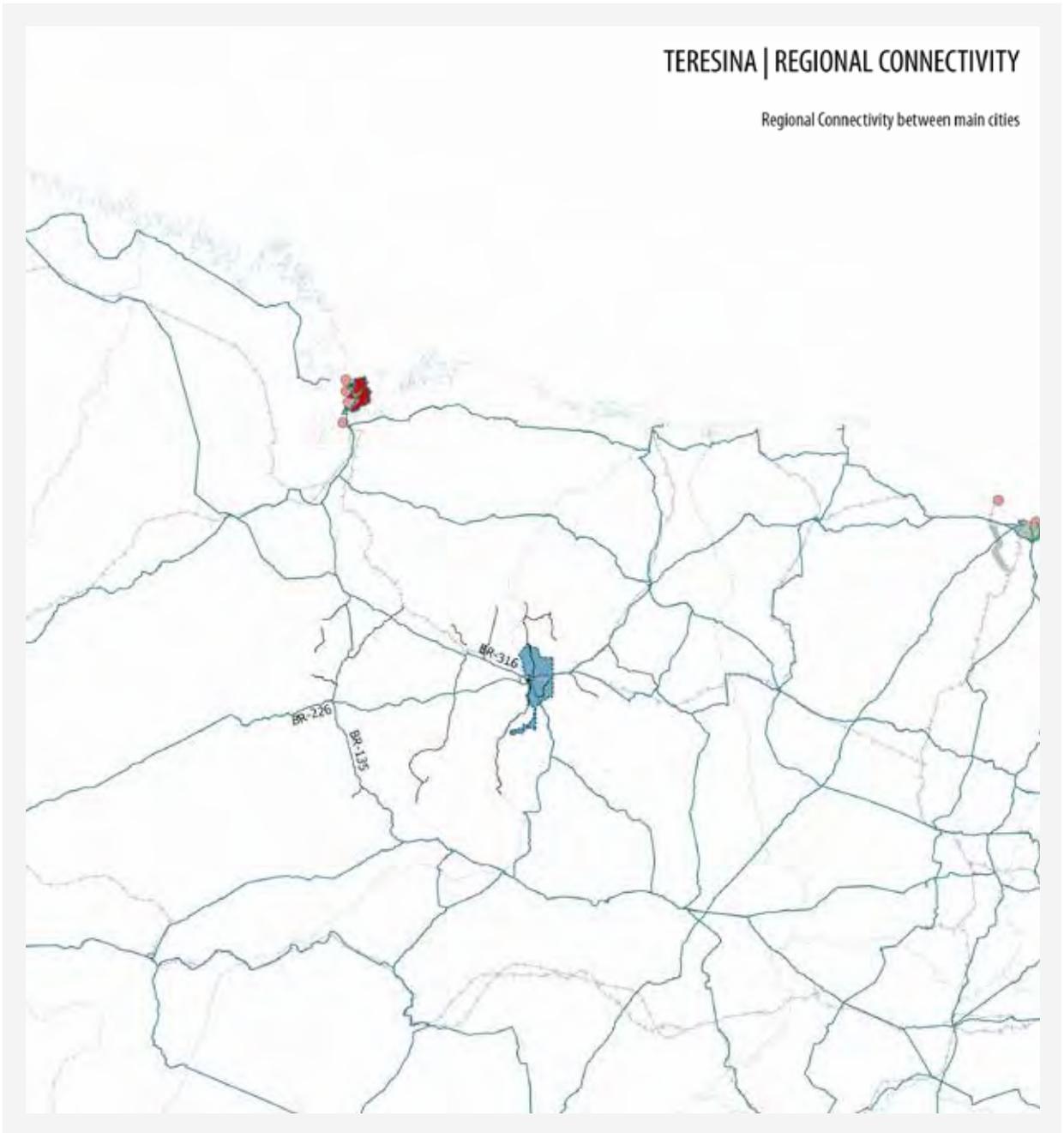


Figure 43: City Business. Source: SEMPLAN and SEBRAE (2018).



- limites mun. e cidades vizinhas
- Highways
 - Railways
 - Ports
 - Regionals Railways
 - Teresina
 - Brazil
 - Fortaleza
 - São Luís

0 75 150 km 

Figure 44: Regional Connectivity. Source: IBGE (2020).

Risks Associated with Economic Underperformance



Local revenue losses

While municipal revenue witnessed a sharp growth in the first half of the decade manifesting an impressive performance nationally, the municipality's own revenue started to plunge by mid 2016 as the effects of the national financial crisis propagated across the country. This fall in revenues resulted in undermining the municipality's capacity for service provision. This new situation forced the local government to undertake major budgetary reforms and fiscal policy changes which were conducive to resuming revenues growth, in addition to seeking external financing. This trend started to change again early 2020 due to Covid-19 crisis and the consequent lockdown. In short, while Teresina's municipal growth has been in general steady, the city's economic underperformance (explained above) has made the city more vulnerable to the impacts of national and international financial threats.

Insights from CRPT Urban Performance Indicators

7.2.1.2	Proportion of total local government revenue that is own-source		22,5%
7.2.1.3	Trends in own-source revenue (last 5 years)	Increased	45%
7.2.2.3	Existence of performance indicators and goals for tracking budget execution	Yes and results from performance indicators and goals are incorporated into the following budget	

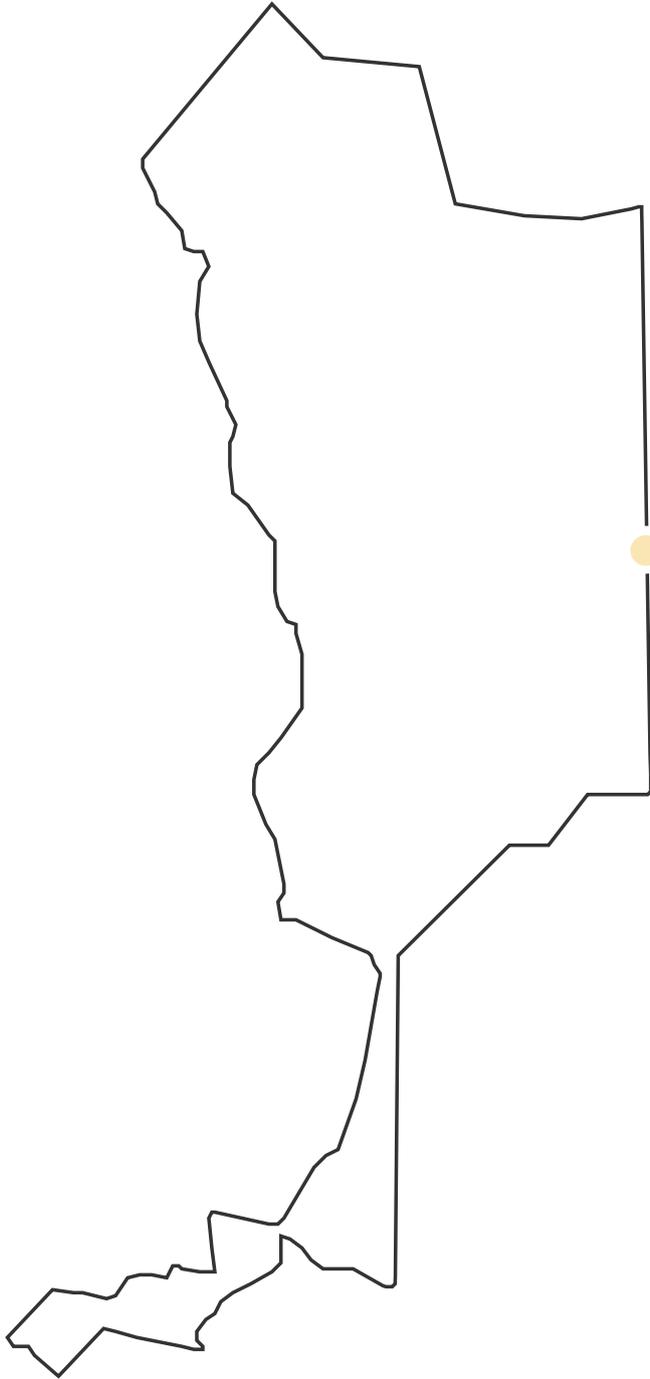


Unemployment

The levels of unemployment on the local scale strongly follow the trends of the national economy, with small particular variations in the city. The Brazilian economy, with the strong impact of the national financial crisis, showed strong growth in the unemployment rate as of 2015, reaching its peak in 2017. In recent years, the unemployment rate has fallen again, however slowly. The local unemployment rate is higher than the national estimate, but lower than regional figures. These data demonstrate a greater economic vulnerability in the region, which may be more impacted by future financial crises. With the current COVID-19 crisis, in the event of a weak economic recovery, growing unemployment is a risk that must be considered.

Insights from CRPT Urban Performance Indicators

7.1.3.1.2	Local government job share		40%
7.1.3.1.1	Manufacturing job share		5%
7.1.3.1.3	Self-employed job share		31%
7.1.3.2	Unemployment rate	Total	13,7%
		Female	13,8%
		Male	13,6%
		Age under 29	24%
		Age 30-49	10,6%
		Age above >50	7,2%



Chapter 3

Chapter 3
Urban Development and
Resilience Trajectory

Chapter 3

Urban Development and Resilience Trajectory

Building upon the findings displayed in chapter 2 - the current state of urban resilience in Teresina -, this chapter illustrates the results of an extensive review of policies, plans, initiatives, including risk reduction measures, in place or under-development that have the potential to influence, on different levels, priority matters for resilience in Teresina. Through the knowledge of the policy context, awareness of the risks and how they interact, and a review of the existing plans and initiatives in Teresina to address these issues, the urban development and resilience trajectory of the city through each determined priority matter is mapped out and key findings are derived.

Before delving into the review of policies, plans and initiatives (PPI) per each determined priority matter, this chapter provides a brief display of some global trends, namely the Covid-19 pandemic, and its local implications in Teresina. In addition the chapter presents the outcomes of a number of studies and projects on context-specific climate change trends. Given the rapidly changing situations due to Covid-19 and Climate change trends, this display is very essential to highlight the extent to which the existing policy context can adapt and maintain continuity in the light of these new realities.

3.1. Covid-19: Emerging trends

The Covid-19 crisis poses a global threat to social development and economic growth as the pandemic has triggered the most severe economic crisis in a century. Considering the Latin American context, it affected a region already struggling with low growth, and in the Brazilian case with growing poverty and extreme poverty, accentuated vulnerabilities and inequality, high polarisation and weakening social cohesion. While measures preventing physical social interaction are needed to constrain the virus spread and life losses, it is leading to more unemployment and decreasing personal and household earnings. According to the Economic Commission for Latin American and the Caribbean, income losses are primarily hitting those living in or vulnerable to poverty, including workers more exposed to layoffs and pay cuts and, in general, those in precarious jobs⁴¹.

As the crisis is unfolding, the COVID-19 pandemic has brought about extreme uncertainty, with more than half of the world's population enduring lockdowns or strict containment restrictions, while the European countries are undergoing the second wave of the pandemic. The Organisation for Economic Cooperation and Development (OECD) prognosticates world GDP to fall between 6% and 7.6% in 2020, depending on the impacts of the second wave of infections⁴². According to the Teresina Finance Department, there is a high uncertainty in local budget estimates for 2020 (See Annex 4), but multiple scenario modeling have indicated the negative impacts of COVID-19 crisis on local fiscal stability. The first scenario projected in 2020, before the crisis outbreak, estimated an GDP growth of about 2,3%. The second scenario was elaborated in May 2020. Taking in consideration the economic conjuncture, in the end of 2020 it would have a retraction of 7% in its production and with an inflation (IPCA) of 1,59%. This would result in an estimated amount of R\$1,530,128,092.40 and consequently a reduction of 10.5% in relation to the previously projected. The third scenario, elaborated at the same time as the partial reopening of the economy started, shows a situation of recovery, with the GDP pointing to -4.8% and IPCA with an expectation of 3.4% resulting in a revenue expectation of around R\$ 1,568,050,953.63.

According to the World Economic Forum (2020) the shock's impacts will be felt for a prolonged time as the direct response, and subsequent recovery and rebuilding efforts may last for years. In the case of Brazil, many households

⁴¹ CEPAL, 2020

⁴² World Economic Forum, 2020

benefited from emergency financial aids, and resuming these benefits next year brings uncertainties for the cities local economies. In Teresina, according to the municipality, the economy has managed to survive with the injection of income through the national Emergency Aid, which covers 38,8% of cities population. In total, almost half billion BRL were directed to Teresina's citizens from Apr-Jul. In the state of Piauí, data from IBGE shows that more than 60% of the households received the benefit⁴³.

The resulting economic crisis may inflate unemployment rates, more profound inequality, generational conflicts and continued stress on well-being. Governments should also consider the risks of failing public services if the situation is prolonged, with safety nets and public goods under pressure. Moreover, COVID related priorities (largely healthcare and unemployment compensations) disrupting the already limited funding available for other societal imperatives and reduce investments in education, housing, urban development, environment, among other policies.

On the other hand, the pandemic crisis accelerated the digitisation of public and private services, and Teresina is no exception. The necessary switch of the internal government procedures and online services for citizens signals a trend that is certain to be accentuated. It also accelerated data governance as sound and refined statistics and data analysis are needed, especially for services and sectors facing limited capacities. In the private sector, it fueled innovation by boosting tech-enabled contact-free economy, including online retail, telemedicine, and social distancing delivery and logistics, which is expected to expand employment in particular sectors. While telematics services, like education and health, have become usual, the region's large digital disparity should be kept in mind. The opportunities and skills to access communication technologies, ensuring equitable access to digital city services, to remote health care, to online public schools, and to remote work possibilities, need to be addressed as a priority to reduce vulnerability gaps.

While the effects on urban development patterns are uncertain in the long run, many municipalities are already advocating towards polycentric sustainable cities, encouraging active mobility and adapting public transportation systems. Cities in developing countries are struggling with the maintenance of public transportation services in the face of decreasing revenues. According to the Brazilian National Association of Urban Transport Operators, daily fare losses are estimated to have cost as much as USD188 million/day⁴⁴. Limitations in public transportation provision also pose a risk of increasing paratransit modes.

In the challenge of overcoming these impacts and seeking opportunities for adaptation and growth, cities need comprehensive strategies that involve not only the different levels of government but also communities, companies and universities. Local governments can benefit from platforms to facilitate constructive dialogues that look not only at the city and regional level but discussing neighbourhood-by-neighbourhood impacts.

⁴³ IBGE, 2020

⁴⁴ Ibold et al., 2020

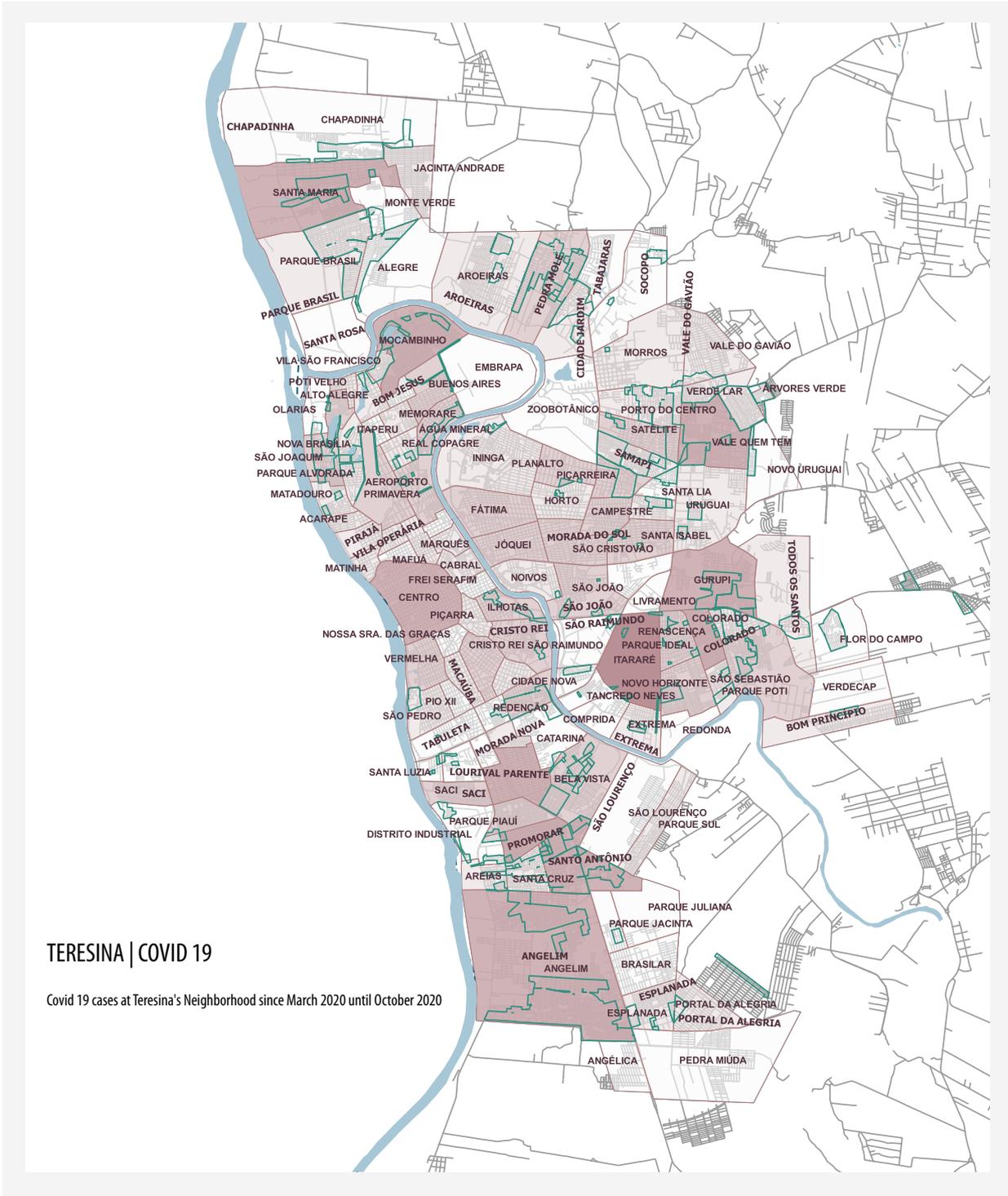


Figure 45: COVID 19 cases at Teresina's Neighborhoods since March 2020 until October 2020. Source: CRGP/SEMPLAN (2020).

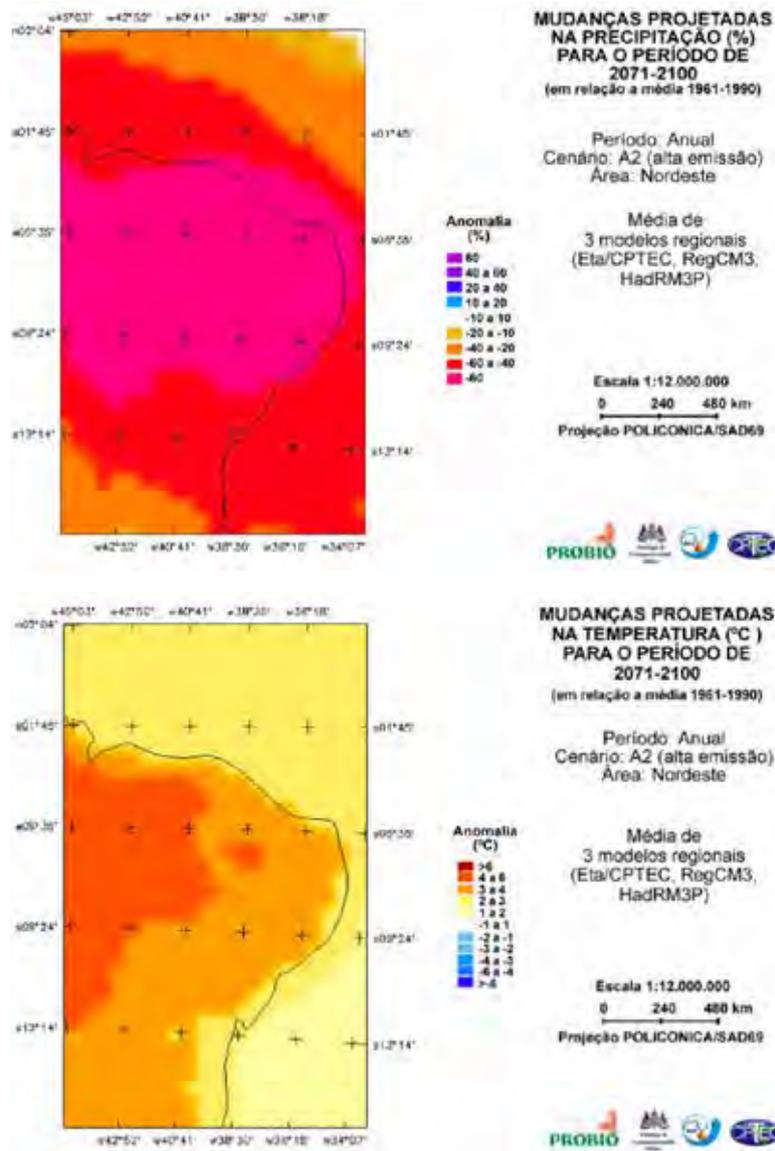
3.2. Climate change trends

3.2.1. Climate Change Impact Trends in Brazil and the Brazilian Northeast

The IPCC Fourth Assessment Report, under the Technical Summary of Working Group II, presents a review on "Impacts, Adaptation and Vulnerability" to major adverse impacts that may affect Brazil and South America in the future because of global climate change. Among the key findings pointed out in the 4th report is the extremely high probability that areas in the arid and semi-arid Brazilian Northeast are particularly vulnerable to the impacts of global climate change in terms of water resources, with reduced water supply. This scenario is especially concerning when considering that population growth leads to an expected increase in demand for water.

Regarding impacts on biodiversity, it reports a high probability of a considerable number of species to go extinct in the coming decades in the tropical region of Latin America. It also foresees the replacement of tropical forests by cerrado biome, in the Amazon eastern region, and some semi-arid areas by arid, in northeastern Brazil (desertification), due to temperature rise and reduced groundwater. Northeastern Brazil already faces water scarcity, and the population and ecosystems are vulnerable to less frequent and more variable rainfall due to global climate change. Leading to severe consequences for agricultural and food production in the region.

Figure 46: Estimated changes in precipitation and temperature for the Brazilian Northeast 2071-2100. Source: INPE (2020).



Since higher rainfall is the principal climate change-related factor that will exacerbate erosion impacts, Northeastern Brazil is vulnerable considering that erosion in this region has already caused the sedimentation of reservoirs and, consequently, reduced storage capacity and water supply. Also, urban areas in developing regions are especially vulnerable to erosion, especially to landslide occurrence in risk-prone informal settlements.

Finally, global climate change may impact the city's public health, as cases of flood-related diseases have been reported in Brazil, such as diarrhoea, and increase in schistosomiasis cases (*Schistosoma* genus). Increase in wildfires also impacts public health due to its impacts on local air quality. According to studies from the global Heat and Health Network, future changes in heatwave-related excess mortality are highly affected by greenhouse gas emissions and human adaptation to climate change. Heatwave-related excess mortality is expected to increase the most in tropical and subtropical countries/regions, including in Teresina, according to the following map.

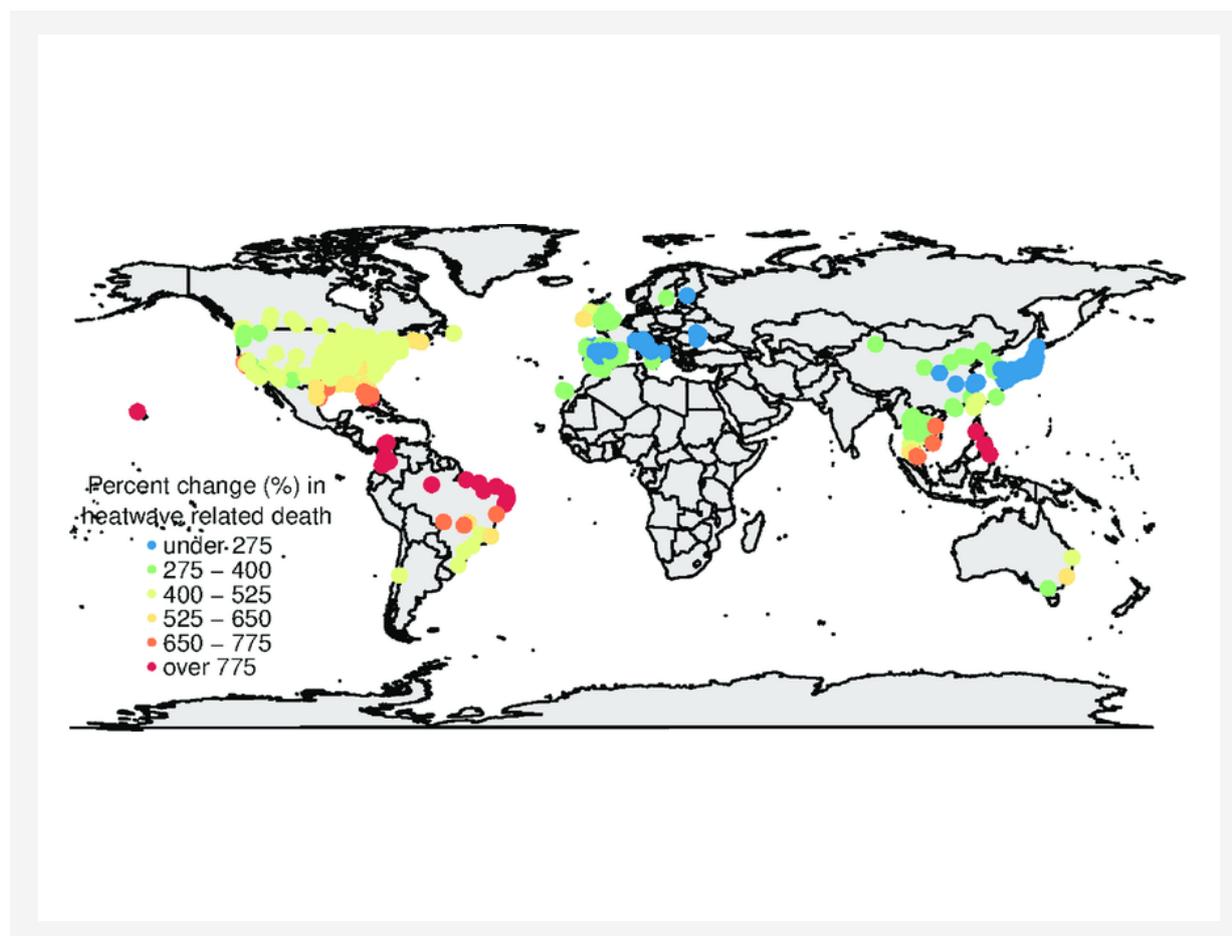


Figure 47: Locations of communities and mean percent change of heatwave-related excess deaths in 2031–2080 compared to 1971–2020, under RCP8.5 scenario and high-variant population scenario, with assumption of non adaptation. Source: Guo Y, Gasparrini A, Li S, Sera F, Vicedo-Cabrera AM, de Sousa Zanotti Stagliorio Coelho M, et al. (2018).

3.2.2. Downscaled Climate Trends for Teresina Region

As part of its cooperation with UN-Habitat CRGP, Lobelia carried out climate change trends research into the consequent effects in Teresina over the next 80 years (See Annex V). This report aimed at (1) assessing the magnitude of climate risks in Teresina through analysis of climate trends; (2) executing the Lobelia Climate Engine methodology to provide evidence in support of CRGP climate resilience plans at the urban scale; and (3) providing an assessment report for Teresina with key messages and associated key values of climate projections and local extreme event indices

Using a multi-model that ensembles 4 regional climate projections from the South-America CORDEX domain with a spatial resolution of 0.22° (~22km) and a daily temporal resolution, the projected changes describe the possible future evolutions of the local urban climate for the next 80 years, over three time horizons (near future - 2011-2040; mid-future - 2041-2070; and far-future - 2071-2100). The projections cover the expected changes in air temperature (mean, maximum and minimum), precipitation and some associated extremes.

The findings are presented per two main scenarios: one representing climate change projection in a stringent mitigation scenario which implies a major change in the global socio-economic system in order to reduce net global CO₂ emissions to 0 by year 2050, aiming at maintaining the mean global warming below 2°C (RCP2.5); the second one is the business as usual scenario, represented by RCP8.5, and accounting for a pathway without additional efforts to constrain emission.

In summary, the report findings suggest the following trends to take place in Teresina:

- The local climate will grow warmer and drier throughout most of the year;
- Local warming will be significant both during night-time and daytime;
- Heat waves will become more frequent and much more persistent;
- Warm (tropical) nights will become very frequent in most months of the year, especially at beginning of the hot season (June to August interval);
- The dry season will become drier and hotter;
- The hot season will become hotter, longer and drier (especially in June, September and October);
- Precipitation will decrease throughout most of the year under both emission scenarios;
- Dry spells will become more persistent favouring the gradual transition towards a drier local climate;
- The frequency of heavy rainfall events and the extreme rainfall amounts in time sequences of 1 and 5 days will significantly increase (20%-40%) over the December to February interval (the beginning of the wet season), especially in the mid- and far-future under RCP8.5; a slight increase in the extreme precipitation amounts is also expected at the end of the wet season (from March to May).

According to the report, annual mean temperatures are expected to increase significantly for both scenarios (RCP2.6 and RCP8.5) although with a clear distinction between them (figure XX). A dramatic increase in the frequency and duration of hot weather extremes is expected in the area of Teresina city.

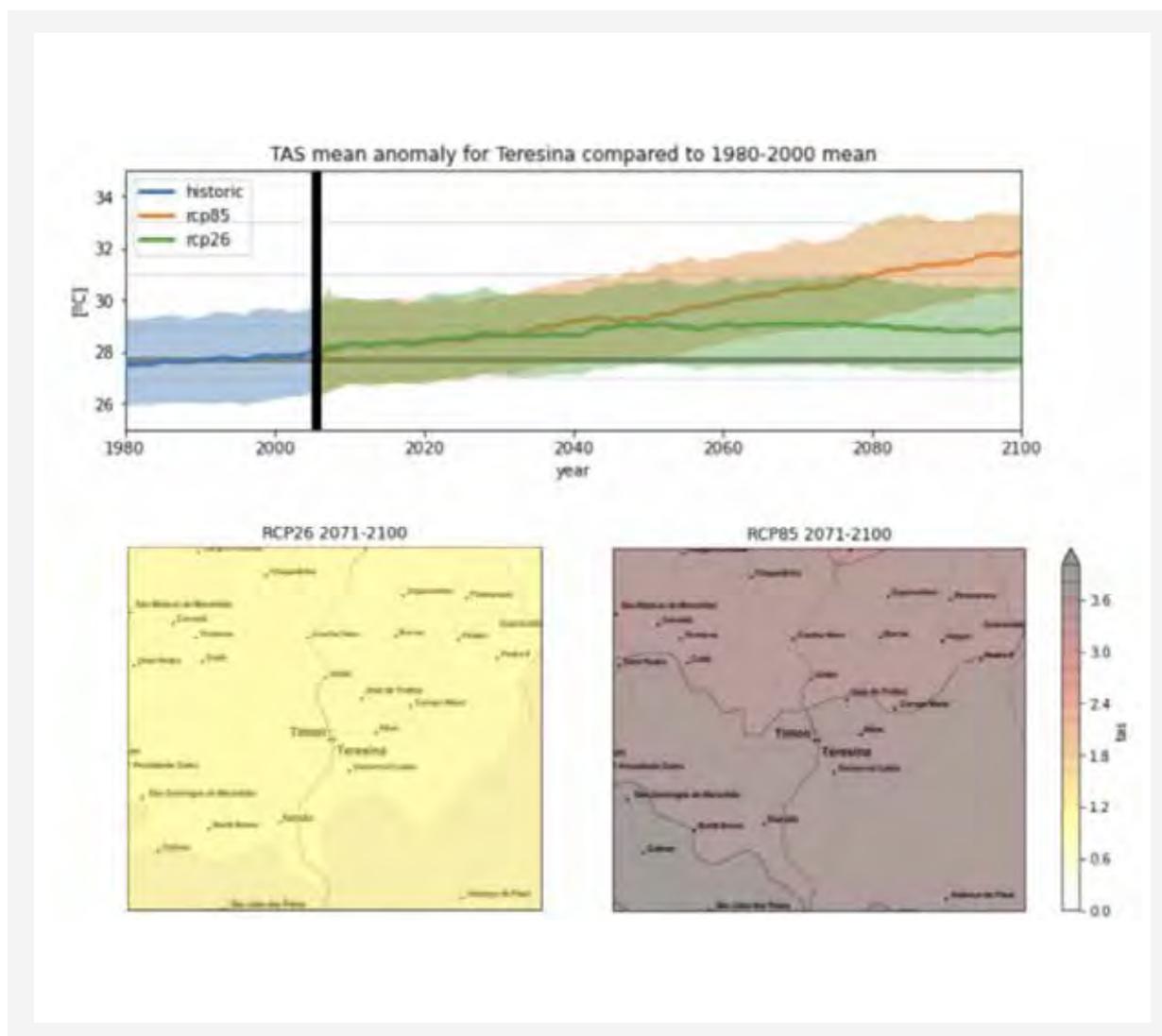


Figure 48: Top panel: Time series of the projected annual mean surface temperature [°C] in Teresina during XXI century for the two scenarios (RCP2.6 and RCP8.5). Shaded coloured area represents the region between the minimum and maximum values within the multi-model ensemble. This interval provides an estimation of the uncertainty related to the natural variability, i.e. the interannual variation for a given year may fall within this shaded area. Horizontal grey line indicates the average annual temperature for the historical period. Bottom panel: Projected annual mean change in surface temperature [°C] for period 2071-2100 with respect to the reference period (1980-2000) for the two scenarios. Positive values indicate an increase in temperature in the future. Source: Lobelia (2021).

Future climate change is expected to aggravate the existing environmental, health and urban problems and to increase risk, especially for communities already living in vulnerable conditions. Increasing heat-health risks, due to the augmented heat stress and urban heat island effects, in response to the significant temperature increase both daytime and nighttime; additional risks for residents and tourists is expected to be posed by the increasing frequency of warm (tropical) nights and heat wave duration.

Owing to its location, at the confluence of the Parnaíba and Poti rivers, Teresina will be increasingly exposed to the risk of fluvial and pluvial floods in the light of observed climate change projections, particularly due to increasing torrential rainfalls (e.g. heavy precipitation days with at least 20 mm and extreme rainfall amounts in 1 and 5 consecutive days) projected at the beginning of the wet season (from December to February). Given the analysis findings displayed in Chapter 2, if the current inadequate waste management continues in future, these plausible fluvial floods will pose major contamination levels for local water surfaces and soil in the adjacent areas, leading to marked social vulnerabilities along these zones.

Most importantly, this will lead to rising levels of exposure to health risks, namely diseases such as dengue, zika e chikungunya, which have been endemic in Teresina. However, other factors (e.g. individual behaviour, immunity and socioeconomic factors), showing non-linear relationships with the disease incidence, together with the effectiveness

of implemented preventive measures such as vaccination campaigns, disease surveillance and vector control might be more relevant in understanding the seasonal timing of outbreaks under the future climate.

On the other hand, the increasing duration of dry spells is likely to have hydrological and agricultural implications, through more occurrences of hydrological drought events, deficiencies in water supply and decreased soil moisture. This has the potential to increase socio-economic challenges in Teresina due to migration movements from rural areas towards the city.

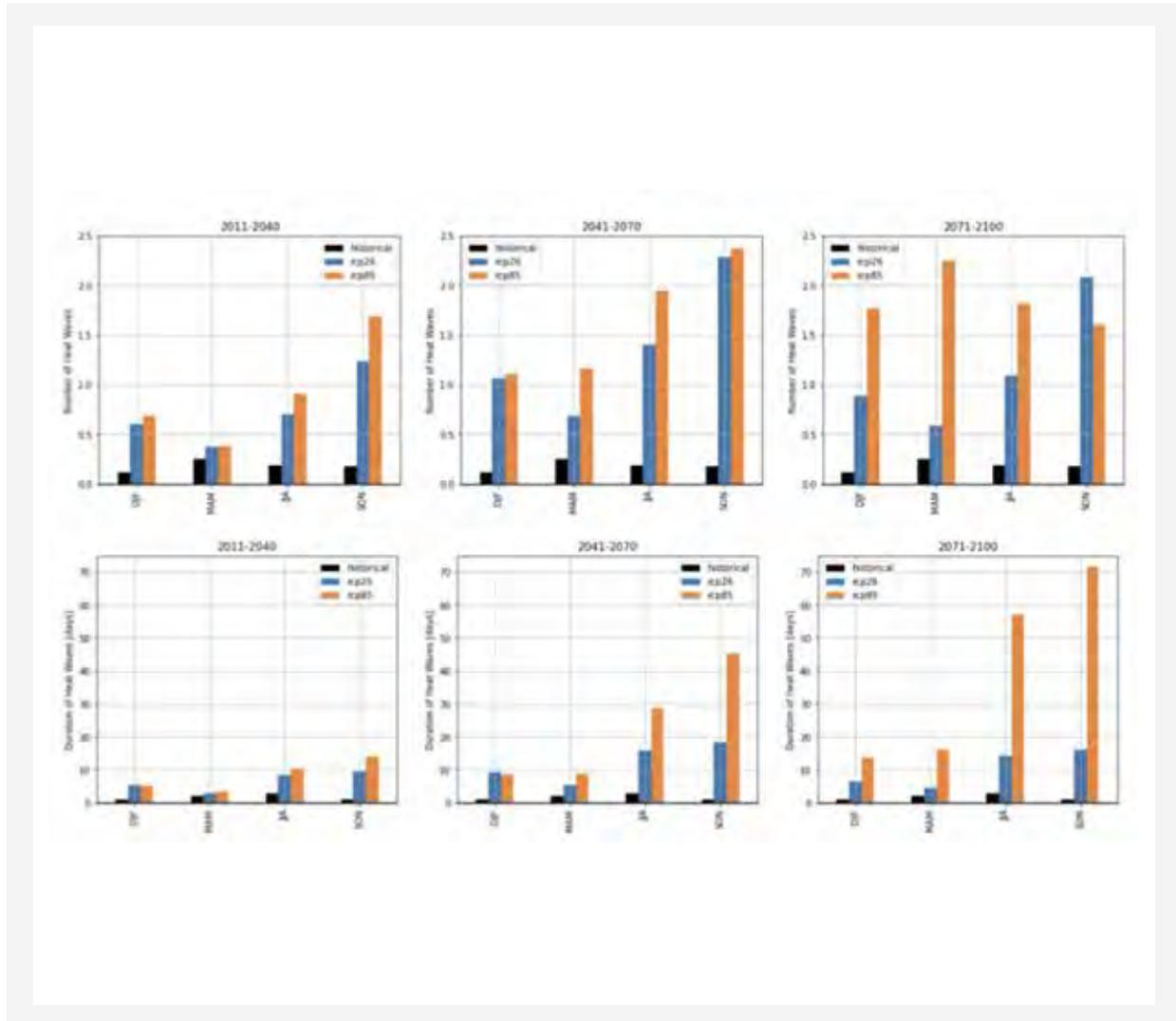


Figure 49: Average number (top) and duration in days (bottom) of heat waves for different periods and scenarios.

Source: Lobelia (2021).

3.3 Priority Matters and Urban Development trajectories A review of Policies, Plans, and Initiatives in Teresina

The review was conducted through selecting relevant legal documents during the data collection process, as well as additional reports, studies, articles, and interviews with different department representatives from the municipality. The value of this analysis lies in its ability to not only highlight the multitude of policies, legislations, initiatives and projects in place, but to also identify gaps in the policy context for which actions to address them will be proposed as part of the Actions for Resilience phase. In short, the findings of this review will lay the ground for the formulation of Recommendations for Actions for Resilience. An inventory of all policies, plans and initiative (reviewed below) are presented in **Annex III**.

Priority Matter 1: Water Cycle Mismanagement



Disruption of natural hydrological dynamics



Mismanagement of urban metabolism



Inadequate Risk Reduction Measures



Additional Programmes and Projects

Priority Matter 2: Ecosystem Imbalance



Environmental Pollution



Vegetation Loss



Additional Programmes and Projects

Priority Matter 3: Economic Underperformance



Limited Business Attractiveness



Weak Economic Diversification



Reduced Productivity

3.3.1. Priority Matter 1: Water Cycle Mismanagement

As it was explained extensively in Chapter 2, rapid urbanisation and spatial expansion in Teresina over the past two decades, coupled with poverty, lack of access to land and housing, and mainstream urban planning ideologies especially during the eighties and nineties resulted in altering the natural water flow due to deforestation, the disruption of water streams and destruction of natural protective structures. Moreover, lack of sustainable methods for managing urban metabolism, particularly solid waste, wastewater and stormwater systems undermined further the urban water cycle management with serious implications for the city's ecological balance, increasing the potentials of more risks to emerge such as floods, landslides, infrastructure failure apart from the marked socio-economic impacts on the city's inhabitants.

The review of policies, plans and initiatives across different levels of the government shows that overall, there is a clear consensus on the importance of addressing the root causes of this priority matter rather than merely focusing on short-term emergency response to the associated risks of water cycle mismanagement. Nonetheless, many of the PPIs displayed below are quite recent (either recently approved or under development), which means it is hard to evaluate their impacts and implications yet. Therefore, it should be noted that this review and evaluation of policies plans and initiative is mostly based on the content of their respective documents and the stated aims and goals.

While the organisation of the outcomes of PPI review per each priority matter (including water cycle management) is done per each underlying driver, some policies, plans or initiatives are rather territorial and cross-sectoral and touch on every driver of water cycle mismanagement in **Teresina, most notably the Teresina's Urban Development Master Plan (PDOT 2020)**.

Geared towards promoting sustainable urban planning and growth, the newly approved plan (2020) is a Transit-Oriented Development Plan, aiming at increasing density around transit infrastructure, while reducing urban sprawl and low-density developments. Thus, the plan promotes a shift towards a rather poly-centric spatial configuration. For this purpose, the plan incentivises the real estate sector to stop sprawling and concentrate development around the projected new sub-centres. Further, the plan restricts developments in risk-prone areas and urban greenfields. More importantly, the plan is associated with powerful means that ensure its implementation, mainly the requirement of developer's compliance with zoning codes and planning regulations.

While the masterplan appears to be conceptually a very strong document in promoting sustainability and enhancing urban resilience, the next several years should unveil the extent to which this master plan addresses the current issues in Teresina. However, drawing on the analysis findings in Chapter 2, a number of concerns can be raised regarding the potentials of this plan. Namely, the transit-oriented development and the consequent polycentric urban form. Considering the implications of the current public transport system and network in Teresina which have proved to be inefficient and with major consequences for efficient mobility and economic productivity, it is not clear the extent to which those promoted new centres are based on a comprehensive transport network. This analysis must go beyond the mere land-use adjustment around transit infrastructure, but to observe how changes in origins and destinations affect interaction flow between zones. Something seen essential for ensuring the viability of the goals and objectives of **Teresina's Urban Development Master Plan** since the urban transport network plays a major role in the distribution of economic activities and opportunities.



Disruption of natural hydrological dynamics

As it was illustrated in chapter 2, Disruption of natural hydrological dynamics is attributed to disruption of water streams and destruction of natural protective barriers as a result of rapid urban expansion in the light of poverty and consequent lack of adequate access to land and housing, and dominant urban planning ideologies for decades. To constrain rapid expansion, the municipality of Teresina adopted a major policy - **Urban Perimeter Act** – in 2015 for freezing the urban perimeter. While Previous local legislations attempted to limit expansion by allowing development to take place nearby existing ones, this meant constant extension of the urban perimeter, the case of many housing developments during the turn of the decade. After long battles with the construction sector, the city council legislated the **Urban Perimeter Act** to stop this permanently and avoid further spatial expansion towards urban greenfields and rural areas. This local policy proves very useful for the effective implementation of the recently approved **Teresina's Urban Development Master Plan**.

While this Act serves as a strong instrument to constrain further urban spatial expansion, it falls short in addressing some factors lying behind spatial expansion, mainly inadequate access to and unaffordability of land and housing in inner districts of the city. This in turn has led to the emergence of informal settlements many of which are located in flood and landslides prone areas, lacking adequate sanitation and drainage systems, rendering inhabitants more vulnerable and exacerbating further existing risks.

In tackling the issue of access to land and housing, the national urban policy **City Statute**, approved in 2001, represents a major milestone in Brazil. This policy emphasizes on what is understood as the right to the city for all citizens, and provides guidance for local authorities on how to realize it. While It offered an implementation toolbox for cities, evidence suggests difficulties in regulating these tools at the local level as it resulted in several cases of conflicts among several influential sectors since it reduces certain stakeholders' privileges in the name of collective interest. For instance, the policy favoured differentiated urban regulation for informal areas or social housing. It also creates the "urban usucapião", which authorises the property rights transfer in case of land occupations for over 5 years, leading to major contestation with traditional property rights.

Against this background, new laws were necessary. **The National Policy for Land Regularization** was approved in 2017. It supports local authorities to advance in land regularisation through the relaxation of certain strict national regulations for special cases, such as informal settlement upgrading. Prior to this legislation, many local land tenure regularization programs were hampered by the inability of the local government to grant land titles in informal subdivisions which didn't comply with national regulations, like minimum street width, street network/land rates, minimum thresholds of public and green areas. This law exempts informal settlements from such constraining codes and other requirements, hence facilitating the progress of regularization projects in recent years.

In summary, **City Statute constitutes the umbrella national policy for many national, supra local and local policies**, initiatives and projects for housing provision. It has allocated marked importance to supporting land tenure rights for those in informal settlements and risk prone areas. However, inadequate implementation mechanisms meant that on the local scales many housing initiatives and projects have triggered new problems, posing new threats on such developments' inhabitants. For instance, the national programme MCMV - **Minha casa, Minha Vida (My House, My Life)** - an extensive national housing programme, which definitely changed many cities' development as much as the old **BNH** housing programmes resulted in major housing developments that are currently where most of flash floods are frequently occur. It was a decentralised housing development programme (companies could build and then sell to governments that would pay under a cap price). Many companies were offered large and cheap sites, which consequently underwent deforestation and terrain alteration in the absence of comprehensive environmental policies. Most of the built settlements were low density, that all together created serious drainage problems. Only recently these implications were addressed through the 2020 **National Housing Programme (Minha Casa Verde Amarela)** which replaces the MCMV.

At the local level, City Statute and **The National Policy for Land Regularization** of 2017 have been translated into local policies, namely through the **Teresina Urban Land Regularization Policy** approved in 2019. This law incorporates at the local level the main points of the legislation already presented at the national level, and presents the regulation for the application of the national rule at the local level, greatly facilitating land regularisation in the municipality. While it is very early to assess its effectiveness, it is viewed as promising as the 2017 national legislation came to untie several knots that existed in the processes of land regularisation, something that had been demanded by city hall for a long time.

Nevertheless, the municipality of Teresina is still struggling with the localisation of these national policies. The progress in this respect has been described as very slow. A new package of local policies and mechanisms for implementing this national policy was set by the Municipality of Teresina recently as part of its Urban Development Master Plan (PDOT). It included mechanisms such as the **Public Concession of Building Rights**, defining a 'free building cap' per each urban zone and conceding fiscal stimulus to build on infrastructured centralities over non-developed areas. The plan also incorporated land use tools that were regulated previously on a loose basis, as the **Progressive Property Tax** (2015) which incentivises the development of vacant private properties inside the city.

One of the major issues facing housing provision on the local level is the overlapping of many governmental jurisdictions in certain areas of the city, specifically in local areas that fall within the state or federal jurisdictions, paralysing the municipality in terms of setting any initiatives or programmes. This issue was partially tackled through the **Urban Land Regularization Policy in Piauí** - a state level initiative - in 2019. While not related to Housing in hazardous areas, it facilitates land tenure regularisation exclusively in areas belonging to the state government. Similar to previous initiatives, it is quite early to evaluate its implementation and implications.

In addition to the aforementioned issue of governmental competencies and jurisdictions, there exist in Teresina several state-owned social housing which lacked legal status. During the 1970-1990's the state-owned housing company built several social housing developments without legally approving them with municipalities and with no provision of land registry to those who benefitted from the programmes. The **Minha Casa Legal** (Tenure Formalisation) state level initiative came to action in 2015 and lasted for 5 years to formalise these units by offering property rights documents to the owners. It should be noted, these settlements were not considered informal. Many of these are now middle-income houses. Neighbourhoods in Teresina covered by this initiative are: São Pedro, Saci, Primavera I e II, Angelim I e II Promorar, Dirceu Arcoverde, Morada Nova, Bela Vista, Renascença, Mocambinho, Monte Castelo, Stand de Tiros, DER, Cristo Rei, João Emílio Falcão, Redenção, Tabuleta, Tancredo Neves, Julia Maione, Itaperu, São Joaquim, Cíntya Portela, União I e II, Residencial Deus Quer, Cidade 2000, Boa Esperança, Portal da Esperança, Tenho Fé, Nova Teresina, Condomínios Verde Te Quero Verde, Pasárgada, Alô Teresina, Conjunto O Sonho Não Acabou, Condomínio Santa Luzia -Carteira lapep/Funprev.

Financially, the above-mentioned national legislation have been supported by some recent national initiatives such as **PRÓ-MORADIA** (2020) - expected to help states, municipalities, or government agencies, through credit systems for urbanisation and regularisation of informal settlements for the urban poor, in addition to the supra level 2019 **Moradia para Todos** (Micro Credit for Housing Improvement). Nevertheless, given the large deficit in housing provision especially for those socio-economically disadvantaged inhabitants and in risk prone zones, more financial instruments are highly needed.

On the local level, the **PLHIS - Local Social Housing Plan** was adopted in Teresina in 2013. The plan mapped most of the informal settlements in the city, informed the city's housing deficit by drawing on the national government statistics. It further estimated the financial capacities required to close the deficit gap within specific time-frames and scenarios. It served as a base for Informal settlement land regularisation programmes. But, while the project provides comprehensive mapping and sets a number of goals, it lacks clear strategies and mechanisms for implementation conducive to meet the project's goals.



Mismanagement of urban metabolism

Urban metabolism as a concept focuses on the potential of sustainable patterns of consumption and production in an urban system by connecting material and non-material flows with ecological and social processes. The degrading natural and urban water cycle in Teresina is strongly linked with the management of such processes of flows and circulation, particularly the unsustainable management of solid waste, wastewater and stormwater.

In tackling stormwater and drainage issues in Teresina, the Municipality adopted in 2015 the **Drainage Act**, an important local legislation which obliged the private sector to present their drainage infrastructure plans for relevant developments (with footprint greater than 500m²) as a requirement for construction permission. While this local policy has the potential to reduce the risks of flooding and consequent risks, it only covers those developments built after 2015. However, lack of adequate drainage solutions is widespread in Teresina and goes back to decades of unsustainable urbanisation and construction practices. To address this significant drainage problem, the municipality set the **Urban Drainage Plan** in 2015 with very clear priorities and goals. The plan mapped all the city's hydrological micro-basins and defined priority actions and regions according to risks and vulnerabilities through a comprehensive drainage system. Despite its massive benefits for the city especially on the long run as it has the potential to reduce the dire impacts of flooding and offers an opportunity for better management of stormwater, the costs of the plan are significant to the extent that the city was never able to secure funding neither from the national government, nor the international partners.

Notwithstanding, the municipality is currently in the process of developing an initiative - **PPP Drainage Systems** – that promotes public private partnership in addressing the financial challenges encountered by the local government in addressing the drainage issue in Teresina. Accordingly, the City Hall will be able to delegate to private entities the investments necessary to solve the urban drainage problem. The initiative also attributes to the private partner the obligation to operate and maintain the structures built for a period of up to 35 years, ensuring its full functionality. The studies are expected to be completed in 2021, allowing the City to tender for the hiring of the private partner who will carry out the works.

As for sanitation services, namely wastewater, the **Municipal Basic Sanitation Plan** was adopted by the local government in 2016. It established the municipal goals for the provision of basic sanitation. For example, the plan set a target of providing 33% of the population with a sewage network by 2019. According to data collected by CRGP on basic infrastructure, indeed the 33% target was met on time. Nevertheless, as explained in chapter 2, this coverage is still below CRPT's established benchmarks for adequate coverage of wastewater network. Moreover, this limited coverage meant that the majority of people are dependent on unsustainable methods of wastewater disposal, leading to major environmental implications and health threats. Therefore, while performing well, the implementation needs significant acceleration, the thing which will require marked human, technical and financial capacities at the local level.

On solid waste management, the **National Solid Waste Policy**, adopted in 2010, represents a marked legislation in this field. Beyond merely setting guidelines for national solid waste policy, it led to the creation of useful tools, such as the national solid waste information system, where service providers must update data on solid waste management. This was important in "forcing" relevant departments to gather, process and provide information on waste management. It also obliged Municipal governments to prepare their local solid waste management plans as a prerequisite for access to national funds in this sector. The legislation further informs the basic aspects on which such plans should focus.

In response to this national law, Teresina has been regularly updating its solid waste management plan, most recently is the 2018 **Municipal Plan for Integrated Solid Waste Management**. The goal of this plan is the universalization of waste collection and urban cleaning services. It is estimated that the total amount of investments required to meet the plan's long-term goals is around R \$ 2 billion, with landfills taking the biggest share of such investments as they will require massive upgrading processes and adaptation, and closure of some municipal landfills. But the plan has been described as inadequate as it lacks a robust and comprehensive implementation strategy. As a result, unsustainable

methods of waste disposal continue to be the case in Teresina with landfills posing serious environmental risks on ecosystem degradation.

Despite the existence of a number of regulations for the landfills management, such as **CONAMA Resolution No. 307/2002** and the **PNRS on Civil Construction Waste management (RCD)** in Teresina, companies still do not comply with the established guidelines due to the absence of enforcement mechanisms and regular inspection by any of the environmental agencies present in the state be it a municipal body, a state level or a federal one. This raises the danger of such practices on the environment given that these landfill sites are in areas with visible damage to the local natural system.



Inadequate Risk Reduction Measures

This part of the PPI review looks into the following measures in place: risk assessment, early warning systems, risk management, emergency response, and recovery.

Although the **National Civil Defence and Protection Policy**, approved in 2012, established the duties of the different levels of government (national government, the States, the Federal District and the Municipalities) to adopt the necessary measures to reduce the risks of disaster, this has not been accompanied with clear mechanisms for implementation. The 2012 **SINPDEC** was legislated to follow up with the implementation of the established duties in the National Civil Defence and Protection Policy. It should be noted that Teresina still lacks adequate civil defence units essential for timely response in times of emergency.

Nonetheless, a number of national policies and initiatives were adopted to ensure early risk monitoring, assessment and risk communications through the establishment of early warning systems. For instance, the **National Civil Defence System** which was approved in 2010 provided support to local and regional authorities by conducting risk assessment and studies. As part of this legislation, the national government financed and conducted the Teresina's risk-prone areas cadastre. Moreover, it created a national early warning system that informs municipalities when a risk is imminent. Citizens could also register using their postal codes to receive push alerts via phone in the case of an event in their areas.

The establishment of the **S2iD (Integrated Disaster Information System)** was an important initiative by the national government which aims at gathering and providing real-time information and data regarding on-going threatening events in the country per city. These services are provided through the S2iD platform publicly accessible for everyone. As for the longer terms risk mitigation measures, a number of national and local initiatives have been adopted, namely: The **National Plan for the Recovery of Native Vegetation (Planaveg)** approved in 2017. The plan aims to raise awareness to the importance of native vegetation, to facilitate actions for native vegetation conservations and reforestation. Though, while some articles are concerned with vegetation conservation within the urban environment, this plan is mostly focused on rural areas. Given the severe impacts of urbanisation and consequent deforestation in addition to the mismanagement of urban metabolism, the issue of vegetation loss, specifically native plants constitute a major challenge in the urban areas. Therefore, more policies and initiatives in this respect are highly needed.



Additional Programmes and Projects

Teresina Natural Based Solutions Strategies

This is an under-development local project that is piloting the use of NBS to reduce flash-floods in specific neighbourhoods in Teresina's urban area. The pilot area for this project is the southern district, where many flash-floods are reported. The project was granted financial support by the French Development Agency.

Programa Lagoas do Norte (Northern Lagoons Programme) initiated in 2006

This is the largest and most comprehensive local program to reduce vulnerabilities to floods and reduce risks. The design of the project began in the 1990s. Funding was secured in the 2000s from the World Bank, and implementation started in 2006. This program has proved effective in increasing hydrological stability in the lake areas of the northern zone, which comprises 14 neighbourhoods. The program has several components, the infrastructure components which invests in DRR related infrastructure, including dikes, channels, pumping stations, etc., in addition to drainage systems, sewage, drinking water, mobility, urban design, parks and public squares, etc. The social components are focused on reducing vulnerabilities, such as poverty reduction, low schooling, professional training, crime and violence by focusing on marginalised groups and domestic violence. The environmental component of this project is concerned with the decontamination of the lagoons and environmental recovery of riverside areas, and the promotion of campaign on the preservation of biodiversity.

The program is set to be implemented in 4 phases. It is currently in phase 2 – considered as the heaviest phase and with the largest volume of interventions -. Moreover, for effective implementation, this program has a component on the modernization of municipal management, which invests heavily in civil servants training, the efficiency of bidding processes and supervision of contracts, and in the improvement of municipal infrastructure such as the improvement of buildings and public facilities, including equipment.

Vila da Paz Urbanisation Project (initiated in 2013)

This local project aims at reducing risks in flood-prone neighbourhoods at Vila da Paz Region. The programme is already under implementation. The project implied the removal of residential units within the risk-prone zones, and the construction of the water protective structures (water canals). In addition, a major action of this project was the reforestation of the stream basins, the foundation of a linear park alongside the canal, and construction of some social facilities. However, as this project was financed by national funds, the funds were halted as the government changed, and the project remained incomplete. Although the municipality has been attempting to secure international funds from the CAF to finish the project, as the area's occupation changed when the project stopped, the project needs to be revised and adapted to the new realities.

3.3.2. Priority Matter 2: Ecosystem Imbalance

Numerous factors contribute to undermining the balance of the ecosystem, namely: the global warming and greenhouse effects, and pollution. Locally, some of the major causes are rapid urbanisation, disposal of toxic wastes in water bodies, soil erosion, deforestation and agricultural practices, among others. The effects of this issue are becoming quite evident in Teresina through various events, mainly biodiversity loss, and insects, animals and plants infestation which in turn caused both significant public health problems and considerable socio-economic impacts.

Chapter 02 – priority matter 2 illustrated how a combination of drivers including both shocks and stresses have been among the most pressing factors behind ecosystem imbalance. These are: environmental pollution including soil and water contamination, vegetation loss driven by urbanisation processes and lack of regulations supported by enforcement measures, and wildfires which are becoming more frequent within the region and the metropolitan areas. The following review of policies, plans and initiatives, therefore, evaluates the policy context and its underlying means and mechanism that are related to these main drivers of ecosystem imbalance in Teresina. Overall, the findings of this review show that so far, ecosystem imbalance has not been explicitly recognized as a serious matter despite its evident effects and associated risks that are becoming more frequent such as plants and insect infestation and urban heat islands. Further, ecosystem balance is treated as a dividend of the adoption and implementation of certain policies or plans, rather than viewing it as a major issue central to building resilience and sustainability.

A number of policies and initiatives are in place, either on the national, supra local or the local level, which although do not directly aim to address ecosystem imbalance, some of their goals and targets are related to aspects of ecosystem imbalance in the city given the breadth of the scope of such policies and their cross-sectoral nature. Most evidently are Climate Change focused ones. For instance, the State **Policy on Climate Change and Combating Poverty** was adopted in 2011 by the state government of Piauí through its Secretariats and other competent bodies with the goal of creating technical and regulatory structures to develop the **State Plan on Climate Change and Combating Poverty, Environmental Conservation and Sustainable Development of Piauí**. The State government has also put in place its **Ecological ICMS** which is a tax benefit conceded to municipalities that allow a greater allocation of resources from the Tax on Circulation of Goods and Services (ICMS). The higher the number of environmental projects and actions a municipality has, the higher the revenues it can receive through this initiative. Indeed, this programme has been very useful for Teresina as the city has been receiving funds from the state government in return for the implementation of environmental and climate related policies that are annually reported to the state government.

Moreover, the 2010 **State Water Resources Plan**, which is broadly concerned with water cycle management, included strategies to strengthen state capacities for water resources management, implementing IWRM tools (as hydrological basins plans, and state water monitoring system). It also included the programme to expand water supply, mitigation measures to reduce water contamination, control of water demand, and mitigation measures for reducing impacts induced by natural or man-made causes on water resources (reforestation of river basins, awareness raising campaigns, flood early warning systems, mapping flood-prone areas).

On the local level, Teresina is currently in the bidding process for the development of its **Climate Action Plan** which will incorporate the construction of trend scenarios, mitigation strategies and adaptation to the impacts of climate change.

The **Teresina's Urban Development Master Plan**, recently approved in 2020, has also the potential to address several aspects of the ecosystem imbalance problem through its strong promotion for a more compact urban form and development densification along transit corridors, with the aim of significantly reducing urban sprawl and its consequent deforestation and biodiversity loss.



Environmental Pollution

During the years of rapid urban growth, unregulated occupation of the riverbanks of the Poti and Parnaíba Rivers took place in the absence of a adequate planning and building regulations. This brought about many clandestine connections with raw sewage in rainwater drainage pipes which have been causing serious health and environmental consequences, most noted in deprived areas without basic infrastructure. Apart from the effects of the unregulated spatial expansion in these areas, the inadequate management of wastewater in the city has greatly affected the quality of the water resources, leading to serious levels of soil and water contamination in the basins. With almost 70% of Teresina's population not having access to proper waste water networks, individual sewage systems such as septic tanks, sinks and infiltration ditches are the only options available for the majority of the city's residents, raising concerns regarding soil, rivers and groundwater contamination.

In tackling environmental pollution, particularly soil and water contamination, multiple policies and plans can be referred to. Namely, the **National Policy for Basic Sanitation**, approved in 2007. It established the national basic sanitation guidelines for urban areas. An important advancement in this respect was the creation of **SINISA - the National Basic Sanitation Information System**, which required the collection, processing and dissemination of information on basic sanitation, to support national monitoring of sanitation goals at national, state and local levels.

The **Municipal Basic Sanitation Plan** was adopted by the local government in 2016. It established the municipal goals for the provision of basic sanitation. For example, the plan set a target of providing 33% of the population with a sewage network by 2019. According to data collected by CRGP on basic infrastructure, indeed the 33% target was met on time. Nevertheless, as explained in chapter 2, this coverage is still below CRPT's established benchmarks for adequate coverage of wastewater network. Moreover, this limited coverage meant that the majority of people are dependent on unsustainable methods of wastewater disposal, leading to major environmental implications and health threats. Therefore, while performing well, the implementation needs significant acceleration, the thing which will require marked human, technical and financial capacities at the local level.

On solid waste management, which contributes hugely to water and soil contamination in Teresina due to unsustainable modes of waste disposal, the **National Solid Waste Policy**, adopted in 2010, represents a marked legislation in this field. Beyond merely setting guidelines for national solid waste policy, it led to the creation of useful tools, such as the national solid waste information system, where service providers must update data on solid waste management. This was important in "forcing" relevant departments to gather, process and provide information on waste management. It also obliged Municipal governments to prepare their local solid waste management plans as a prerequisite for access to national funds in this sector. The legislation further informs the basic aspects on which such plans should focus.

In response to this national law, Teresina has been regularly updating its solid waste management plan, most recently is the 2018 **Municipal Plan for Integrated Solid Waste Management**. The goal of this plan is the universalisation of waste collection and urban cleaning services. It is estimated that the total amount of investments required to meet the plan's long-term goals is around R\$ 2 billion, with landfills taking the biggest share of such investments as they will require massive upgrading processes and adaptation, and closure of municipal landfill. But the plan has some inadequacies as it lacks a robust and comprehensive implementation strategy. As a result, unsustainable methods of waste disposal continue to be the case in Teresina with landfills posing serious environmental risks on ecosystem degradation.

In alleviating these risks, the municipality has been undertaking a number of initiatives, such as the **Teresina Recycling Programme**, which offers 21 recycling points in the city where citizens can deliver separate waste for recycling. The percentage of waste delivered for recycling is still low, but it has been increasing rapidly in the city in recent years (the total amount doubled from 2017 to 2019). Additionally, the **Zero Waste Programme** started in 2013, according to which the municipality can collect fines in cases where people throw garbage on public spaces.

It should be noted that similar to many cities around the world, some waste recycling is happening in Teresina thanks to informal waste pickers, nevertheless, when not addressed adequately, this can pose serious health risks on those involved. An initiative has been set very recently (2020) named: **Women for Climate – Recycling**. The initiative works

closely with different vulnerable women groups. The project aims to support poor women working in waste recycling to improve their work conditions through the construction of pre-treatment eco points for them to work. In return, those women receive electric cargo bikes to support their collection work.



Vegetation Loss

Rapid urban expansion in Teresina meant significant loss of vegetation cover over the past 2 decades as a result of deforestation. While marked cover of vegetation still exists in the city as part of backyards, private gardens and sidewalks within private residential complexes, these are mostly private disconnected green areas with no access for the public. Also, the city lacks adequate coverage of green areas which can form connected green networks that provide integrated habitats for urban wildlife apart from their role in improving living qualities in the city.

In short, the major stressors leading to vegetation loss in Teresina are deforestation, urban vegetation loss, and inadequate green infrastructures and nature-based solutions.

On a broader level, two policies are in place, albeit not addressing vegetation loss within the urban area directly. These are the 2015 national legislation **PAN-Brazil** and the **PAE Piauí** initiative. Both are rather concerned with combating desertification. The PAN-Brazil is more of a general law, which establishes national guidelines and mechanisms to support areas most vulnerable to drought. It has a larger area of activity in the interior parts of the state, in the semi-arid hinterland. Nonetheless, Teresina is benefitting indirectly from this plan as it has the potential to avoid rural migration to the capital due to the socio-economic impacts of desertification on rural areas.

Whereas the **PAE Piauí**, which came as a result of the **PAN Brazil** law, is a state action plan to combat desertification. In the plan, Teresina is considered within the "surrounding areas" of the North-eastern semi-arid, but not semi-arid, but it states that 67% of the Piauí's area are susceptible to desertification. Its main lines of action are focused on reducing poverty in the semi-arid region, increase educational levels, food security, improve infrastructure for irrigation, institutional capacity building, and invest in research at state universities on adaptation to droughts which have always been characteristic of the region.

It was mentioned earlier that green cover rates in the city are significantly low according to CRPT's established thresholds for minimum public urban green spaces. In this regard, the municipality of Teresina has been undertaking a number of policies and initiatives. Nonetheless, most of these initiatives are quite recent. Therefore, it is early to assess the extent to which they can address the problem of vegetation loss in Teresina. Below - Additional Programmes and Projects -, a summary of their goals and targets is displayed. It should be noted though that in 2014, Teresina adopted the **Law 4555/2014** which obliges the construction sector to plant trees in low density urban developments. In addition, Teresina adopted the **Adopt the Green Program** in 2014 which aims to promote partnerships between the public authorities and the private sector and the third sector, for the maintenance and conservation of municipal green areas, in order to improve public spaces and preserve the environment. Evidence shows that commitment to this program was low, due to the lack of incentives for the private sector and NGOs to cooperate.



Additional Programmes and Projects

Teresina 2030: Teresina Natural Based Solutions Strategies and Restructuring and creation of environmental parks

This is an under-development local project financed by the French Development Agency. It comprises several development axes, and includes the Teresina NBS Strategies and the expansion of urban green parks network. Teresina Natural Based Solutions Strategies is an initiative that aims at piloting the use of NBS to reduce flash-floods in specific neighbourhoods in Teresina's urban area. The pilot area for this project is the southern district, where many flash-floods are reported. Regarding the expansion of public parks networks, the municipality has two new parks under

construction. Other two park projects are currently under development, and the projects for four new ones are set to be launched for bidding soon within the Teresina 2030 programme.

The Municipal Afforestation Plan

While this project has been approved several years ago, several setbacks hindered its development during the last years. The municipality obtained the first financing of the plan through CODEVASF, but the bidding process was interrupted by the state judiciary to adapt the contract to specifications required by them. However, the financing amounts did not accommodate such demands, but a deadlock negotiation, the municipality missed the deadline for implementing the fund, having to seek new financing possibilities and start a whole new process of contracting resources and then the plan. In the last years, the city managed to advance in a new financing possibility, within the Teresina Sustentável CAF credit program. 6 years later, the municipality finally has the plan under development. It is hoped that the plan will bring the Tree cadastre for the entire city, and that its action plan will increase urban green cover and also protect biodiversity.

GEF RIDE Great Teresina

This project was already approved by the GEF international and UNEP, and is now under development. Specifically, it is currently in the phase of preparing the implementation mechanisms, to be then launched for bidding. The project has three main research outputs:

1. Integrated Urban Planning: aims at developing institutional capacities to adapt management tools for RIDE Grande Teresina, including data sharing platforms between municipalities in the metropolitan region, platforms for coordinated actions, and institutional training for municipalities.
2. Metropolitan Level Studies: Focused mainly on the Metropolitan Basic Sanitation Plan, Metropolitan Resilience Plan, Metropolitan Mobility, and the Metropolitan Drainage Plan, among other plans.
3. Environment and Biodiversity: it encompasses studies on mapping threats to biodiversity and conservation strategies; studies on social and demographic changes, including migration scenarios and economic impacts related to climate change; and Heatwave Management Plan.

Some of the projects that are going to be covered by these studies are: Teresina-Timon Low Emission Zone (LEZ): a Study to optimize the use of clean renewable energy (integrated into the state wind / solar energy plan); the Urban Structuring Plan for Teresina / Timon City Centres: (Diagnosis / Action Plan Housing, Density, Built Heritage, Green Areas, Mobility, Drainage, Climate, Carbon Emissions); the LEZ Mobility (improving cycling, Teresina-Timon solar-energy water bus, Teresina-Timon electric buses); the LEZ Public Spaces (Planting 2,000 Trees along the banks of the river in addition to cycling and walking paths; Grants for Vertical Gardens / Green Ceilings; Requalification of Squares in Central Areas; LED lighting); the LEZ Climate Resilience (System for Monitoring Temperature and Air Quality and Early Warning for Heat Waves, Fires, Floods, and tropical diseases); the LEZ Built Heritage (Grants for restoration of historic buildings and Urban Art in the city center); the LEZ Complete streets (street paving retrofit, arborisation, lighting, furniture, etc.)

Women for Climate - Urban Gardens

This project was selected by the TAP / ICLEI program for funding its development, and is one of the sub-axes of the Women for Climate project. The focus here is on urban female horticultural workers. It aims to improve the infrastructure of urban gardens, provide guidance and support for creating cooperatives, training horticulturists in agroecology and finance, developing educational campaigns and encouraging diversification of production, meeting the demands of the local market, and increasing the production of organic food.

A Tree in My Life Project

The project has developed a website through which people can request the municipality's help on the type of plants they would like to have in their private gardens, and how to carry it out. Experts then provide recommendations on the types of plants people can have, with priority given to native ones. Nevertheless, it was pointed out in the consultative workshops with Teresina's Resilience Committee that requests for tree removal continue to outnumber those requesting tree plantation. Something that requires the municipality to better address.

3.3.3. Priority Matter 3: Economic Underperformance

Teresina is the capital city of one of the least developed regions of Brazil. It has historically suffered the consequences of the peripheral nature of its location which has been most of time far away or at the fringes of major national economic hubs and their spheres of influence. It therefore never had any major strategic industries and relevant infrastructure. This also left the region and the city under-served by well-connected national and interregional networks of transportation and supply chains, which in turn have undermined the city's economic development and growth.

It was explained in detail, as part of chapter 2, that the main drivers behind the economic underperformance in Teresina are: Limited business attractiveness, weak economic diversification, informal economy and reduced productivity, which all together have led to marked implications in terms of low levels of employment, reduced municipal revenues. The following review will focus on policies, plan and initiative at the national, state and local level intended to stimulate the city's economic performance.

Overall, the review shows that while a diverse portfolio of policies, initiatives and programmes exists in this respect, the majority attempts to address the symptoms of the economic underperformance rather than tackling the root causes such as weak connectivity and regional economic integration, as well as inadequate economic diversification. This will be illustrated further per each driver along which this review is organised.

It should be noted that the city's economic development strategies and related budgeting are set every four years as part of the **PPA/Piauí** – the state-level budgeting cycle. Each cycle starts during the second year of the mayor/governor term and lasts until the end of the first year of the next government. Accordingly, cities and states are obliged to present all their planned governmental actions and required budgets throughout the 4 years cycle. These are then approved by the legislative body. While local governments are allowed to adopt new actions outside the 4 years development plan, the allocated budget is not allowed to be spent on those additional actions that were not set in the plan. Teresina is reaching the end of the current cycle, which means preparation for the next cycle is ongoing.



Limited Business Attractiveness

Major stressors are market disconnectivity, inefficiency of local public services, and limited availability of capital and human resources.

A combination of policies and initiatives are in place, aimed at incentivising entrepreneurship in the city and attracting businesses. Most prominently is the **National Microentrepreneurs Act**, legislated in 2008. This national act covers micro individual entrepreneurs (MEI) as well as small, medium and large businesses. The incentives offered through this legislative are certain levels of tax exemptions and bureaucratic requirements in order to facilitate the process of establishing the business.

In practice, a number of national initiatives have been adopted recently with the purpose of helping local governments to attract businesses by offering financial incentives and support, namely the 2020 **PRONAMPE**, a national programme to support micro and small businesses, and the **BNDES Small Business Credit Line**, a national credit programme initiated to manage the effects of Covid-19 crisis on small businesses.

On the local level, the **Popular Bank of Teresina (BP)**, is already in operation. It is a Municipal bank that aims to offer credit lines to microentrepreneurs. By August 2019, an amount of R\$ 1,863,172.98 has been assigned for micro loans. The institution promotes the goals of raising income levels and generating jobs for the low-income population of Teresina.

One of the most prominent steps taken at the local level in terms of generating an environment that is attractive for businesses in the city is the **Teresina Competitiva** funded by the World Bank.. This strategy focuses on the biggest value chains in the city: healthcare, construction, education, trying to understand and grasp which aspects require the municipal or state government to adjust in order to have a better business environment. Also, it tries to reduce

bureaucracy that is a burden to these businesses and to seek new investments. After 2015 this has been one of the main strategies to plan ahead the economic growth of the city.

Apart from financial incentives and support, other policies and initiatives have been set to tackle administrative inefficiency, and skills building. In the case of the former – administrative inefficiency -, the National initiative **Efficient Brazil** was established in 2017. It brings together measures to reduce bureaucracy, modernize, and improve the provision of services to society. Among its main outcomes is the Services Portal - a platform that brings together many public services with the aim of eliminating queues, and reducing costs -; the National Digital Driver's License is a service that offers cell phones consultation; and the INSS Digital which provides social security consultation, and the extraction and scheduling of inspections. Moreover, according to this initiative, citizens are no longer obliged to present printed documents that are already in the government database. In this way, **Efficient Brazil** is seen to enable fraud prevention, reduce costs and speed up administrative processes.

The **REDESIM** is another national initiative, in place since 2007, which integrates the processes of all bodies and entities responsible for the registration, alteration, cancellation, and licensing of legal entities, through a single entry of data and documents, accessed through the REDESIM Portal. The portal also integrates a set of computerized, interoperable systems that have been made available to citizens to carry out processes of registering and legalizing entities. Note this platform now incorporates similar platforms on lower levels such as the state-level **Piauí Digital**, and **Teresinense Digital** initiatives.

While Piauí Digital (established in 2016) is responsible for business registration and licensing in the state, the **Teresinense Digital 2020** aims at fully transforming municipal administrative services execution to online modes, particularly following the Covid-19 crisis. This initiative represents the full membership of the capital of Piauí to the National Network for the **Simplification of Registration and Legalization of Companies and Businesses - Redesim**. It is estimated that the new average time for opening a company would be 45 days in Teresina, an average similar to that of Rio de Janeiro, according to Doing Business. Currently, it takes an average time of 110 days to start a business in Teresina. For this initiative to become effective, internal municipal processes were revised to clearly define the competencies of the various Municipal and State actors, regarding establishing businesses.

Similar initiatives have been in place for facilitating other administrative services such as the **Construa Fácil** (Easy Building) active since 2018. It is an online system that reduces the bureaucratic procedures needed for obtaining civil works licensing in Teresina. Before, the building licensing process was in-person, and paper-based. Now architects and engineers can demand the building permit in all-online modes.

Moreover, the municipality of Teresina started in 2018 the process of financing the **Teresina Open Data Plan** aimed at: (1) building an integrated inventory of data that must be publicly accessible by different departments at the local government; (2) structuring the process for opening data in the city (i.e. Setting clear duties and responsibilities, and workflow); (3) developing the city's open data platform; (4) training and support for data uploading into the platform. The plan is now under a bidding process.

As it could be seen, there is a clear tendency towards digitalising municipal administrative services on different levels of the government, which has the potential to massively facilitate business operations, especially at the local level. Nevertheless, more efforts are needed to ensure the full integration of such services and avoid potential fragmentation and work in silos.

As for the promotion of skills building, a number of local plans and initiatives have been taking place. Most obviously is the establishment of the **Professional Training Programs at FWF** which is a local department with the function of training and qualifying the workforce in Teresina. It offers several professional training programmes such as "**Professionalize Teresina, Professionalize Women, My First Job Program**". The skills offered varies, from ICT courses (including software), hairdressing, event organisation, digital media marketing, secretariat, cell phone maintenance, etc. In 2019 the department trained more than 2700 people in the city. **Professionalize Women** offered 14 courses to 294 women, including building painting, cell phone maintenance, social media marketing, cooking, handicrafts, etc.

The **Commercial and Creative Technology**, initiated recently in 2020, aiming at training, financing and monitoring small entrepreneurs to use technological and communication resources and tools to publicize their products and services and to make sales, actions aimed at reinserting, and business support mechanisms to adapt to the new situations implied by the Covid-19 Pandemic.

On a more spatial micro scale, the **Empreende Bairro Project** (Community Entrepreneur Project) was established in 2019. It aims at training the neighbourhood entrepreneurs to strengthen the neighbourhood's economy, generate wealth and increase employment.

In addressing the Covid-10 impacts, **Active Teresina** (Covid-19 Economic Recovery) was adopted recently. It aims to create a policy for the recovery of the city's economy that is impacted by Coronavirus pandemic through Institutional articulation to support local companies, the provision of support to companies in identifying credit solutions, support in the development of new products, services and administrative strategies, and the building of new partnerships to promote research and technological innovation.



Weak Economic Diversification

The weak economic diversity in Teresina is ascribed to multiple issues, namely weak regional connectivity, weak business attraction, lack of skilled human capital, weak development and growth management strategies, and lack of loans and entrepreneurs. The interest rate in Brazil now is high in comparison to other countries despite the recent reductions considering inflations rates. According to many observers, both the state and municipality have been unsuccessful when designing economic development strategies.

The review in this regard shows that although several policies and plans have been adopted across different levels of the government, there is a clear lack of a comprehensive strategy on the local level that directly touches on the issue of economic diversification in the city.

At the national level, the **Industry 4.0 Action Plan** was adopted in 2019. It is a strategic plan to guide the actions of several institutions at the national level for the promotion and structuring of industries. the plan is translated to the local level through the programmes of different locally active agencies such as the local office of the industry federation, or the business support service. For the state of Piauí, there are 63 mapped initiatives that can be checked here: www.mapeamento40.mctic.gov.br/#/map-iniciativas

At the Supra-Local level, in 2016 the **Piauí 2050**, which is a State-level Economic Development Plan was adopted. The plan includes several elements that have to do with economic development in Teresina. Particularly, Teresina is placed within the opportunity areas of investment for Tourism (business-related), and Non-Metal Mining and Infrastructure. This is seen to be aligned with the 2011 **Integrated Development Plan for Sustainable Tourism (PDITS)** in Teresina.

On the local level, the **Municipal Governance Program** (CAF) started in 2018, is an initiative that comprises a training programme for civil servants in the fields of Public Innovation, Open Government, and Urban Resilience. It is currently in the process of hiring consultancy to carry out training.

In addition, **THEch Programme**, active since 2018, is an innovation hub aimed to foster IT business, and support innovation in the municipality. It is implemented under a PPP scheme. More specifically, the creation of the Teresina TEch Programme came to foster entrepreneurship, innovation and the production culture, as well as to promote research, teaching and institutional development to carry out studies and to support activities for the municipality of Teresina. The municipality of Teresina is the major actor in enabling the work of this hub through the optimisation of the **Innovation Programme** of its Municipal Secretariat for Economic Development and Tourism (SEMDEC) and the execution of Softex. THEch is divided into 5 main axes: THEch Maker, THEch Valley, THEch Educação, THEch Startups and THEch Investments. Targeted groups are young people who develop applications, and open startups, with the objective of transforming the city into a storehouse of innovative projects in several areas, and the creation of a technology space at Praça Ocílio Lago.



Reduced Productivity

While reduced productivity is normally driven by diverse economic and social factors shaped by existing fiscal and regulatory policies, on the local level additional factors namely urban mobility have the potential to exacerbate low productivity. This is particularly relevant in Teresina. Therefore, as it could be seen in the policies, plans and initiatives displayed below, there is a clear focus on addressing mobility issues in Teresina.

It should be pointed here that one of the most influential policies in this respect is the **National Urban Mobility Policy** which was legislated in 2012. This national Policy made it mandatory for municipalities with more than 20 thousand inhabitants to have an urban mobility plan, with priority to active and more sustainable modes, and the prioritisation of public mode over motorized private ones. Currently, having an approved mobility plan is a condition for accessing national resources in the sector.

A number of initiatives at the national level were adopted to support the funding and financing of mobility plans on local levels, most prominently is the **Advancing Cities – Mobility** initiative, approved in 2017. Under this initiative, Teresina made 2 proposals: The Mobility Plan Revision, and the City Centre Streets Retrofit. But none of these two have been selected for funding so far. However, the city has been able to secure funding through other funding mechanisms. In addition, the national programme of **REFROTA** was adopted in 2017. It is a credit programme that aims to facilitate financing for private operators to upgrade the urban bus fleet. Indeed, many operators in Teresina have benefited from this programme since its founding.

On the local level, Teresina was awarded the **Euroclima + Innovation for better Mobility** in 2018 by the EU/DEVCO fund. The programme focuses on promoting innovative practices through bringing technology and social participation closer together to improve public transport quality and ridership. At this point, the project has produced a diagnosis of public transport, and the mapping of various technologies that can contribute to solving the problems raised by research, surveys and public consultation workshops. The next step is an open innovation contest to develop pilots for solving these problems.

Moreover, Teresina started the operation of its **INTHEGRA BRT System** in 2018. However, the full operation of the system is now suspended due to the Covid-19 crisis. This points out issues regarding the adaptive capacity of the system to cope with such a crisis, suggesting the need for serious revision of how the system is operated. Currently, **Teresina's Sustainable Urban Mobility Plan** is under development. The program works on several axes, and seeks to improve the economic, social and environmental development of Teresina, aiming mainly at improving mobility, urban-environmental qualities, and improving municipal management. The programme is funded by CAF. Among the various anticipated interventions are the Via Sul avenue and the urban requalification of degraded areas in Vila da Paz, the 2nd phase of the reform of the Central Market, the fossil forest park, with the construction of the Palaeontology Museum, and the elaboration of the project and investment in the Teresina cycling system, among other works and actions.

Furthermore, Teresina was selected to be one of the cities benefiting from the 2019 **IDB/Brazil DOT Technical Cooperation programme**. The aim here is to provide the department of urban planning the technical skills to improve plans and policies towards Transit Oriented Development strategies. The technical cooperation provided is through capacity building in the form of workshops and training events.

However, the city lacks an adequate integrated assessment of logistics infrastructure. The city is currently developing a PPP framework for a new airport since the current one's expansion is constrained due to its location, and the city has not been able to make the case for funding a new one through the national government.

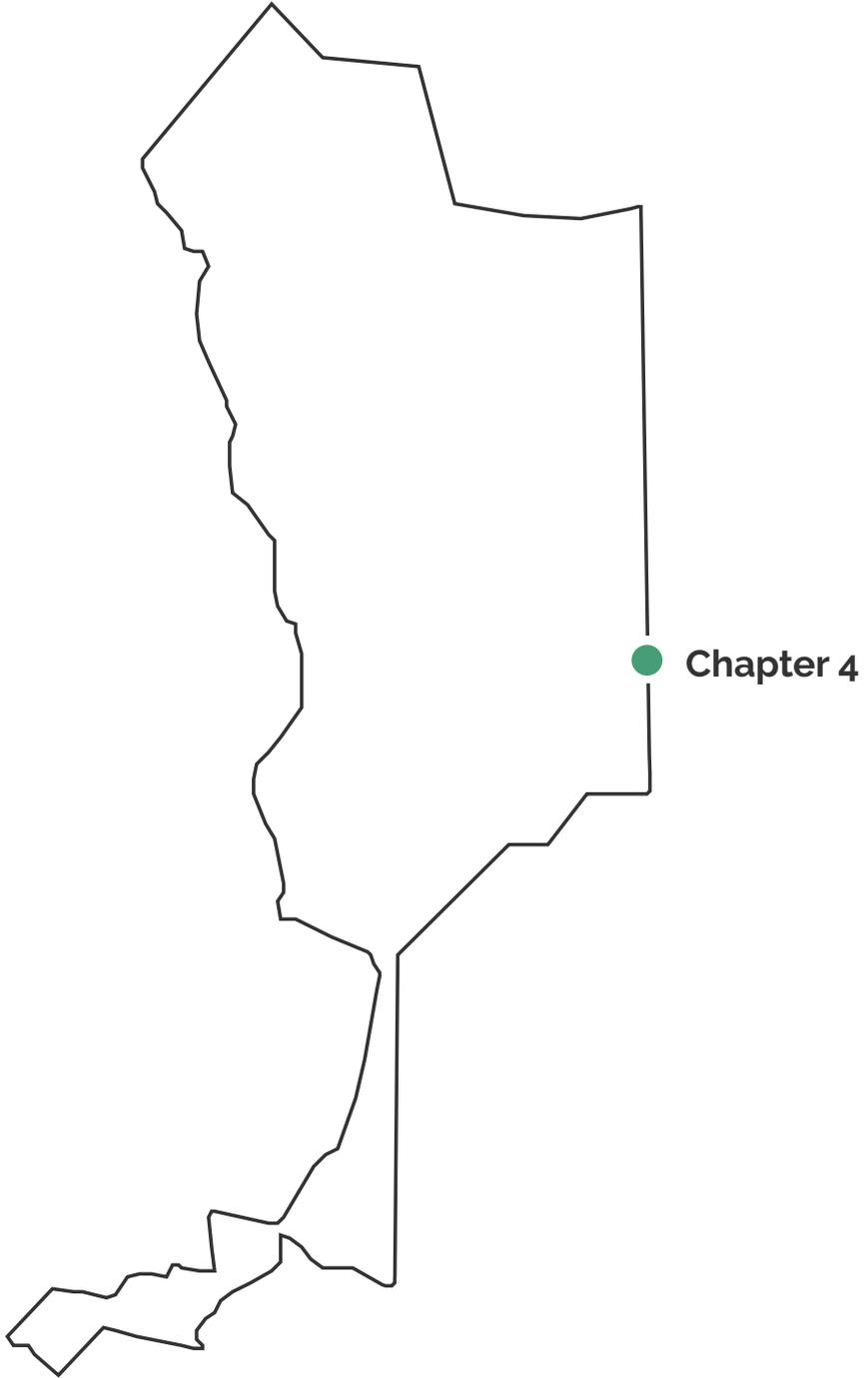
The above review indicates that there is a clear absence of policies or strategies for addressing the issue of informal economy which is considered significant in Teresina and has resulted in serious socio-economic implications in addition to its impacts on municipal public revenue. Nevertheless, several initiatives have been taking place in the city to address the municipal public revenue shortcomings, albeit not addressing the informal economy. Most prominently

is the 2015 "**Gestão Cidadã**" Programme, which is still ongoing. The programme aims to optimize expenses in all the municipal agencies of Teresina to overcome the effects of the national economic crisis and the consequent dropping of national and state level financial transfers to the local authorities. The Program comprises 149 actions proposed to optimize spending and maintain the City's financial balance. Now the programme focuses on recovering the municipal finances in the aftermath of Covid -19 crisis.

Some of the actions that the city has been adopting to optimise municipal spending is the **Colab Teresina** initiative. It is a framework+app for citizens collaboration and monitoring. Through the app Colab, citizens can notify and open requests to the municipality (example: pavement holes, non-functioning lighting, garbage on the street, not operating services, etc). The app opens a formal request (with an ID) through which citizens can check the progress made on their requests. Also, through this service, the municipality conducts public surveys, where users can answer directly through the app or its online website.

Regarding unemployment, Teresina adopted a local policy for the establishment of the **Municipal Employment Council – COMETE**. The council convenes with several labour unions in the city regularly to assess and approve employment related policies in the city. In 2019, the council granted tax incentives to 3 companies with estimated investments of R \$ 47.3 million, through which an estimated 382 direct jobs will be generated in the city.

As it was pointed out in Chapter 2, the local unemployment rate in Teresina is higher than the national rate, but lower than regional figures. Data demonstrate a greater economic vulnerability in the region, which may be more impacted by future financial crises. With the current COVID-19 crisis, in the event of a weak economic recovery, rising unemployment is a risk that must be considered.



Chapter 4

Synthesis & Diagnosis

Chapter 4

Synthesis & Diagnosis

This chapter brings together the findings displayed through the previous chapters of this report, towards outlining an integrated synthesis of findings, in an attempt to provide a diagnosis of urban resilience in Teresina by drawing on resilience characteristics as a framework for evaluation. This chapter is divided into two parts: synthesis of findings, and diagnosis. While the former provides a combined illustration of risks and constraints in Teresina, the latter evaluates urban development efforts in the city using resilience characteristics as criteria.

4.1. Synthesis of Findings

As seen in the previous chapter, a multitude of strategies, plans and programmes that targets the stated priority matters already exists, implying that, although many are very recent, if properly implemented and enforced, Teresina is well underway in addressing many of its risks and some of its priority matters. Thus, perhaps the focus should be on the implementation mechanisms, their governance, and the extent to which they embody urban resilience principles and characteristics, rather than creating and developing new measures. Building upon the findings of the previous chapters, namely chapter 2 and 3, the following observations are inferred:

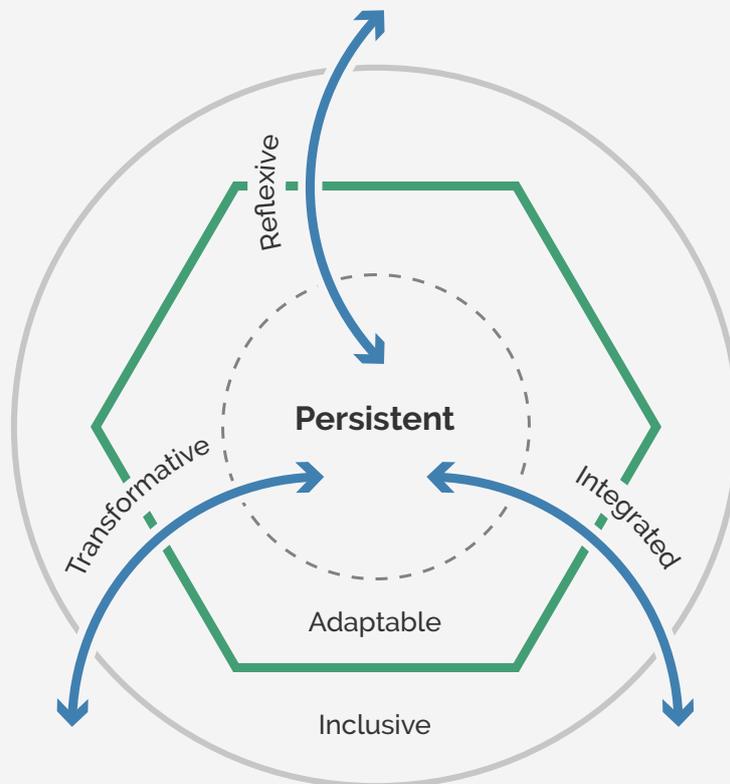
- The Northeast of Brazil is seen as one of the least developed parts of the country. Teresina as a state capital faces not only the overall developmental difficulties in the region, but also the consequent internal dynamics this generate in terms of migratory movements from rural areas and less developed cities in Piauí towards Teresina where access to jobs, resources and services is relatively better, thus intensifying pressure on available resources, expanding the informal economy, undermining the municipal fiscal capacities, exacerbating poverty and inequality, and triggering new risks in the city.
- In general, most of the plausible and present risks in Teresina originate in the urban system due to the existence of protracted vulnerabilities on multiple levels, rather than being driven by external natural factors or events. Nevertheless, ongoing climate change trends suggest that external events will rise in frequency and intensity such as heavy rainfall seasons and severe heat waves. Implying that while the city urgently needs to address existing vulnerabilities such as securing equal access to basic urban and social services, building and strengthening preventive infrastructures, promotion of coordinated and integrated processes of management and governance, to name but a few, Teresina also needs adaptation strategies to the new realities posed by climate change and global events such as Covid-19 pandemic.
- The city is prioritising investment for ensuring the adequate coverage of urban basic services, such as clear water provision, solid waste collection and sanitation (albeit relatively less is made in this respect), and drainage systems, which are highly essential. However, these efforts have not been adequately accompanied with strategies for ensuring sustainable management, and environmentally-friendly urban development and growth. For instance, most of the policies and plans reviewed in terms of solid waste, sanitation and drainage systems, lack strategies on waste treatment, landfills and wastewater plants management and the treatment and re-use of stormwater.
- Perhaps one of the major factors limiting effective response to current resilience building issues in Teresina is the multiplicity of government levels, jurisdiction overlaps, and the difficulties these pose in terms of inter-governmental coordination, especially vertical coordination. It was illustrated through many of the policies reviewed, that inter-governmental coordination meant lingering development and approval processes which in many cases resulted in missing funding opportunities, whereas in some other cases, led to a dead end. Moreover, such overlaps in Teresina have spatial dimensions where many parts of the city, especially those considered risk-prone areas along the rivers are subject to different government levels' competences. For resilience building in particular, this has been very challenging as decision making processes in such areas are described as very bureaucratic and contentious in some incidences especially those related to housing, economic development and environmental conservation policies.

- Both human and financial capacities are major constraints when it comes to setting innovative approaches for addressing urban resilience-related issues towards enabling transformational changes. While the municipality has made marked progress in narrowing its financial deficit gap through increasing the efficiency of its administrative processes, more is needed in terms of strengthening the urban economic performance. Something that requires the city to intensify its advocacy efforts on state, country and international level towards improving the city's regional and national connectivity and economic integration.

4.2. Diagnosis of Urban Resilience building in Teresina

Urban Resilience Characteristics

The following characteristics articulate the characteristics of resilient city by describing what comprises being resilient – being persistent, adaptable, and inclusive – and how resilience can be achieved – through being integrated, reflexive and transformative.



What	Persistent Adaptable Inclusive
How	Integrated Reflexive Transformative

Persistent	A persistent city anticipates impacts in order to prepare itself for current and future shocks and stresses. It builds robustness by incorporating coping mechanisms to withstand disturbances and protect people and assets. It encourages redundancy in its networks by generating spare capacity and back-ups to maintain and restore basic services, ensuring reliability during and after disruption.
Adaptable	An adaptable city considers not only foreseeable risks, but also accepts current and future uncertainty. Going beyond redundancy, it diversifies its services, functions and processes by establishing alternatives. It is resourceful in its capacity to repurpose human, financial and physical capital. It pursues a flexibility that encourages it to absorb, adjust and evolve in the face of changing circumstances, dynamically responding by turning change into opportunity.
Inclusive	An inclusive city centres on people by understanding that being resilient entails protecting each person from any negative impact. Recognising that people in vulnerable situations are among the most affected by hazards, it actively strives towards social inclusion by promoting equality, equity, and fulfilment of human rights. It fosters social cohesion and empowers comprehensive and meaningful participation in all governance processes in order to develop resilience.
Integrated	An integrated city appreciates that it is composed of and influenced by indivisible, interdependent, and interacting systems. It combines and aligns many lenses to ensure input is holistic, coherent, and mutually supportive towards a common cause. It enables a transdisciplinary collaboration that encourages open communication and facilitates strategic coordination. It supports the collective functioning of the city and guarantees far-reaching, positive, and durable change.
Reflexive	A reflexive city understands that its system and surroundings are continuously changing. It is aware that past trends have shaped current urban processes yet appreciates its potential to transform through shocks and stresses over time. It is reflective, conveying the capacity to learn from knowledge, past experiences, and new information. It also learns by doing and installs mechanisms to iteratively examine progress as well as systematically update and improve structures.
Transformative	A transformative city adopts a proactive approach to building resilience in order to generate positive change. It actively strives to alleviate and ultimately eradicate untenable circumstances. It fosters ingenuity and pursues forward-looking, innovative solutions that over time create a system that is no longer prone to risk. A transformative city is focused and goal-oriented towards a shared vision of the resilient city.

It is evident that there is a continuing concerted effort to build up the **persistence** of the city – ensuring that anticipated risks have been assessed, prepared and accounted for, and the related systems are made more robust in terms of water cycle management and some extent for maintaining the ecological balance. These involve various programmes and projects from the national to local levels on different stages of completion, though the challenge of implementing these measures, many of which require significant financing and technological solutions, and extensive cooperation among various actors, remains. Such efforts are not evident in the case of economic performance as the city remains highly vulnerable to financial shocks due to inadequate economic diversification and regional connectivity.

The city is gradually, albeit slowly, **adapting** itself to some challenges posed by its location and context, through multiple legislations and plans, either recently approved, or under development, such as investment in climate change adaptation strategies, Nature-Based Solutions, and building strategic partnerships with state, national and international actors to secure funding for addressing this matter and the encountered technical and financial barriers. But the process is described very slow and inadequate to cope with ongoing changes.

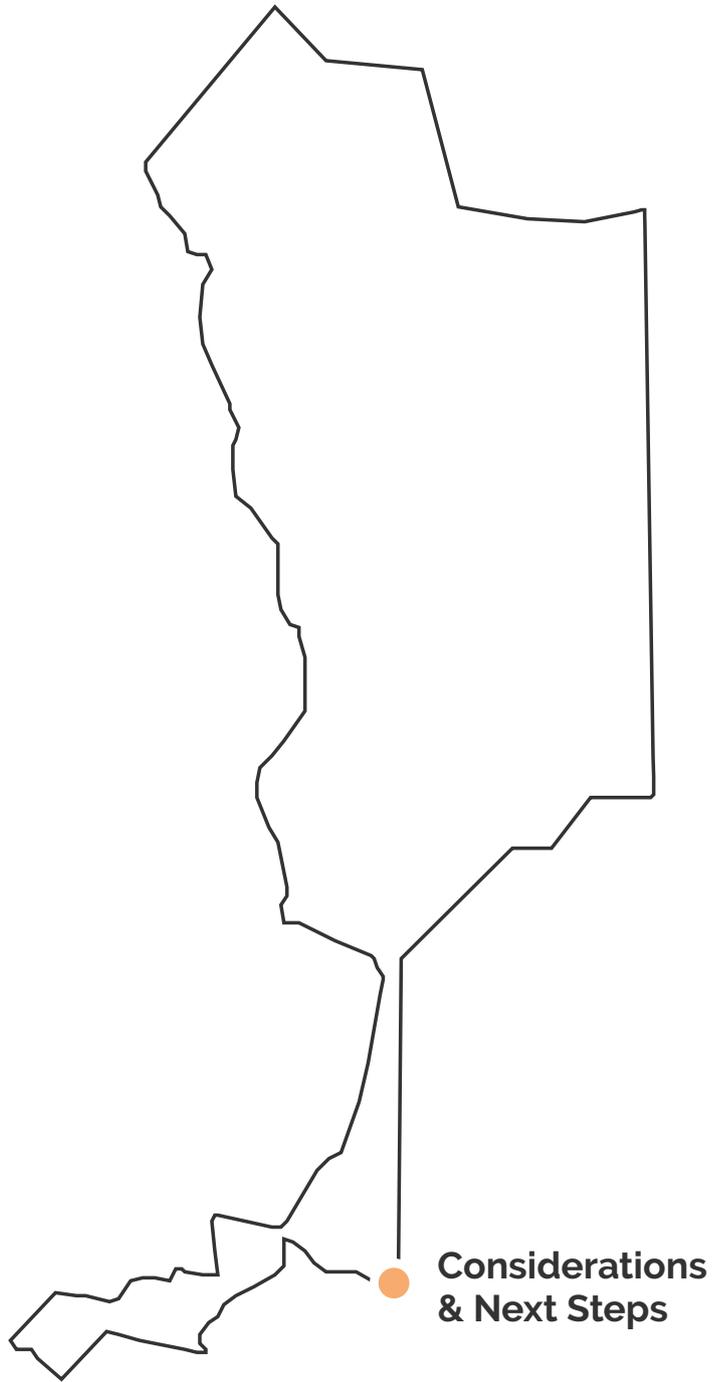
In tackling water cycle mismanagement, the city recognises the essence of **inclusive** distribution of resources and access to service in reducing pressure on the natural system and alleviating vulnerabilities in the city, it therefore gives particular attention to services provision and increases access to land and housing. Nonetheless, to ensure more

inclusive development, the city needs to further promote active public participation in decision making, which requires strengthening the civil society and third sector and provision of incentives to ensure active participation especially by the most vulnerable and in risk population. As for economic performance, ensuring inclusive development entails significant efforts towards the integration of the informal sector in the city and addressing employment rates, an aspect that has not received enough attention yet.

Integrated processes of management and governing, and inter-departmental coordination, are well underway on the municipal level through a number of recent programmes and initiatives aimed at improving financial resources and administrative processes efficiency and increasing the city's attractiveness for businesses. Such efforts are lacking on vertical levels of governing (between the municipality, state government and national government). This issue poses major challenges for the city when it comes to addressing multi-scalar issues such as environmental and ecosystem related ones or economic integration.

Perhaps these barriers to integrated management and governance explain the city's weak learning and **reflective** capacities to take stock of continuous changes in the urban system and other interrelated systems, learn from past experiences and accumulated local knowledge. This is more evident when it comes to spatial development, housing, informal economy, ecosystem degradation, among others.

Recent policies and plans on different levels of the government suggest a strong tendency towards enabling **transformational** changes in addressing water cycle mismanagement and some drivers of ecosystem imbalance. Yet the absence of clear implementation mechanisms coupled with weak human, technical and financial capacities constrain innovative approaches crucial for the realisation of such transformations. However, in regards to economic performance, while a diverse portfolio of policies, initiatives and programmes exists in this respect, the majority attempts to address the symptoms of the economic underperformance rather than tackling the root causes such as weak connectivity and regional economic integration, as well as inadequate economic diversification.



Considerations & Next Steps

Considerations & Next Steps

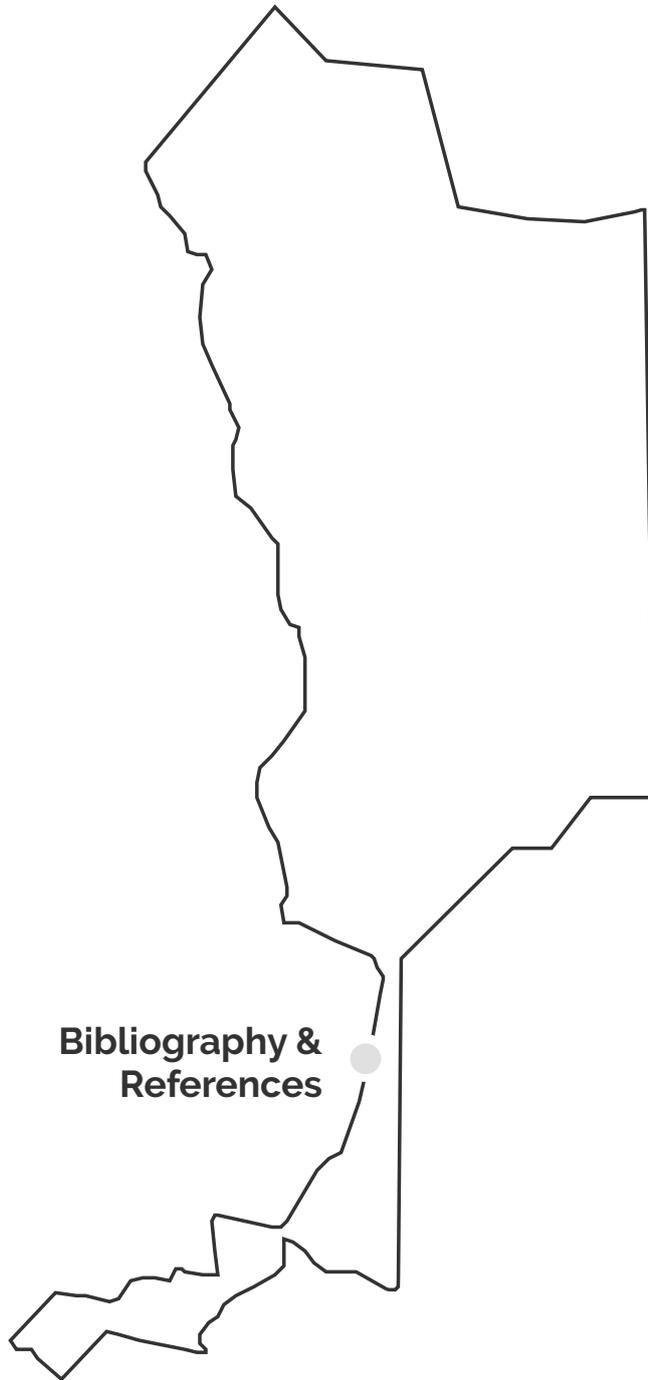
The construction of the Teresina's 'Urban Resilience Diagnosis comprises four main steps, including the initial report on the urban context, and subsequently the analysis of the current of urban resilience in the city identifying its priority matters, the assessment of related policies plans and initiatives to characterise the city's resilience trajectory, and finally, a synthesis and diagnosis framed by urban resilience defining characteristics.

The construction of the local profile provides an overview of the city where the CRPT tool is being implemented, gathering contextual information on various topics that portray the city's unique identity. This chapter presented the Urban Context, which explores the narrative of the city's development through its historical and spatial contexts, specifically in the aspects of climate, ecosystems, urban areas and physical elements. It also introduces its administrative structure, characteristics and local strategies, highlighting those related to resilience and describes the inhabitants of the city through its composition, characteristics and dynamics, in addition to outlining basic information about the economy and means of subsistence. Through this document, the CRGP adapts the tool to the realities of the city, reassessing indicators and issues, and requesting more in-depth investigations in the subsequent data collection sets. Contextual information is also used for diagnosis and action, as it provides an initial idea of the risks and challenges the city may face, including those attributed to climate change and humanitarian issues.

The Analytical part, composed of chapter 2, 3 and 4, brings an in-depth assessment of the urban resilience status, through the investigation on Teresina's relevant shocks, stresses and challenges with the aim to define the priority matters to be considered for action. This part was enriched by the vision of local civil servants, through several workshops, where they mapped and characterized various urban phenomena. In addition, this report offers an extensive set of indicators that relate directly or indirectly to these priority matters and that provide quantitative and qualitative views on these issues and its observed trends, while allowing for future impact monitoring. To assess the public sector response and preparedness, a survey was conducted and an inventory of public policies, plans, programs and initiatives that relate to different aspects of these priority matters was built. Chapter 3, then, brings the analysis of extrinsic and intrinsic trends that mark the trajectory of urban resilience in the city.

The analysis contributes to the formulation of a comprehensive diagnosis of the urban system through capturing weaknesses, pressures, and contextual changes, thereby creating a foundation for the design of implementable and adaptable actions aimed at decreasing the possible impacts of these threats at the urban scale. This assessment will be essential for the construction of recommendations that do not start from scratch, but that consider efforts already made through a critical view of the effectiveness of these existing public policies. Finally, this analysis is synthesized and evaluated against a set of characteristics that circumscribe the definition of resilient cities.

The upcoming steps involve a participatory process for the construction of the city's Recommended Actions for Resilience and Sustainability (RAR-S). It is hoped that the next step will provide a roadmap for local governments to initiate positive changes through transformative actions based on verifiable evidence on the indicated priority matters and structural issues that affect the city's resilience capacity.



Bibliography & References

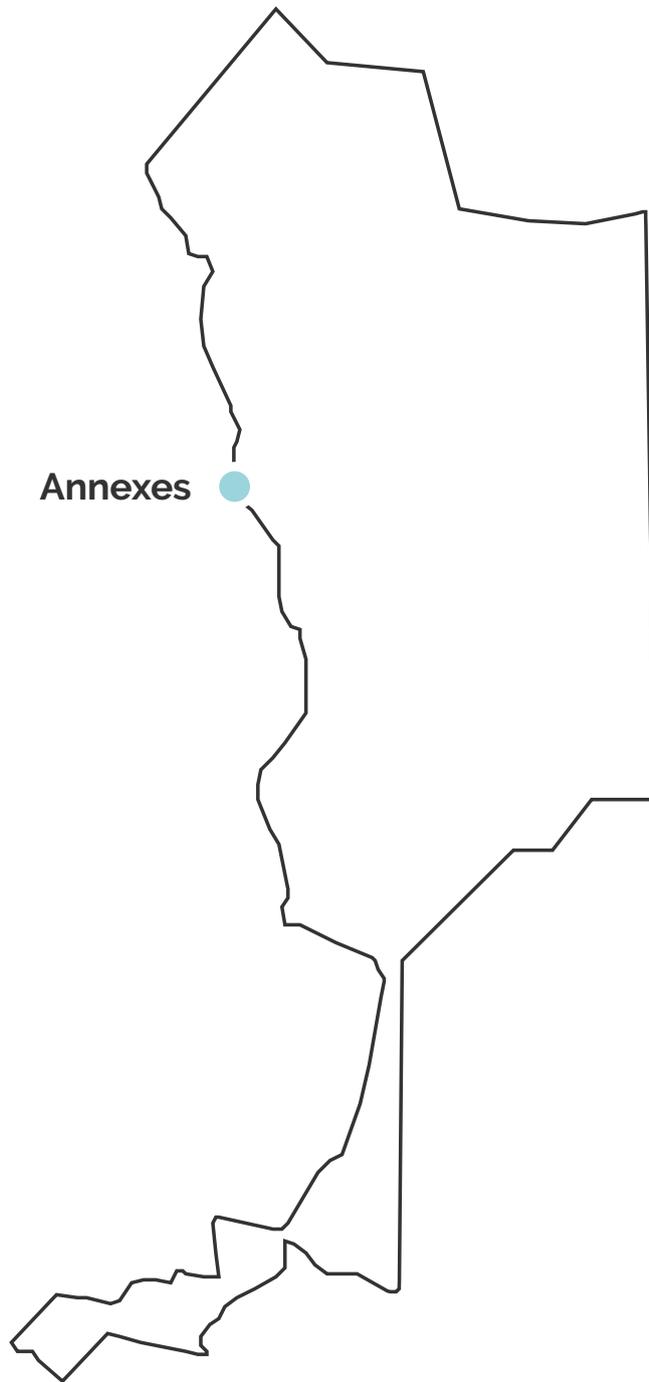
Bibliography & References

- Alves, A. y Lima, I.E.** (2017). Modelagem da qualidade da água do rio Poti em Teresina (PI). Ing. Sanit. Ambiente. vol.23 no.1 Rio de Janeiro ene./fev. 2018 Epub 06-Jul-2017. Disponible en: <https://doi.org/10.1590/s1413-41522017142354>
- Alves, T. & Santos, M.** (2018). A GESTÃO DE RESÍDUOS DA CONSTRUÇÃO CIVIL EM TERESINA – PIAUÍ [The management of waste of civil construction in Teresina – Piauí]. REEC - Revista Eletrônica de Engenharia Civil. Vol. 15. Nº1, 112-124. Doi: 10.5216/reec.v15i1.50156. Available at: www.pdfsemanticscholar.org/59ab/02b8d868a6411b6cfe5aa29d0de6b2e66f79.pdf
- Araujo, K. & Andrade, C** (2017). Ilhas de calor em Teresina-PI: episódios de verão. Revista ENTRE-LUGAR, [S.l.], v. 8, n. 16, p. 32-54, dez. 2017. ISSN 2177-7829. doi: www.doi.org/10.30612/el.v8i16.8070
- Bettencourt, L., Samaniego, H. & Youn, H.** (2014). Professional diversity and the productivity of cities. Sci Rep 4, 5393. 2014. <https://doi.org/10.1038/srep05393>. Available at: www.nature.com/articles/srep05393
- Branco de Vasconcelos Filho, P.C.,** (2019), MOBILIDADE NO CENTRO URBANO DE TERESINA. CAU/PI Conselho de Arquitetura e Urbanismo do Brasil. Available at: www.caupi.gov.br/wp-content/uploads/2019/03/ARTIGO-CAU-2-MOBILIDADE-NO-CENTRO-URBANO-DE-TERESINA.pdf [Accessed 28th October 2020]
- Broto, C. et al.,** (2012). Interdisciplinary Perspectives on Urban Metabolism. Journal of Industrial Ecology. 16. 851-861. 10.1111/j.1530-9290.2012.00556.x. Available at: www.researchgate.net/publication/256041727_Interdisciplinary_Perspectives_on_Urban_Metabolism
- Carcará, M.C. & Leal Junior, J. H.,** (2016). Região integrada de desenvolvimento- Ride Grande Teresina: isolamento e dispersão no planejamento urbano. A: Seminario Internacional de Investigación en Urbanismo. "VIII Seminario Internacional de Investigación en Urbanismo, Barcelona-Balneário Camboriú, Junio 2016". Barcelona: DUOT, 2016. DOI10.5821/siiu.6316 Available at: www.upcommons.upc.edu/bitstream/handle/2117/101706/21CAM_LEAL%20JUNIOR%20Y%20CARCARA.pdf?sequence=1&isAllowed=y
- Cardoso de Sousa, B. et al** (2019). Gerenciamento dos resíduos sólidos no município de Teresina-PI por meio dos pontos de recebimento de resíduos. X Congresso Brasileiro de Gestão Ambiental. Fortaleza/CE. Available at: www.ibeas.org.br/congresso/Trabalhos2019/III-117.pdf
- Carvalho, C. & Collet, G.** (2009), Desenvolvimento urbano e regional de Teresina, Piauí, Brasil e sua importância no atual quadro de influência na Rede Urbana Regional no Brasil. 15 Congresso da APDR. P.3599-3600. Available at: www.apdr.pt/congresso/2009/pdf/Sess%C3%A3o%2037/245A.pdf
- Cerqueira, D. et al.,** (2020). Atlas da Violência 2020. Instituto de Pesquisa Econômica Aplicada – IPEA, 2020. Available at: www.ipea.gov.br/atlasviolencia/download/24/atlas-da-violencia-2020
- CHMURA, n.d., Economic Diversity Index [online].** Chmura Economics & Analytics, JobsEQ. Available at: www.chmuraecon.com/interactive/economic-diversity/ [Accessed 2 November 2020].
- Clímaco de Lima, N. et al.,** (2008). O processo de degradação ambiental do Rio Parnaíba no trecho urbano Bairro Sacy até o encontro com o Rio Poty, em Teresina-PI. XXV EREGENE: "Geografia e Meio Ambiente: Discutindo o Nordeste nos 25 anos de EREGENE. Available at: www.uespi.br/prop/siteantigo/XSIMPOSIO/TRABALHOS/PRODUCAO/Ciencias%20Humanas%20e%20Letras/O%20PROCESSO%20DE%20DEGRADACAO%20AMBIENTAL%20DO%20RIO%20PARNAIBA%20NO%20TRECHO%20URBANO%20BAIRRO%20SACY%20ATE%20O%20ENCONTRO%20COM%20O%20RIO%20POTY,%20EM%20TERESINA-PI.pdf

- Damasceno, I. et al.** (2017). Evaluation of pollution level caused by domestic effluent in the Poty River - Teresina PI - Brazil. *Eclética Química Journal*. 37. 51. 10.26850/1678-4618eqj.v37.1.2012.p51-60. Available at: www.researchgate.net/publication/322907436_Evaluation_of_pollution_level_caused_by_domestic_effluent_in_the_Poty_River_-_Teresina_PI_-_Bra_zil
- Damasceno, L.** (2015). WATER QUALITY MANAGEMENT AND EVALUATE IN POTY RIVER, AT TERESINA, PIAUI STATE, BRAZIL. Available at: www.researchgate.net/publication/275650205_WATER_QUALITY_MANAGEMENT_AND_EVALUATE_IN_POTY_RIVER_AT_TERESINA_PIAUI_STATE_BRAZIL
- Dersseh, M.G. et al.** (2019). Chapter 19 - Water hyacinth: review of its impacts on hydrology and ecosystem services—Lessons for management of Lake Tana. *Extreme Hydrology and Climate Variability. Monitoring, Modelling, Adaptation and Mitigation 2019*, Pages 237-251. Available at: www.sciencedirect.com/science/article/pii/B9780128159989000191
- Dyck, S.** (1990). Integrated water planning and management of water resources (Guidance material for courses for engineers, planners and decision-makers). International Hydrological Programme, United Nations Educational, Scientific and Cultural Organization, UNESCO. Available at: www.unesdoc.unesco.org/ark:/48223/pf0000155111
- ECLAC.** (2020). The social challenge in times of COVID-19. Special Report COVID-19, nº3. Economic Commission for Latin America and the Caribbean (ECLAC). United Nations. 12th May 2020. Available at: www.repositorio.cepal.org/bitstream/handle/11362/45544/1/S2000324_en.pdf
- Feitosa, M., Nobrega, R., Junior, J.** (2016). Vulnerability environmental and flood risk in Poti river, Teresina, Brazil. *Revista Geama*. Available at: www.researchgate.net/publication/302989095_Vulnerability_environmental_and_flood_risk_in_Poti_river_Teresina_Brazil
- Gomes, D. et al.** (2019). ESTUDO DE CASO: QUANTITATIVO E ANÁLISE ESPACIAL DOS FOCOS DE INCÊNDIO EM TERESINA-PI. *Revista Científica Semana Acadêmica*. 01. Available at: www.semanaacademica.org.br/system/files/artigos/estudo_de_caso_-_quantitativo_e_analise_espacial_dos_focos_de_incendio_em_teresina-pi.pdf
- Gonçalves da Silva, R., and Silva, E.** (2019). ANÁLISE DOS FATORES DETERMINANTES NO NÚMERO DE CASOS DE DENGUE EM TERESINA, ESTADO DO PIAUÍ. Available at: www.revistas.ufpi.br/index.php/geografia/article/view/8888
- Guo Y, Gasparrini A, Li S, Sera F, Vicedo-Cabrera AM, de Sousa Zanotti Stagliorio Coelho M, et al.** (2018) Quantifying excess deaths related to heatwaves under climate change scenarios: A multicountry time series modelling study. *PLoS Med* 15(7): e1002629. www.doi.org/10.1371/journal.pmed.1002629
- G1** (2016). Infestação de besouros assusta moradores da Zona Norte de Teresina. *Globo.com*. Available at: www.g1.globo.com/pi/piaui/noticia/2016/05/infestacao-de-besouros-assusta-moradores-da-zona-norte-de-teresina.html [Accessed 27th November 2020]
- G1** (2018). Aguapés cobrem Rio Poti, em Teresina, e ambientalista alerta sobre os impactos ambientais. *Globo.com*. Available at: www.g1.globo.com/pi/piaui/noticia/2019/10/18/aguapes-cobrem-rio-poti-em-teresina-e-ambientalista-alerta-sobre-os-impactos-ambientais.ghtml [Accessed 23 October 2020]
- IBGE,** (2020). Trabalho: Desocupação, renda, afastamentos, trabalho remoto e outros efeitos da pandemia no trabalho. O IBGE apoiando o combate à COVID-19. Instituto Brasileiro de Geografia e Estatística. [online] Available at: www.covid19.ibge.gov.br/pnad-covid/trabalho.php [Accessed 5 November 2020].
- Ibold, S. et al.** (2020). The COVID-19 outbreak and implications to sustainable urban mobility – some observations. TUMI. Transformative Urban Mobility Initiative. [online] Available at: www.transformative-mobility.org/news/the-covid-19-outbreak-and-implications-to-public-transport-some-observations [Accessed 5 November 2020].

- IPEA, n.d.**. Taxa Homicídios. Instituto de Pesquisa Econômica Aplicada – IPEA. [online] Available at: www.ipea.gov.br/atlasviolencia/dados-series/20 [Accessed 2 November 2020].
- Latus Consultoria**, (2017). REVISÃO E ATUALIZAÇÃO DO PLANO DIRETOR DO MUNICÍPIO DE TERESINA – PI LEITURA TÉCNICA 2º PRODUTO. Available at: www.semplan.teresina.pi.gov.br/wp-content/uploads/sites/39/2018/09/Teresina_Produto-2.pdf
- Lima, I.** (2016). TERESINA: O RELEVO, OS RIOS E A CIDADE. Revista Equador (UFPI). 5. P.375-397. Available at: www.researchgate.net/publication/308696618_TERESINA_O_RELEVO_OS_RIOS_E_A_CIDADE
- Lima, I.** (2002). TERESINA: URBANIZAÇÃO E MEIO AMBIENTE. Scientia et Spes. 1. 181-206. Available at: www.researchgate.net/publication/308696850_TERESINA_URBANIZACAO_E_MEIO_AMBIENTE
- Macedo, J. Samya N., Malheiros, D.** (2019). A problemática da destinação final e coleta seletiva dos resíduos sólidos na cidade de Teresina– PI. EcoDebate. ISSN 2446-9394. Available at: www.ecodebate.com.br/2019/05/20/a-problematica-da-destinacao-final-e-coleta-seletiva-dos-residuos-solidos-na-cidade-de-teresina-pi-por-jonathas-macedo-samya-neves-e-djailson-malheiros
- Moraes, L.A., Machado, R.R., & Araújo, M.F.** (2015). O BABAÇU NA ZONA URBANA DE TERESINA – PI: DISTRIBUIÇÃO E VIABILIDADE PAISAGÍSTICA. Available at: www.revistas.ufpi.br/index.php/equador/article/view/4193
- Marsalek, J. et al.,** (2007). Urban Water Cycle Processes and Interactions. Taylor & Francis Group. ISBN: 978-92-3-104060-3. Available at www.researchgate.net/publication/242591919_Urban_Water_Cycle_Processes_and_Interactions#pf8
- Prefeitura de Teresina**, (2019). THE2019. Relatório anual de atividades e mensagem do prefeito de Teresina à Câmara de Vereadores. Available at: www.pmt.pi.gov.br/wp-content/uploads/sites/34/2020/02/Relat%C3%B3rio-Anual-Teresina-2019.pdf
- Ribeiro, S. et al.** (2011). CONSEQUÊNCIAS DA URBANIZAÇÃO NA VEGETAÇÃO E NA TEMPERATURA DA SUPERFÍCIE DE TERESINA – PIAUI. REVSBAU, Piracicaba – SP, v.6, n.2, p.58-75, 2011. Available at: www.revistas.ufpr.br/revsbau/article/view/66395/38238
- Secretaria Municipal de Planejamento e Coordenação**, (2012). Plano Diretor de Drenagem Urbana de Teresina. Rev.01. Volume 25. Relatório Final Julho/2012. Programa Lagoas do Norte. Prefeitura Municipal de Teresina.
- SEMDEC Prefeitura Municipal de Teresina**, (2016). GUIA DO INVESTIDOR: Indicadores Econômicos e Turísticos 2013 –2016. Teresina, Piauí. Available at: www.semdec.teresina.pi.gov.br/wp-content/uploads/sites/32/2016/06/Guia-do-Investidor-2013-2015-28-de-junho-2016-OK2.pdf
- Sousa, L.S. et al.** (2008). Estudo de influência do Nitrito no crescimento de aguapés no Rio Poty na região de Teresina – PI. 1º Encontro Nacional De Tecnologia Química. Fortaleza/CE- 09 á 11 de Julho de 2008. Available at: www.abq.org.br/entequi/2008/trabalhos/13-227.htm
- SSP-PI** (2020). Relatório de Criminalidade. Governo de Estado Piauí. Secretaria da Segurança Pública do Estado-SSP. Available at: www.ssp.pi.gov.br/download/202001/SSP13_166d0b076a.pdf
- The Economist.** (2004). In The Shadows: The informal economy is neither small nor benign. [online]. Finance & Economics. June 17th 2004 edition. Available at: www.economist.com/finance-and-economics/2004/06/17/in-the-shadows [Accessed 2 November 2020].
- Vasanthi, et al.,** (2008). Impact of poor solid waste management on ground water. Environmental monitoring and assessment. September 2008, Environmental Monitoring and Assessment 143(1-3):227-38. DOI: 10.1007/s10661-007-9971-0. Available at: www.researchgate.net/publication/5848086_Impact_of_poor_solid_waste_management_on_ground_water

- Vieira, S. and Gomes, W.** (2011), "A VULNERABILIDADE SOCIOAMBIENTAL EM TERESINA, PIAUÍ, BRASIL." Revista Geográfica de América Central, Vol. 2, núm., pp.1-17. ISSN: 1011-484X. Available at : www.redalyc.org/articulo.oa?id=4517/451744820705
- UNFCCC**, (2016). The concept of economic diversification in the context of response measures. Technical paper. United Nations Framework Convention on Climate Change. Available at: www.unfccc.int/files/cooperation_support/response_measures/application/pdf/technical_paper_economic_diversification.pdf
- World Economic Forum.** (2020) COVID-19 Risks Outlook: A Preliminary Mapping and Its Implications. www3.weforum.org/docs/WEF_COVID_19_Risks_Outlook_Special_Edition_Pages.pdf



Annex I

**Risks and Priority Matters
Workshop in Teresina**

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Annex I

Risks and Priority Matters Workshop in Teresina

Introduction

This annex explains the approach, methods and techniques adopted by CRGP for the purpose of identifying the various types of present and projected risk in Teresina. It, further, displays the outcomes and findings of this approach and related activities in terms of shocks and stresses identification, and mapping priority matters for enhancing urban resilience in the city.

1. CRPT conceptualization of risks

As explained in the introduction part of this report - CRPT methodological framework -, the Why Lens: Shocks, Stresses and Challenges, provides analysis regarding the existence of, and interactions between shocks and stresses in the presence of existing challenges and constraints in the city. The outcome of this analysis is provided in detail in Chapter 2 - The Current State of Urban Resilience in Teresina.

CRGP defines shocks as Uncertain, abrupt, or long-onset events that have the potential to impact upon the purpose or objective of an urban system.

Stresses are Chronic and ongoing dynamic pressures originated within an urban system with potential for cumulative impacts on the ability and capacity of the system to achieve its objectives.

Challenges, while not considered entirely as risks, are Long-term contextual changes and pressures originating outside the urban system that also undermine the city's capacity for sustainability and resilience.

The relationship between stresses, shocks, and challenges, can be expressed as follows:

- Stresses increase the vulnerability of the city to potential shocks
- Shocks see their impacts compounded by the stresses that the city suffers and they have the potential to generate new stresses if they were not properly responded to.
- Challenges limit or constraint the potentials and options available to the city and local authorities to adequately address stresses and manage the risks of shocks .

As it could be seen, these different forms of risks and threats do not operate in isolation in the urban system. It is important to recognize these relationships when building resilience as proposed actions should reduce vulnerability and help mitigate the impact of an external event. Consequently, the city's ability to regain its pace of performance must be improved. Through exposing the risks that Teresina faces, interactions among risks and the components of the urban system can be drawn – the understanding of which are essential for designing actions seeking to build the city's resilience. A resilient city is one that considers how these various risks affect each other and therefore highlight priority matters to be addressed in order to achieve maximum impact.

To this end, CRGP in close coordination with the Municipality of Teresina adopted an approach for identifying the different types of present and anticipated risks in Teresina, and exploring their underlying drivers and consequent effects. This approach relied mainly on a series of consultation workshops with the different municipal departments in Teresina. This was preceded by the formation of a Monitoring Committee for the Urban Resilience Program of the Municipality of Teresina, instituted through the Municipal Ordinance in December 2018. Composed of 21 civil servants from 14 secretariats, executive secretaries and foundations of the Municipal Administration, the Monitoring Committee, also called the Resilience Committee, was instrumental in building a local panorama of risks, by obtaining data needed for subsequent analysis.

The following sections will describe these consultative activities in detail, and display their findings on which Chapter 2 – the Current State of Urban Resilience is based. The design and organization of these workshops was as follows:

- 3 workshops aimed at identifying and characterizing shocks, mapping their impacts on the urban system, and existing risk reduction measures in Teresina.
- 2 workshops aimed at mapping funding and financial capacities by the local government for emergency response and recovery.
- 2 workshops for identifying and characterizing ongoing stresses, mapping their effects across the urban system, and their role in aggravating the impacts of shocks on the city.
- 1 workshop for the final mapping of the interrelations between shocks, stresses and the urban system in the presence of enduring and emerging challenges in Teresina, towards defining Priority Matters for resilience building in Teresina.

	Theme	Date	N° of participants
Workshop 1	Program Presentation and Shock Identification	June 16, 2020	14
Workshop 2	Following up – the H.A.R.D platform progress on shock Identification	June 23, 2020	11
Workshop 3	Following up – the H.A.R.D platform progress on shock Identification.	June 30, 2020	10
Workshop 4	Finance for DRR	July 7, 2020	11
Workshop 5	Finance for DRR	July 22, 2020	12
Workshop 6	Stress Identification	August 5, 2020	15
Workshop 7	Stress Identification	August 11, 2020	11
Workshop 8	Consensus building on Priority Matters	August 18, 2020	19

2. Shocks in Teresina: Workshops 1-5

	Workshop 1	
	Date:	16/6/2020
	Participation mode:	online

It should be noted that due to COVID-19 restrictive measures imposed by the municipality, in-person workshops were not possible. Therefore CRGP carried out online workshops using Google Meet.

The first workshop was dedicated to presenting the Teresina Resilience Program and the Program Implementation timeline, followed by an introduction to the City Resilience Profiling Tool (CRPT) and its systems thinking based approach to risks and resilience. This workshop represented a training opportunity for the different representatives with the purpose of comprehending the different types of risks CRPT considers in its analysis and how this is utilized in order to draw urban resilience diagnosis.

In addition, the first workshop introduced the means and tools to be used for populating data on shocks in Teresina. Specifically, the participants of the workshop (Teresina Resilience Committee members) were trained on how to use the H.A.R.D platform, an online tool through which data and information on the different types of shocks are input as an alternative for in-person data collection.

Participants were asked to provide data on location, frequency and intensity of events, as well as their impacts on people (e.g. life loss and injuries), assets (e.g. properties and economic losses) and processes (e.g. disruption of urban services). Further, participants were asked to provide information on measures in place per each shock identified, such measures were risk reduction related and existing policies plans and initiatives for addressing the plausible threats and their impacts.

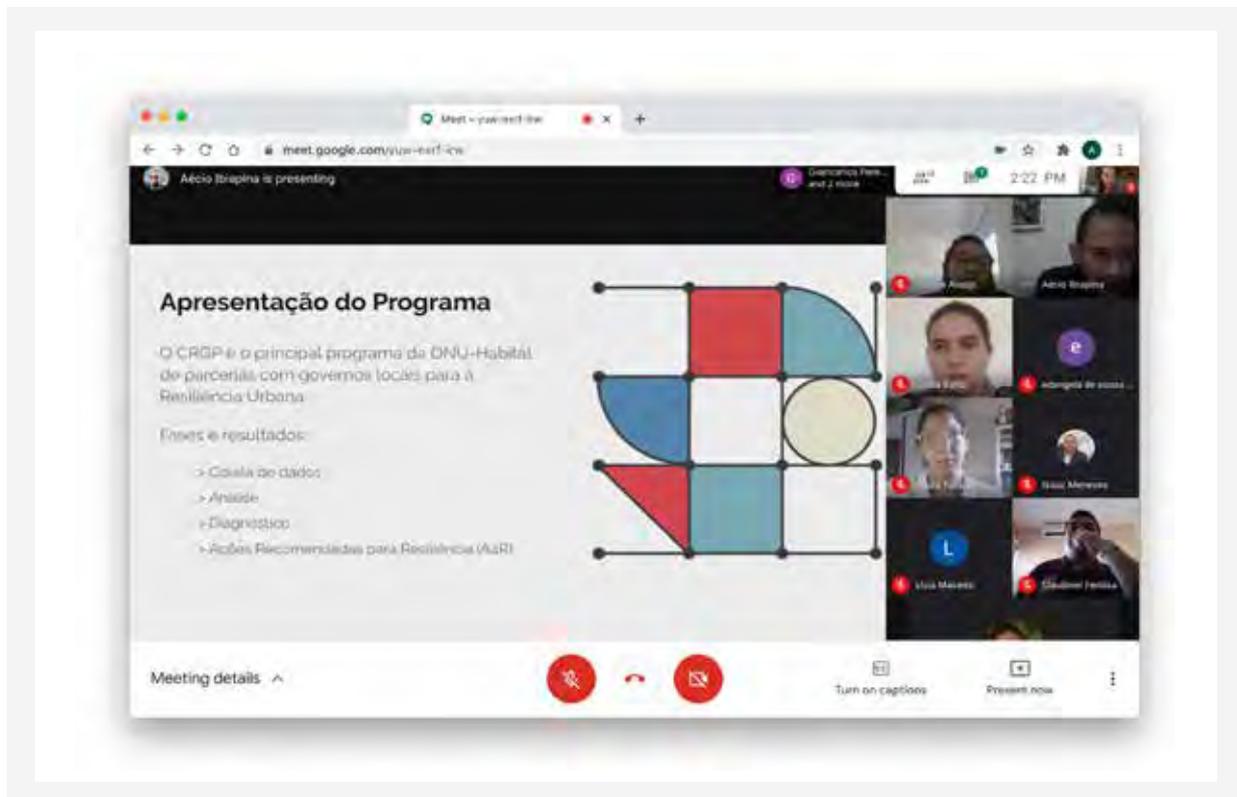


Figure 1: Snapshot of workshop 1.

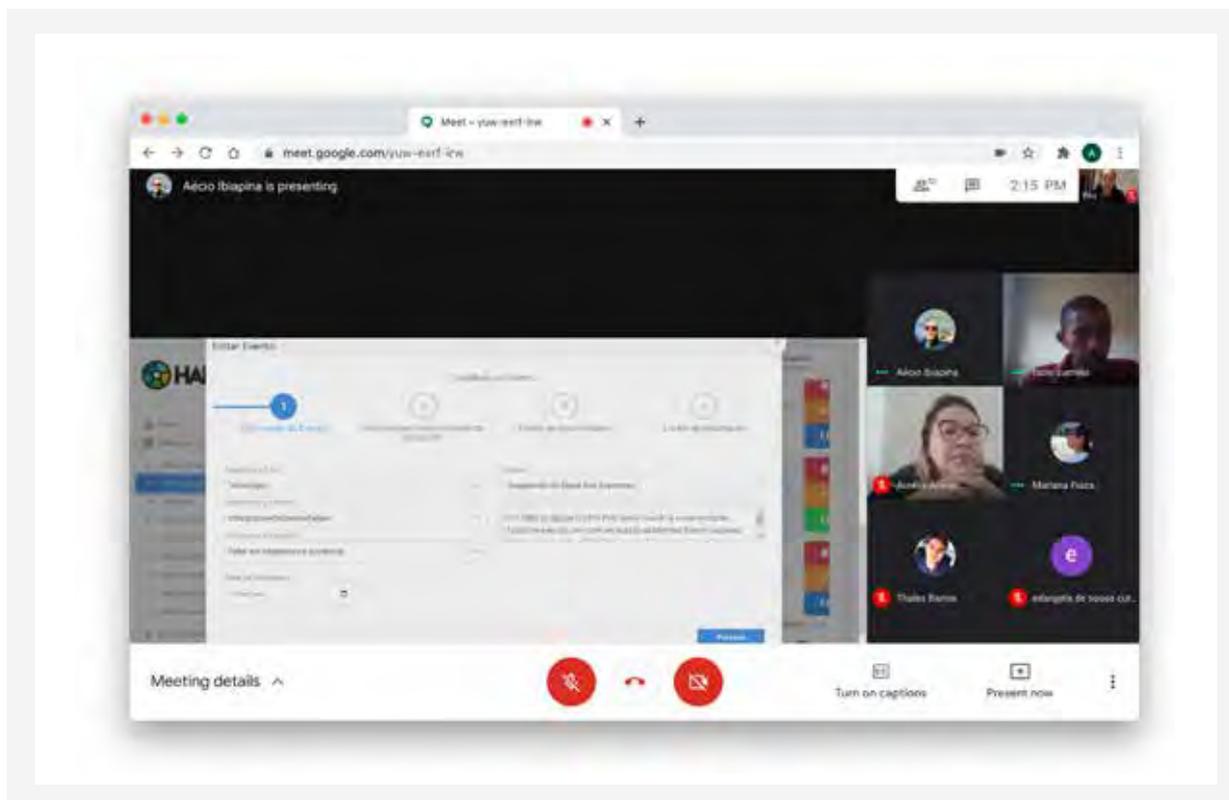


Figure 2: Snapshot of workshop 1.

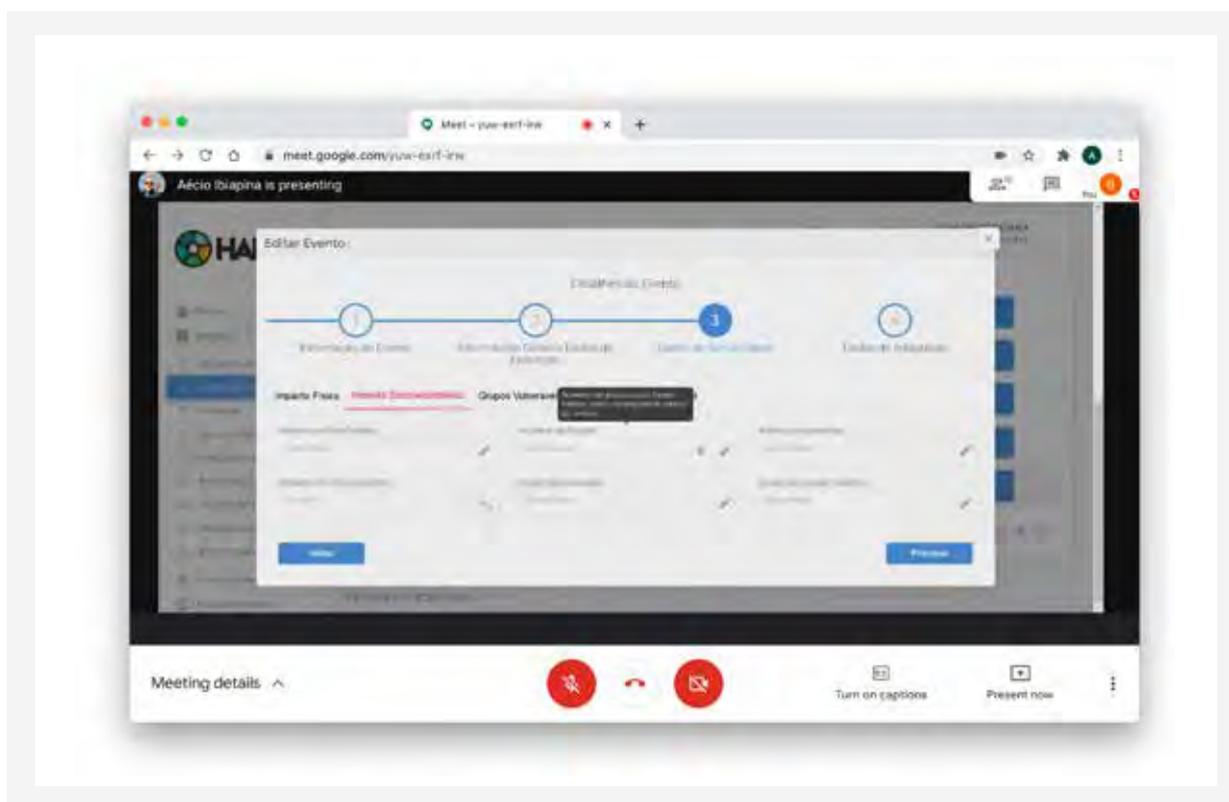


Figure 3: Snapshot of workshop 1.



Workshop 4 and 5

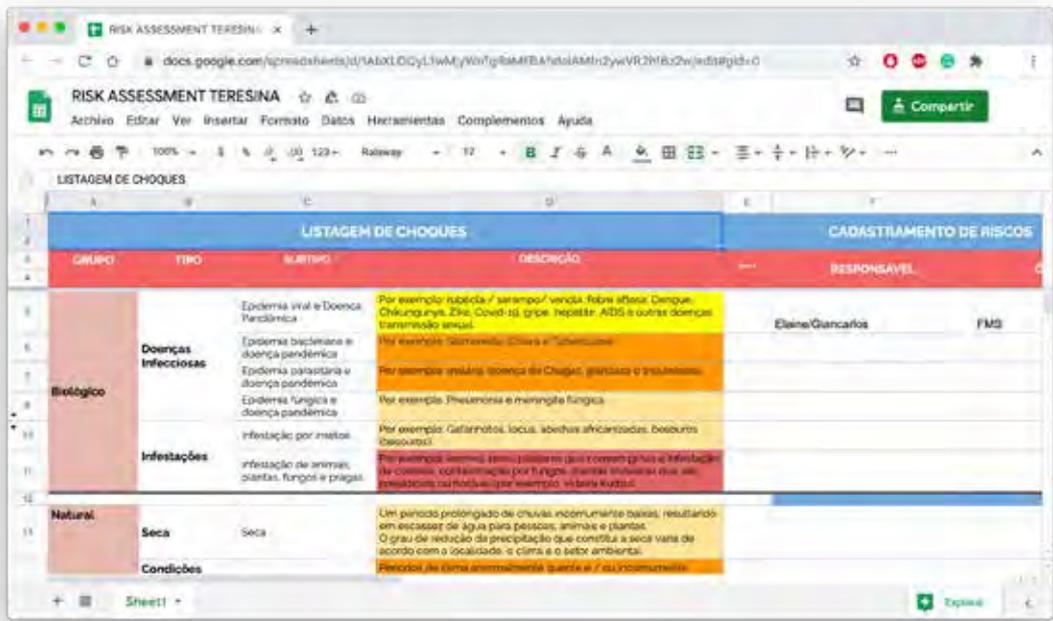
Date: 7/7/2020 and 22/7/2020

Participation mode: online

In the first week of July, another function of the platform was introduced to the Committee, to initiate a financial evaluation of the registered events, divided into historical events, current data and forecasted data. Two weeks were dedicated to searching and filling out financial information related to shocks, before proceeding with the introduction of a new type of risk: stresses.

Through weekly meetings, the team was able to assess progress in registering risks and events, and clarify any possible doubts. After two weeks, 82 shocks had been registered on the platform, ranging from natural to health and financial shocks. Drawing on the impacts of each shock identified on people, processes and assets, and considering the climate change projection and its implications for each shock identified, participants were asked to qualitatively characterize the seriousness of each shock in the list on a scale from low to high (low risk/yellow, medium risk/ orange, high risk/ red).

While the aim of these categorization was to prioritize those shocks with higher risks on the urban system, less significant ones have been also considered in understanding how multiple threats can interplay in the presence of stresses and challenges. Nevertheless, this categorization proved useful in making the subsequent workshops and discussions very focused.



LISTAGEM DE CHOQUES				CADASTRAMENTO DE RISCOS
GRUPO	TIPO	SUBTIPO	DESCRIÇÃO	RESPONSÁVEL
Biológico	Doenças Infeciosas	Epidemia viral e Doença Pandêmica	Por exemplo: rubéola, sarampo, varicela, febre aftosa, Dengue, Chikungunya, Zika, Covid-19, gripe, hepatite, AIDS e outras doenças transmissíveis agudas.	Elaine/Giancarlo FMS
		Epidemia bacteriana e doença pandêmica	Por exemplo: salmonela, shigela e shigelose.	
	Epidemia parasitária e doença pandêmica	Por exemplo: amebíase, doença de Chagas, giardíase e cryptosporídioses.		
	Epidemia fúngica e doença pandêmica	Ver exemplo: Pneumonia e meningite fúngica.		
Infestações	Infestação por insetos	Por exemplo: Gafanhotos, locusts, abelhas africanizadas, Borboletas (caso ataca).		
	Infestação de animais, plantas, fungos e pragas	Por exemplo: animais, insetos, parasitas (que consomem plantas e mineração de casacos), contaminação por fungos, plantas invasoras (que são prejudiciais ao ecossistema) por exemplo: vitória régia.		
Natural	Secas	Seca	Um período prolongado de chuvas incomum/baixas, resultando em escassez de água para pessoas, animais e plantas. O grau de redução da precipitação que constitui a seca varia de acordo com a localidade, o clima e o biótopo ambiental.	
	Condições		Períodos de clima anormalmente quente e/ou incomum.	

Figure 5: Snapshots of the list of Identified shocks in Teresina. The full table is accessible through the following link: www.docs.google.com/spreadsheets/d/1AbXLOQyL1wMjyWnTgRaMFBaHdoiAMfn2yWVR2hf6z2w/edit#gid=0

Based on this characterization, the most serious shocks given their current and anticipated effects are illustrated in figure 3.

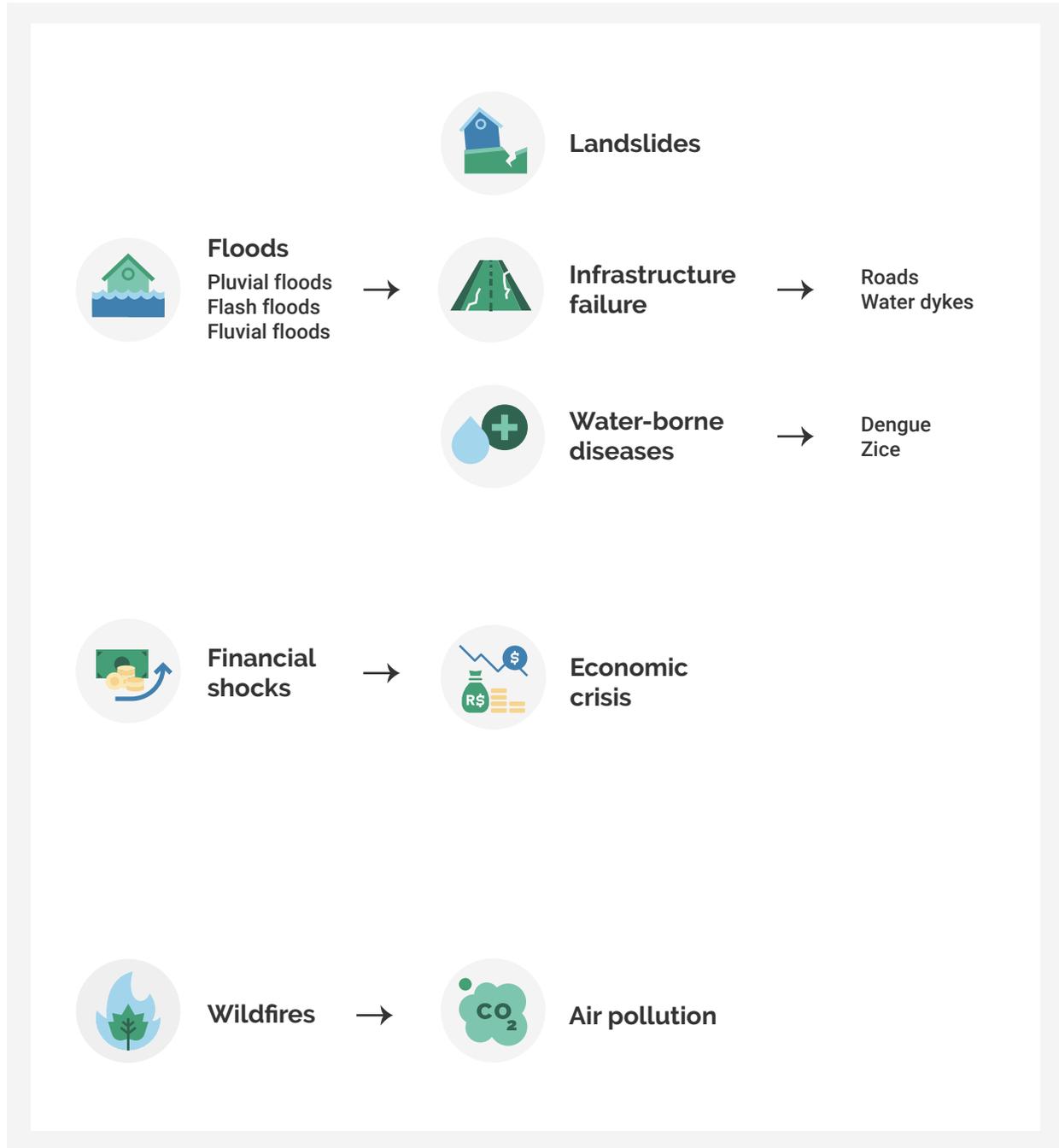


Figure 6: Priority shocks in Teresina and secondary shocks – events triggered by the occurrence of the priority shocks.

3. Stresses in Teresina – Workshops 5 and 6

	Workshop 6	
	Date:	5/8/2020
	Participation mode:	online

In this workshop, participants were introduced to stresses and how they differ from shocks with which most of attendees were already familiar, the interlinks between shocks, stresses and the urban system, and CRPT's approach to identifying stresses, as well as their role in the analysis process and diagnosis. To enhance participants' comprehension of these different concepts and ensure that everyone distinguishes between the different types of threats, attendees were invited to participate in an online activity using the Menti tool.

Stresses identification

Using Menti, participants started to list down different stresses they viewed relevant to the context of Teresina building on their knowledge and experience in their respective fields within the municipality. As a result, 34 stresses were identified as to be present in Teresina and causing major pressure on the urban system (see table 3 – the initial list of identified stresses in Teresina).



Figure 7: Snapshots of Menti tool during the workshop.

Despite the extensive introduction to the concept of stresses and how they differ from shocks, many conflated some shock events with stresses. Moreover, some participants got confused when they were asked to separate between stresses and stressors (Factors, processes, activities or interactions that individually or conjointly lead to the generation of a stress in the urban system).

Stresses in Teresina (Portuguese)	Stresses in Teresina (English)
Perda de cobertura vegetal do município de Teresina	Loss of vegetation cover in the municipality of Teresina
Gestão ineficiente do transporte público	Inefficient public transport management
Sistema de Drenagem Ineficiente	Inefficient Drainage System
Pouca cobertura da rede de saneamento básico	Poor coverage of the basic sanitation network
Despejo de Esgoto nos Rios	Untreated Sewage Disposal in Rivers
Greve de Operadores do Sistema de Transporte Coletivo	Public Transport System Operators Strike
Ilhas de Calor agravadas pela baixa cobertura vegetal	Heat Islands aggravated by sparse vegetation cover
alta ocupação hospitalar por vítimas de acidentes de trânsito	high hospital occupation by traffic accident victims
Uso irregular das calçadas	Irregular use of sidewalks
Formação de ilhas de calor superficiais	Formation of surface heat islands
Falta de acessibilidade nos passeios públicos	Lack of accessibility on public sidewalks
Falta de arborização em passeios e ciclovias	Poor afforestation on sidewalks and cycle paths
Dificuldade de monitoramento e cumprimento de prazos de execução de serviços públicos	Difficulty in monitoring and meeting deadlines for public services
Aumento da área de solo exposto	Increase of exposed soil area
Ineficiência nos processos de gestão e proteção do patrimônio construído e natural	Inefficiency in the management and protection of built and natural heritage
Crescimento econômico não-saudável e desemprego	Unhealthy economic growth and unemployment
Alta ocorrência de crimes urbanos como assaltos, furtos e agressões	High occurrence of urban crimes such as assaults, thefts and harassment
Distribuição irregular de cobertura vegetal	Irregular distribution of vegetation cover
Baixa capacidade de manutenção de espaços públicos	Low public spaces maintenance capacity
Casos frequentes de tentativas de suicídio	Frequent cases of suicide attempts
Pobreza Concentrada	Concentrated Poverty
Segregação Espacial	Spatial Segregation
Cobertura inadequada dos serviços de saneamento básico	Inadequate coverage of basic sanitation services
Discriminação de gênero	Gender discrimination
Má gestão do metabolismo urbano	Poor management of urban metabolism
Diversificação econômica inadequada	Inadequate economic diversification

Baixa diversidade em indústrias e manufaturas	Low diversity in industries and manufactures
Economia informal	Informal economy
Urbanização rápida e irregular	Rapid and irregular urbanization
Incêndios Florestais Recorrentes	Recurring Forest Fires
Altas taxas de crimes	High crime rates
Falta de políticas urbanas integradas e coesão institucional	Lack of integrated urban policies and institutional cohesion
Focos de incêndios urbanos	Urban fires

The last part of the workshop was dedicated to filling up a questionnaire regarding each stress identified. The aim of having this questionnaire was to allow participants to provide in-depth information on the stresses they deemed serious in Teresina. The findings of this questionnaire were used as a basis for extensive desk research by the CRGP team aimed at enriching the discussion and debate in the subsequent workshop (workshop 7). Figure 5 illustrates snaps of the online questionnaire attendees filled up. For each stress listed, each of the civil servants had to answer the following questions:

- Enter the name of the stress
- In your opinion, what are the causes or drivers of this stress?
- Has this stress led to any shocks in the past? if so, specify the type of shocks caused.
- Does this stress have the potential to cause shocks in the future? If so, specify which shocks.
- If possible, specify the approximate number of people affected daily / monthly / annually.
- Which areas / neighborhoods are most affected by this stress?
- If possible, specify what the estimated economic losses caused by stress daily / monthly / annually are?
- Has the municipality (or any other levels of government) taken any actions to deal with this stress so far? If so, briefly describe these actions.
- What are the challenges the municipality faces that limit effective actions in relation to this stress?

The figure displays three sequential screenshots of an online questionnaire titled "Estresse 1".

- First Screenshot:** A purple header bar contains the text "Estresse 1". Below it, a white box contains the question "Informe o nome do estresse *" (Report the name of the stress *) and a text input field with the placeholder "Your answer".
- Second Screenshot:** A white box contains the question "Na sua opinião, quais são as causas ou os fatores determinantes desse estresse?" (In your opinion, what are the causes or determining factors of this stress?) and a text input field with the placeholder "Your answer".
- Third Screenshot:** A white box contains the question "Esse estresse levou à ocorrência de algum choque no passado? se sim, especifique o tipo de choque provocado. *" (Did this stress lead to the occurrence of any shock in the past? if yes, specify the type of shock provoked. *) and a text input field with the placeholder "Your answer".

Figure 8: Snapshots of the online Stresses questionnaire.

		<h2>Workshop 7</h2>
Date:	11/8/2020	
Participation mode:	online	

Prior to this workshop, the CRGP team carried out a process of bringing together the findings of workshop 6. To that end, the 34 stresses identified were reviewed. Duplications and overlaps were eliminated. The list was split into those considered stresses according to CRGP, and to those considered their respective stressors or drivers. Combining the outcomes of the discussion, the surveys and the desk research, the list of stresses was reduced to 9 stresses. The links between each stress and its drivers/stressors were mapped.

The initial nine stresses identified are:

- Biodiversity loss
- Poverty and inequality
- Mismanagement of urban metabolism
- Inadequate management of urban mobility system
- Inadequate municipal public services
- Safety and crime
- Rapid unregulated urbanization
- Unemployment and Inadequate economic diversification
- Inadequate coverage of sanitation networks

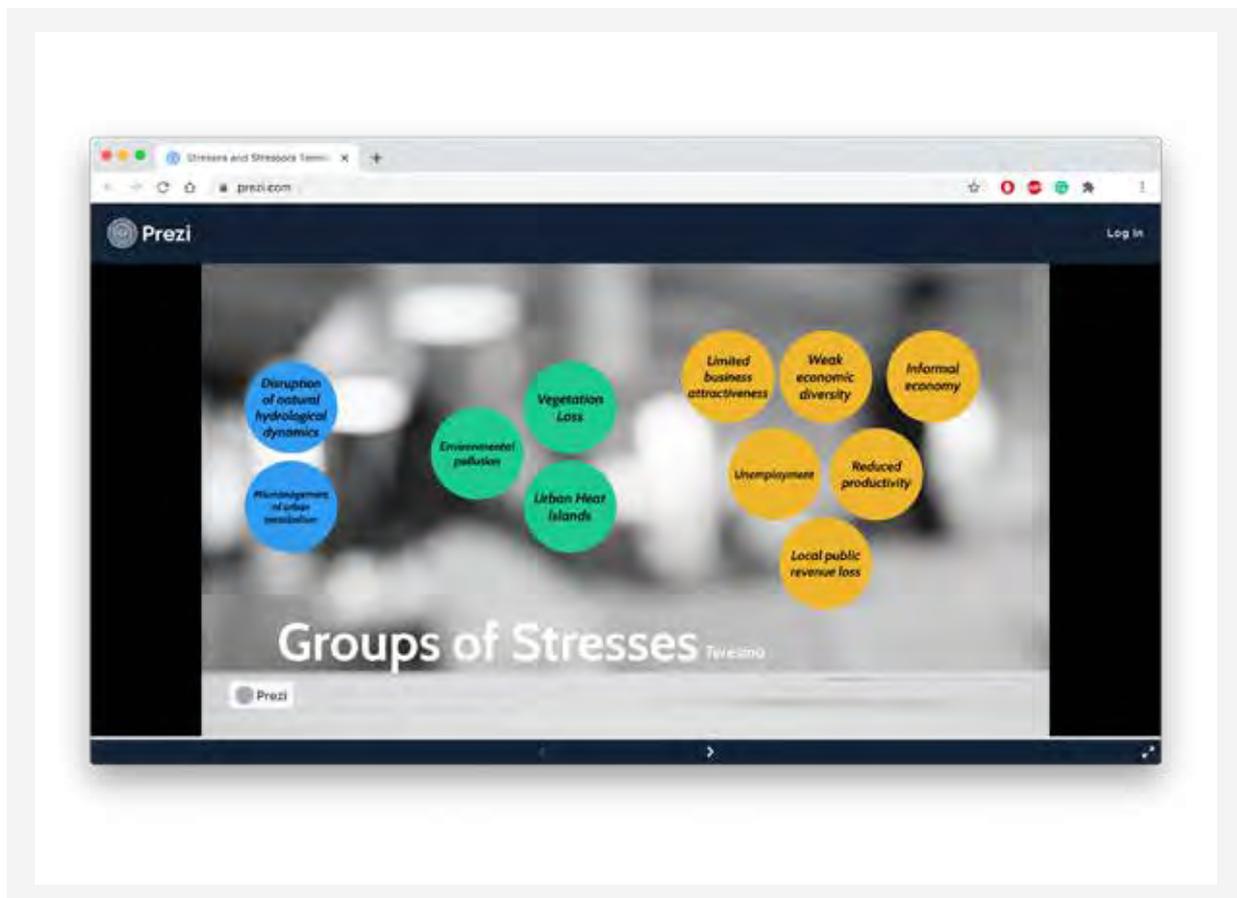


Figure 9: Stresses and stressors in Teresina (snapshots).

To access the mapping, use the following link: www.prezi.com/view/cl0a1515jX0sLheGbNNI

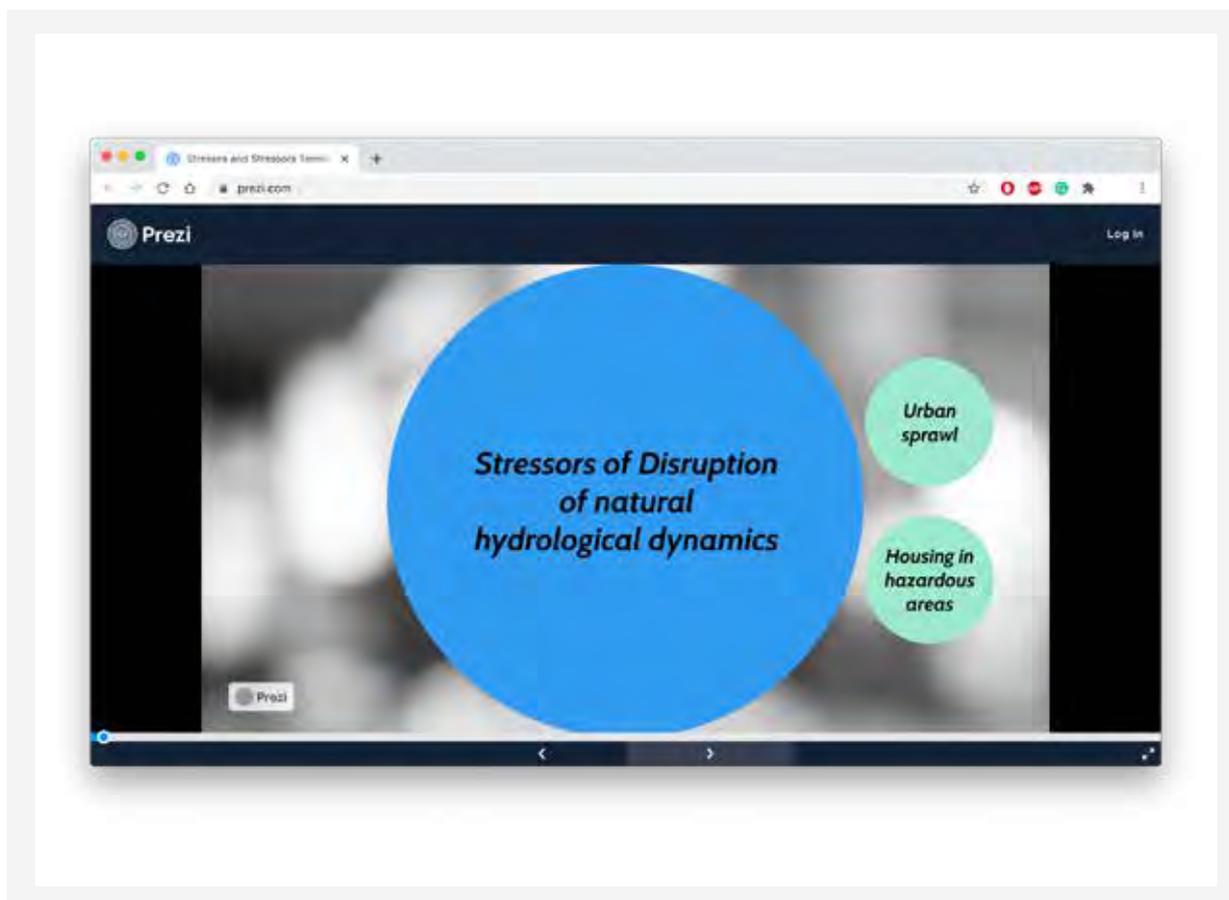


Figure 10: Stresses and stressors in Teresina (snapshots).

To access the mapping, use the following link: www.prezi.com/view/cl0a1515jXOsLheGbNNI

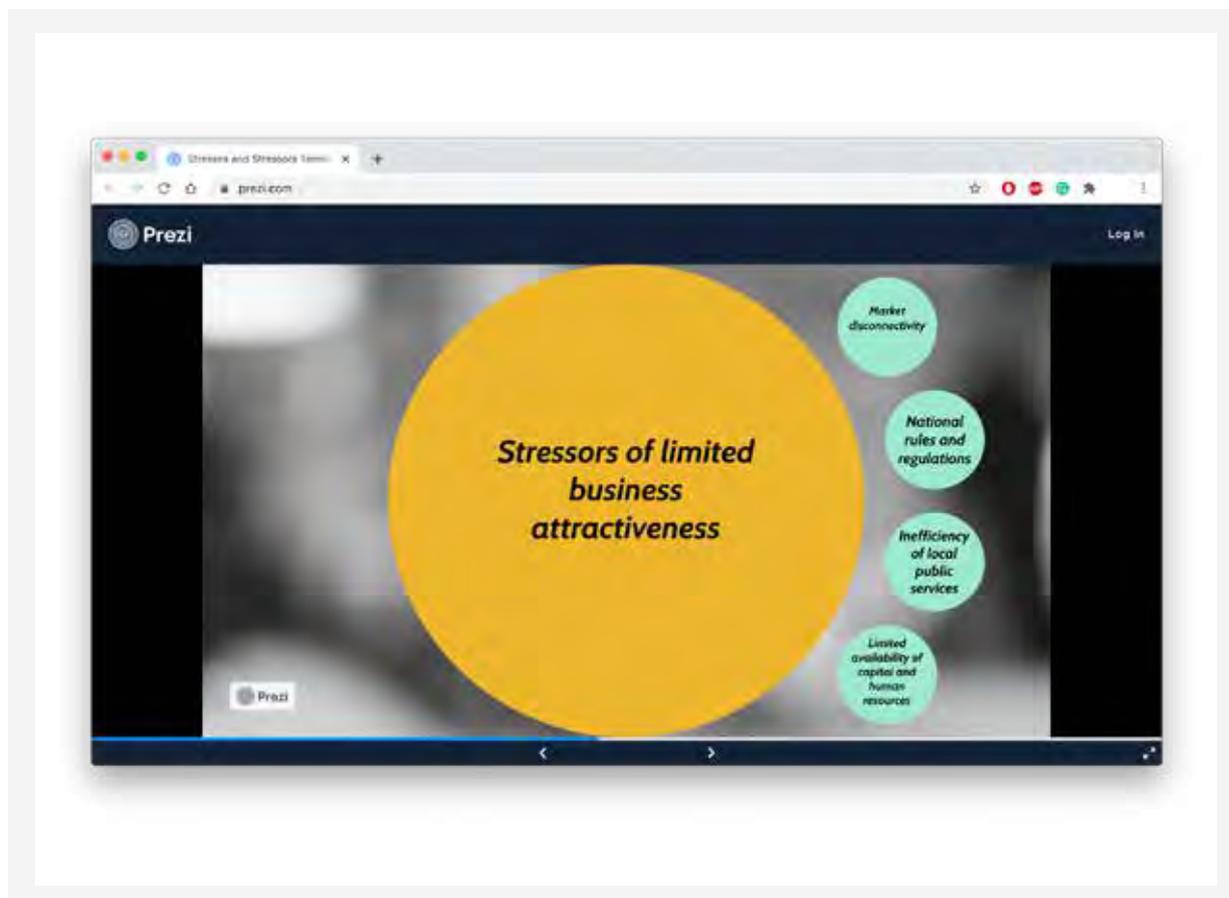


Figure 11: Stresses and stressors in Teresina (snapshots).

To access the mapping, use the following link: www.prezi.com/view/cl0a1515jXOsLheGbNNI

These new results were then presented to the Teresina Resilience Committee during workshop 6 for review, comments and debating. While overall the mapping was verified as accurate by most of the workshop's participants, some links were re-drawn and re-characterized. As a result, the list of stresses was reduced to only 8 main stresses (illustrated in table 4). A more extensive discussion on each stress and its underlying drivers took place. These discussions proved quite informative for the analysis and diagnosis in Chapters 02 and 3.

Stress	Stressors
Disruption of natural hydrological dynamics	<ul style="list-style-type: none"> ● Urban sprawl ● Housing in hazardous areas
Mismanagement of urban metabolism	<ul style="list-style-type: none"> ● Solid waste management ● Wastewater management ● Inefficient stormwater solutions
Environmental pollution	<ul style="list-style-type: none"> ● Water contamination ● Soil degradation
Vegetation Loss	<ul style="list-style-type: none"> ● Deforestation ● Urban vegetation loss ● Inadequate green infrastructures and nature-based solutions
Urban Heat Islands	<ul style="list-style-type: none"> ● Inadequate green cover ● Impermeable surfaces ● Thermal mass
Limited business attractiveness	<ul style="list-style-type: none"> ● Market disconnectivity ● National rules and regulations ● Inefficiency of local public services ● Limited availability of capital and human resources
Weak economic diversity	<ul style="list-style-type: none"> ● Market disconnectivity ● Limited availability of capital and human resources
Informal economy	<ul style="list-style-type: none"> ● Reduced formal jobs opportunities ● National rules and regulations
Reduced productivity	<ul style="list-style-type: none"> ● Labour market dynamics ● Mismanagement of urban mobility ● Inefficient transport networks and supply chains
Unemployment	<ul style="list-style-type: none"> ● Labour market dynamics
Local public revenue loss	<ul style="list-style-type: none"> ● Labour market dynamics

Priority Matters - Workshop 8

Priority matters are where the majority of risks to the urban system converge and concentrate in the presence of certain challenges or constraints/conditioning factors, but are also where opportunities for maximizing the outcome of targeted actions lie.

The determination of priority areas in Teresina was the result of workshop 8 which built upon the outcomes of the preceding 7 workshops of identifying and characterizing shocks and stresses held by CRGP together with the Teresina Resilience Commission. Taking stock of local knowledge and expertise, and similar to previous workshops, this workshop served to discuss the multiplicity of risks including shocks and stresses in Teresina and their interdependencies, and how these are shaped by present challenges and constraints leading to the emergence of certain issues seen as priority matters crucial to be addressed for building and strengthening urban resilience in Teresina (See Chapter 02 for detailed display of the analysis findings).

As an introduction to the workshops, participants were presented by the outcomes of the H.A.R.D platform data collections on shocks. Also, the results of the 2 workshops on stresses – 8 stresses and their underlying stressors– were displayed. Participants were then asked to start mapping the links between shocks and stresses, using Jamboard (an online tool) drawing on their knowledge and experience in their respective fields of expertise. Specifically, members were asked to differentiate between the causes/drivers and effects of each risk when drawing those links. In addition, while making these links participants were required to justify these connections. This allowed for a very informative debate to take place through which the network and comprising links connecting the different types of risks were optimized.

The result of this mapping unveiled the existence of 4 main clusters in which multiple shocks and stresses are concentrated and their effects are intersecting. These four clusters which are now called priority matters were:

- Water cycle mismanagement
- Ecosystem imbalance
- Economic underperformance
- Poverty and inequality

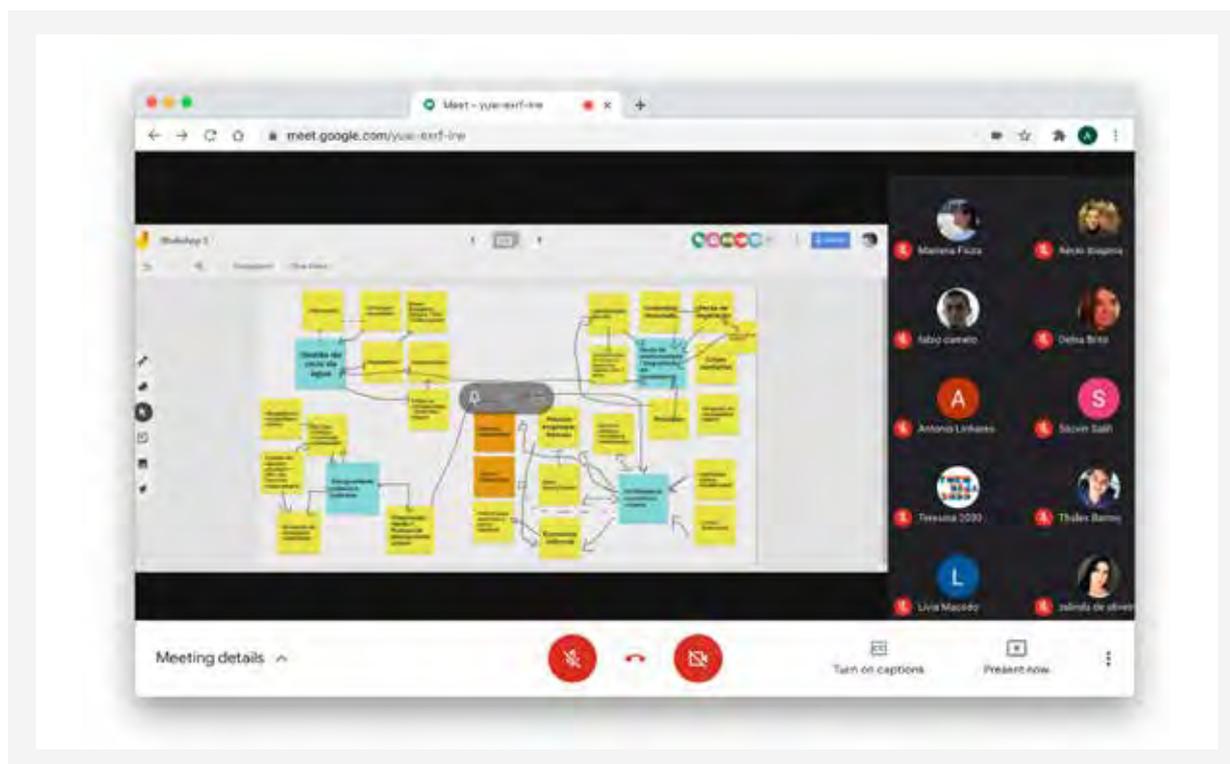


Figure 12: Snapshots of workshop 8 on priority matters.



Figure 13: Snapshots of workshop 8 on priority matters.

However, given the transversal effects of poverty and inequality which means that it is a major driver and a consequence of each of the three other clusters, participants agreed on keeping poverty and inequality as a cross-cutting challenge that shapes how different risks are interrelated under each priority matter. Additionally, this was viewed as a way of promoting actions in later stages of the process which will contribute towards addressing poverty and inequality as part of each priority matter.

In summary, the outcome of this debate was the prioritization of three main priority matters:

- Water cycle mismanagement
- Ecosystem imbalance
- Economic underperformance

The mapping was then redrafted by the CRGP team to clarify the difference between the various links. These maps can be viewed under Chapter 2 – The Current State of Urban Resilience, specifically figures 41, 44 and 46.

Annex II

List of Acronyms and Abbreviations

A4R	Actions for Resilience (Ações para a Resiliência)
Aneel	Agência Nacional de Energia Elétrica
BACEN	Banco Central do Brasil
BNH	Brazil's National Housing Bank
CAU PI	Conselho de Arquitetura e Urbanismo do Piauí
CEPRO PI	Superintendência de Estudos Econômicos e Sociais - Piauí
CONFEN	Conselho Federal de Enfermagem
CRECI PI	Conselho Regional de Corretores de Imóveis
CRGP	City Resilience Global Programme (Programa Global de Cidades Resilientes)
CRPT	City Resilience Profiling Tool (Ferramenta de Perfis de Cidades Resilientes)
DNPM	Departamento Nacional de Produção Mineral
FCMC	Fundação Cultural Monsenhor Chaves
FMS	Fundação Municipal de Saúde de Teresina
IBGE	Instituto Brasileiro de Geografia e Estatística
INEP	Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira
IPHAN	Instituto do Patrimônio Histórico e Artístico Nacional
IUCN	International Union for Conservation of Nature
PDTMU	Plano Diretor de Transportes e Mobilidade Urbana de Teresina
PIEMTUR	Empresa de Turismo do Piauí S/A, extinct in 2010
PMT	Prefeitura Municipal de Teresina
PNAD	Pesquisa Nacional por Amostra de Domicílios
RAIS	Relação anual de informações sociais
RAR-S	Recommendations Actions for Resilience and Sustainability (Recomendações de Ações para Resiliência e Sustentabilidade)
RIDE	Região Integrada de Desenvolvimento (Integrated Development Region)
SAMU	Serviço de Atendimento Móvel de Urgência
SDR	Superintendência Desenvolvimento Rural
SDU	Superintendência Desenvolvimento Urbano
SECRETM	Secretaria Executiva de Captação de Recursos e Monitoramento
SEFAZ	Secretaria do Estado da Fazenda

SEMAM	Secretaria do Meio Ambiente de Teresina
SEMCASPI	Secretaria Municipal de Cidadania, Assistência Social e Políticas Integradas
SEMCOP	Secretaria Municipal de Concessão e Parcerias
SEMDUH	Secretaria Municipal de Desenvolvimento Urbano e Habitação
SEMEC	Secretaria Municipal de Educação
SEMF	Secretaria Municipal de Finanças de Teresina
SEMPPLAN	Secretaria Municipal de Planejamento e Coordenação
SEMTCAS	Secretaria Municipal do Trabalho, Cidadania e Assistência Social
SIS/IBGE	Síntese de Indicadores Sociais
SMPM	Secretaria Municipal de Políticas Públicas
SNIS	Sistema Nacional de Informações sobre Saneamento
SSP-PI	Secretaria de Segurança Pública do Estado do Piauí
STRANS	Superintendência Municipal de Transportes e Trânsito
UN-Habitat	The United Nations Human Settlements Programme

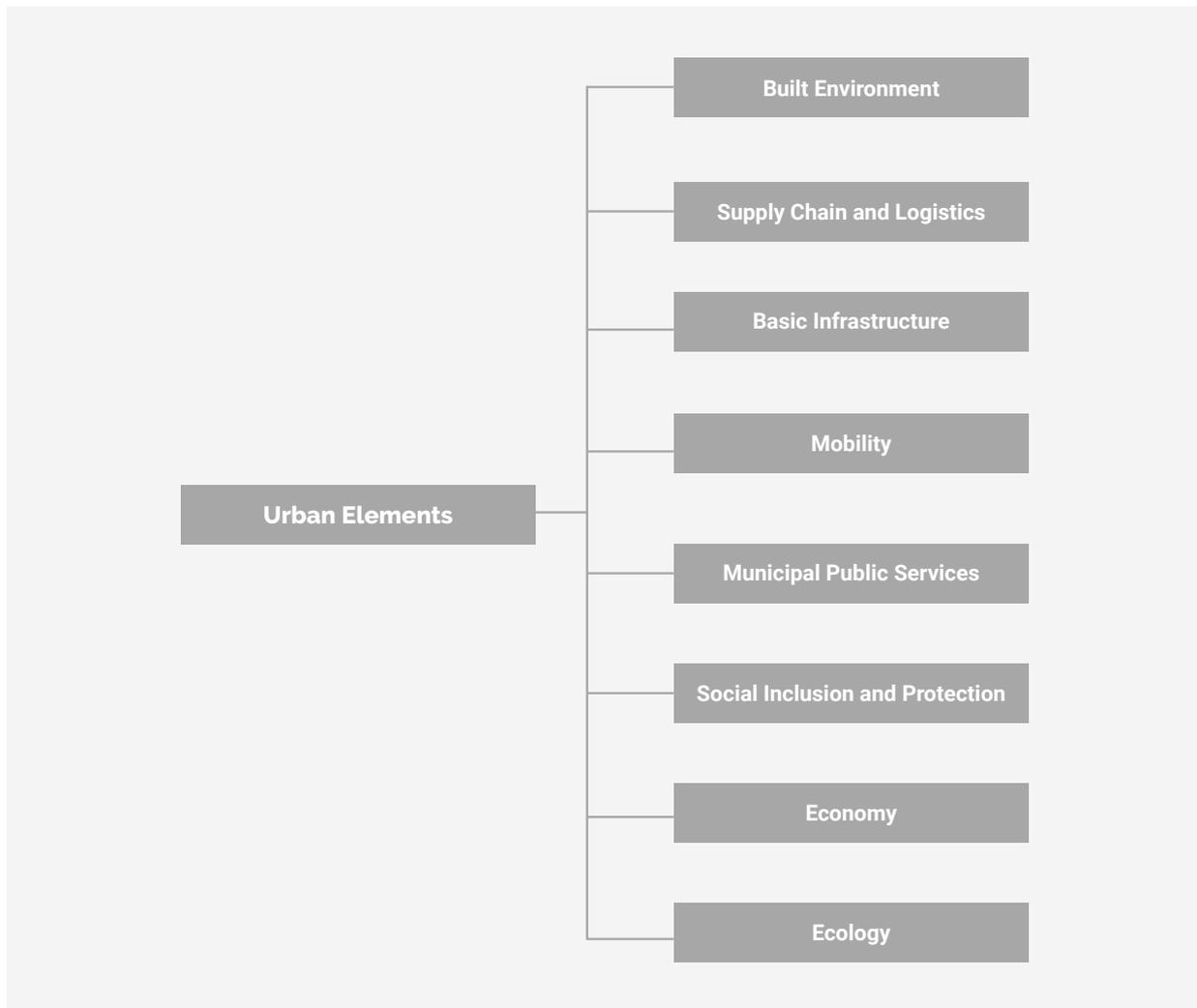
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Annex II

CRPT Indicators

This section provides an overview of the data collected, analysed, and distilled into key findings for each of the eight Urban Elements that comprise the urban system's performance. In addition, key information that is not directly collected through indicators and related questions but provides critical information for better understanding certain complex urban dynamics, is presented herein primarily as a means to further contextualize data findings for the city.



Element overviews are intended to provide a high-level snapshot, not comprehensive analyses. Consequently, all identified vulnerabilities, capacities, and data-related complications are not presented in these overviews. Key findings should therefore be understood as data-borne highlights that have been extracted because they are indicative of common trends identified in more exhaustive data analyses.

Each element overview is comprised of 3 sections:

Data Collection: Summation of data collection completion results, overview of data completion by component, and key findings suggested by data completion. Completion is calculated using three categories: complete, incomplete, alternative, pending, and not available. Complete refers to data sufficient for calculating a benchmark; alternative refers to data insufficient for calculating a benchmark but nonetheless beneficial for the analysis; incomplete refers to composite indicators that only partial data was available and hence insufficient to generate the full indicator; pending

are data that are feasible/available but still under processing or collect; and not available refers to data that was not collected or not available for the city.

Key findings: Executive summary of key takeaways related to all available data. Findings may relate to data collection, performance, contextual factors, or some combination.

Selected Indicators: this section presents the set of indicators selected for analysis and benchmarking, with a summary of collected results, sources and additional information that are relevant to the diagnosis.

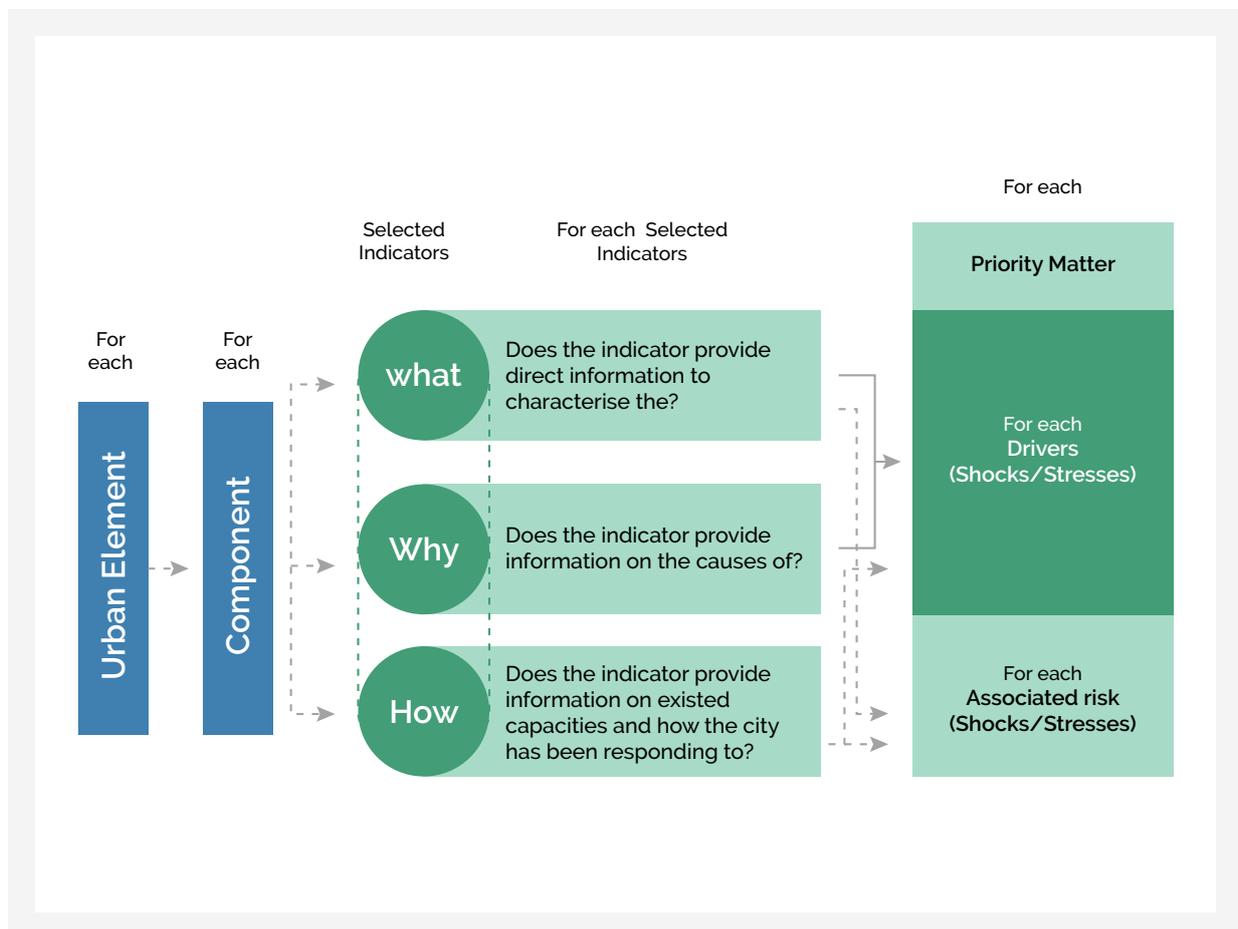
Indicators Selection Methodology and Process

The indicator selection process derives from the mapping of stresses, shocks and risks for each priority matters. From this definition, a process flow is followed to filter, from the set of total indicators of the CRPT tool, those that inform the diagnosis and or the monitoring of issues relevant to the city.

In this workflow, as shown in the graph below, each urban element is analysed, and one by one all its components, if its indicators answer key questions in relation to the priority matters. First, it is analyzed whether the indicator offers contextual information that directly characterizes any of the drivers (shocks or stresses) or associated risk in each of the priority issues. Those indicators refer to our WHAT question.

Secondly, if the indicator provides insights on the causes of the drivers (shocks or stresses) of each priority issue. These indicators offer information on our WHY questions, as well as qualifying the relationships within the each priority matter problem tree.

Finally, it is analysed if the indicator gives information on existing capacities and how the city is responding to associated risks (shocks and stresses) for each priority matter. Here, the indicators will help to clarify HOW the city's resilience capabilities are in a specific subject of analysis. The flow chart below summarizes the indicator selection methodology.



In total, considering all priority issues, 88 indicators were selected, conformed by 229 supporting indicators and other several related questions. The total number of indicators per urban element is shown in the table below. This distribution doesn't characterise the weight of the urban elements for data collection since indicators may vary in complexity and information, hence selecting fewer indicators in an element cannot be implied as fewer information.

Urban Element	Total Indicators Selected	Total Supporting Indicators Selected
Built Environment	8	18
Supply Chain & Logistics	11	22
Basic Infrastructure	25	42
Mobility	7	25
Municipal Public Services	12	43
Social Inclusion & Protection	6	11
Economy	9	33
Ecology	10	35
Total	88	229

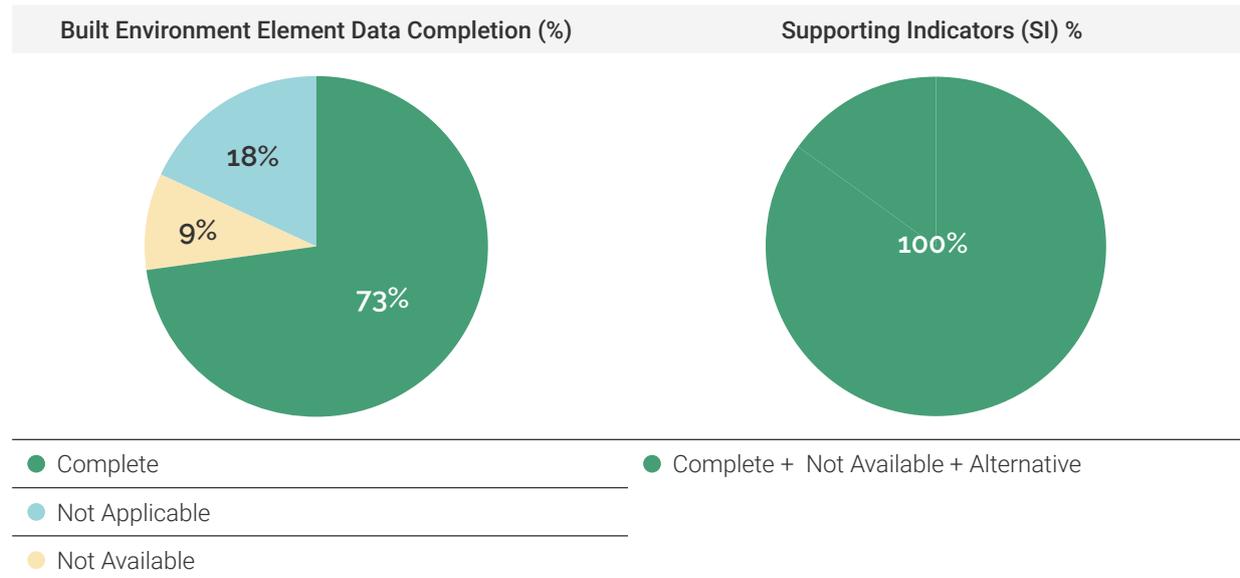
In the scheme below, the relations between the priority matter plus inequality and poverty transversal issues and the several components that constitute the urban elements are drawn, according to how many indicators on these components were selected for analysis. Note that indicators and components may provide information on several issues at once.

1. Built Environment

The Built Environment Element analyses information that spans the urban footprint and its growth and composition, then proceeds to delve deeper into the aspects of land tenure, housing and built assets.

Data Collection

The total completion rate for data collection is 73%, also 9% of the data considered not available and 18% not applicable. Considering only the selected indicators, the completion rate was 100% for this element (including completed and alternative data).



Key Findings

The urban area has a low population density, however land consumption rate has been more stable in the last 10 years.

Percentage of streets within the urban footprint and street intersection density is considerably lower than CRPT benchmarks.

There is a considerable percentage of urban space in hazardous areas. High percentage of homes with inadequate structure, more than 44,000 are uncoated masonry and uncoated cob walls.

Relatively few areas of the city are considered informal as a percentage of the urban area, but figures are high if considering the percentage of households. Poor disaggregated data on the population of areas considered informal.

The city has a broad legal framework to regulate urban space and guarantee citizens' rights.

Selected Indicators

1.1 Urban Form					
1.1.1 Urban Growth Model					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.1.1.1	(Net) Urban population density	3.091 hab/km ²	621,72 people/km ² (Total Area)	Teresina - Panorama Municipal - agosto 2020	2020
1.1.1.2	Land consumption to population growth rate	1,05		PMT; IBGE	2010; 2020
1.1.2 Open Areas Provision					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.1.2.1	Percentage of open areas within the urban footprint	92%		PMT	2020
1.1.2.2	Public open space per 100 000 population	57 ha/pop		PMT	2020
1.1.3 Street Network Connectivity					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.1.3.1	Percentage of streets within the urban footprint	20,64%		PMT	2020
1.1.3.2	Street density	17,98 km/km ²		PMT	2020
1.1.3.3	Street intersection density	87,82 intersections/km ²		PMT	2020
1.2 Built Assets					
1.2.1 Risk Exposure of Built Up Areas					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.2.1.1	Percentage of urban footprint located in hazardous areas	7,745%		Municipality and HARD with CRGP developed Shapefile	2019
1.2.1.1.1	Percentage of built assets located in hazardous areas	3,81%	Trânsito (Critical Infrastructure)	Municipality and HARD with CRGP developed Shapefile	2019
1.2.1.1.2	Trend of urban growth towards hazardous areas in the past 10 years	Sharp increase		HARD Platform	2020
1.2.1.1.3	Are hazardous areas physically marked?	Yes		HARD Platform	2020
1.2.1.2	Trend of urban growth towards hazardous areas in the past 10 years	Sharp Increase		HARD Platform	2020
1.2.1.2.1	Level of dependency of the city on hazard protection systems	High Dependency		Defesa Civil - SEMCASPI	2020
1.2.1.2.2	Level of reliability of hazard protection systems	Moderate reliability		Defesa Civil - SEMCASPI	2020
1.2.2 Durability of Built Assets					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.2.2.1	Percentage of homes with inadequate structure	Greater than 20%		Sidra IBGE	2019
1.2.2.2	Percentage of critical infrastructures with inadequate structure	Less than 10%		PNAD IBGE	2019

1.3 Land and Housing Tenure					
1.3.1 Status of Land and Housing					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.3.1.1	Percentage of city area considered informal	2%		SEMUDH/PMT	2020
1.3.1.2	Quantitative housing shortage	29%	Join data from 3 articles. Due the impossibility of finding the total amount of houses built in Teresina.	ADH-PI; LOPES, W. ; ANDRADE	
1.3.2 Access to Secure Tenure					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.3.2.1	Percentage of households with secure tenure				
1.3.2.2	Percentage of population considered landless, homeless and/or displaced	0,03%	The previous report quantified 270 homeless, landless or displaced people. Most recent data needed to be checked. In 2020, a regional law was established to focus on homeless people.	Plano de Reordenamento do Serviço de Acolhimento para Pessoas em Situação de Rua. SEMTCAS/PMT.	2013
1.3.3 Land and Property Administration					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
1.3.3.1	Percentage of city area with complete land administration data				
1.2.3.1.1	Is there baseline data that proves who owns what piece of vacant land in the city?	Yes		SEMUDH/PMT	2020
1.2.3.1.2	Is the data protected, backed-up and processable in an emergency situation?				
1.3.3.2	Does the authority in charge of land in the city recognise continuum of land rights and practice pro-poor land administration?	Both recognizes and practices		PLHIS- LOCAL HOUSING AND SOCIAL INTEREST PLAN - 2018-2021	2012
1.3.3.3	Are there awareness-raising campaigns and projects regarding the use and ownership of land and property conducted in the city?	Yes, general public		PDOT - Master Plan for Territorial Planning	SEMPLAN/PMT 2020

TERESINA | URBAN FORM

Indicator 1.1 - Urban Growth Model; Open Areas Provision; Street Network Connectivity

-  Urban Perimeter
-  Urban Perimeter in 2010
-  Streets Intersection within the Urban Limit
-  Municipal Public Spaces and Institutional Green Areas
-  Parks
-  Tree Cover
- Road Network
 -  trunk
 -  primary
 -  secondary
 -  tertiary
-  Water streams

Source: CRGP with SEMPLAN, 2020

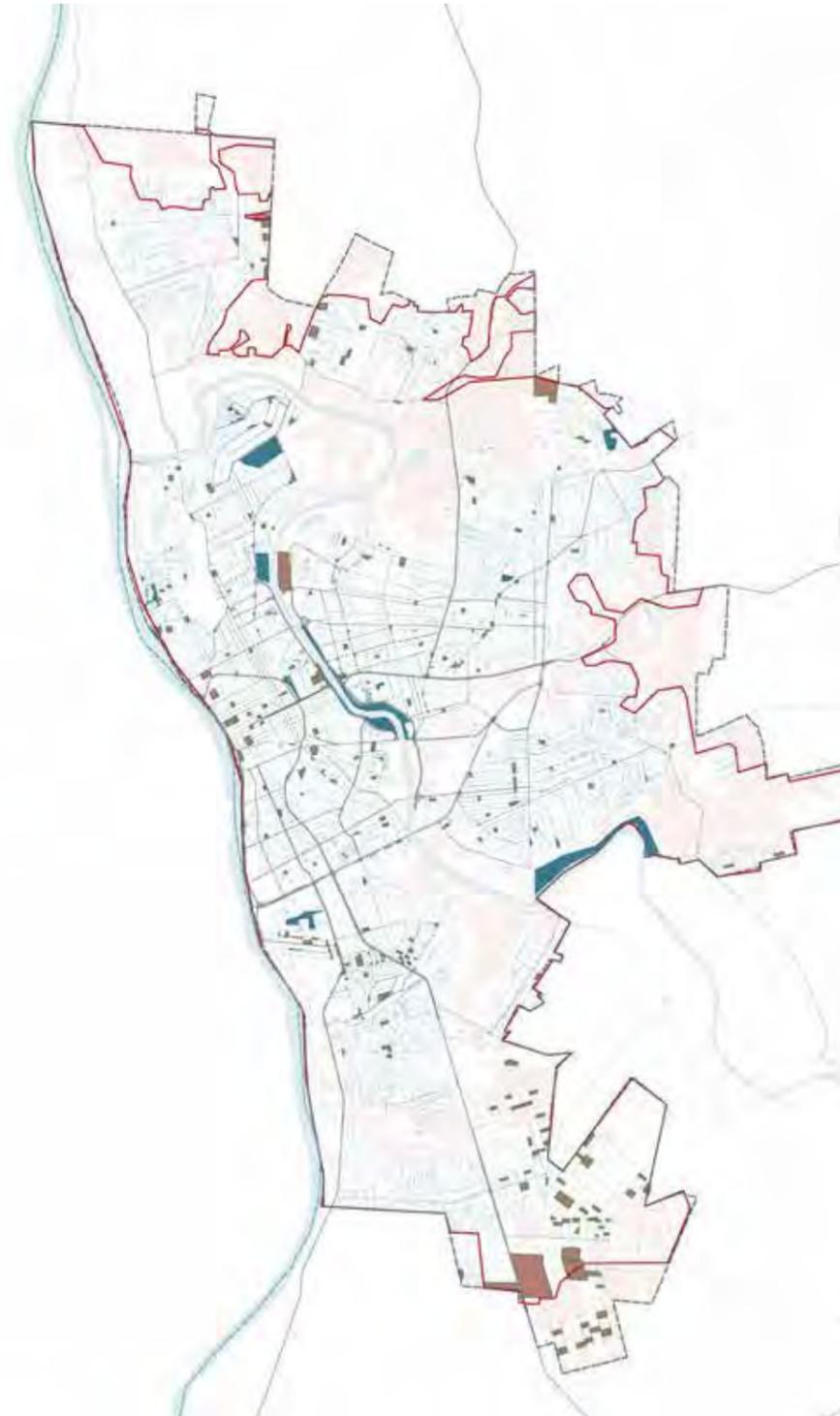
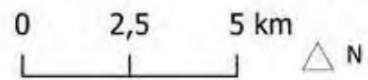


Figure 1: Indicator 1.1. Source: CRGP with SEMPLAN (2020).

TERESINA | BUILDINGS, SHOCKS and INFORMAL SETTLEMENTS

Indicator 1.2 and 1.3

-  Urban Perimeter
-  Informal Settlements
-  Buildings of Informal Settlements in Harzardous areas
-  Buildings in Hazardous Areas
-  Hazardous Areas
-  Teresina's Perimeter
-  Water Streams
-  City Buildings
-  Timon

Source: CRGP with SEMPLAN, 2020

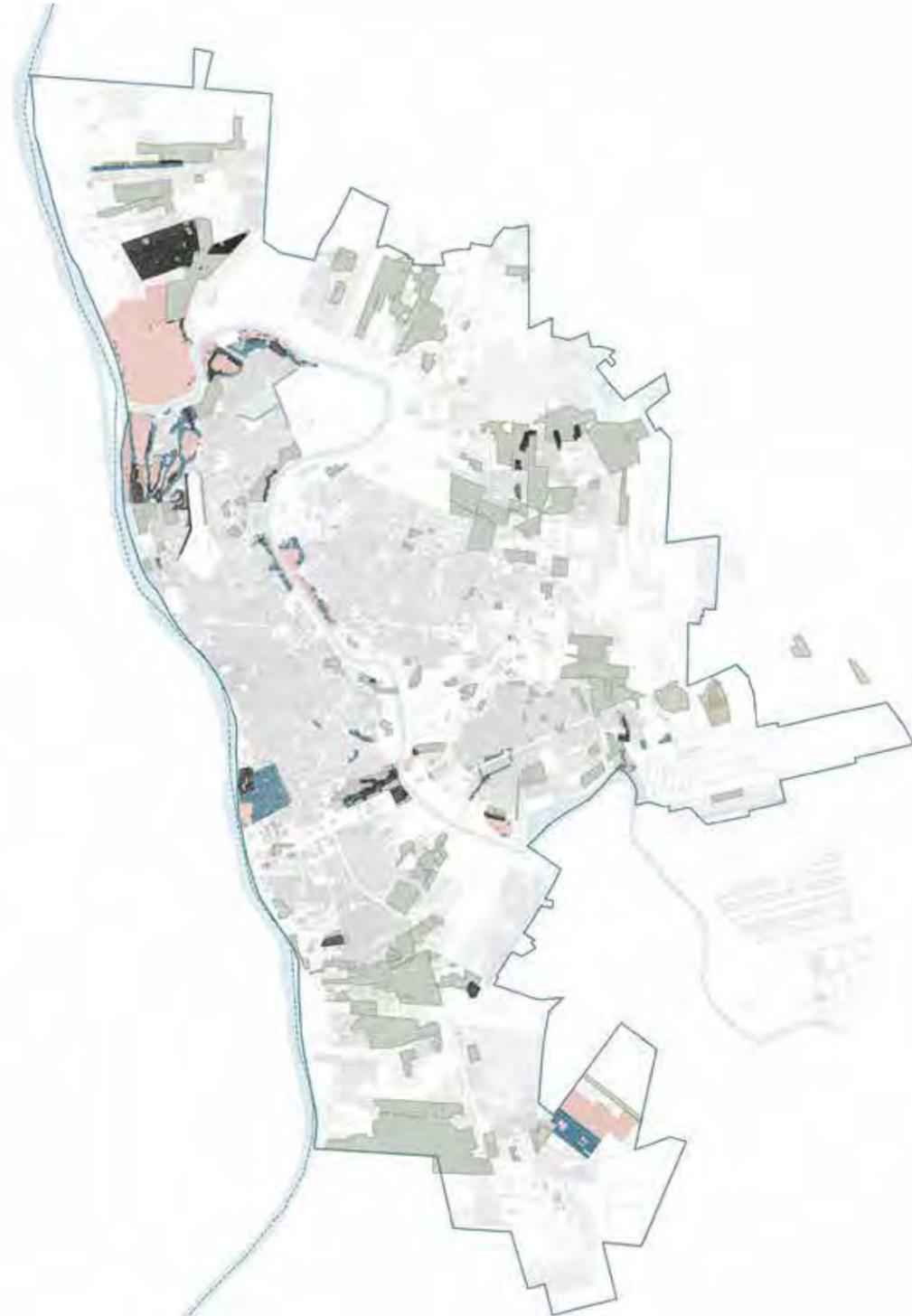
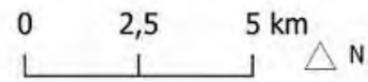


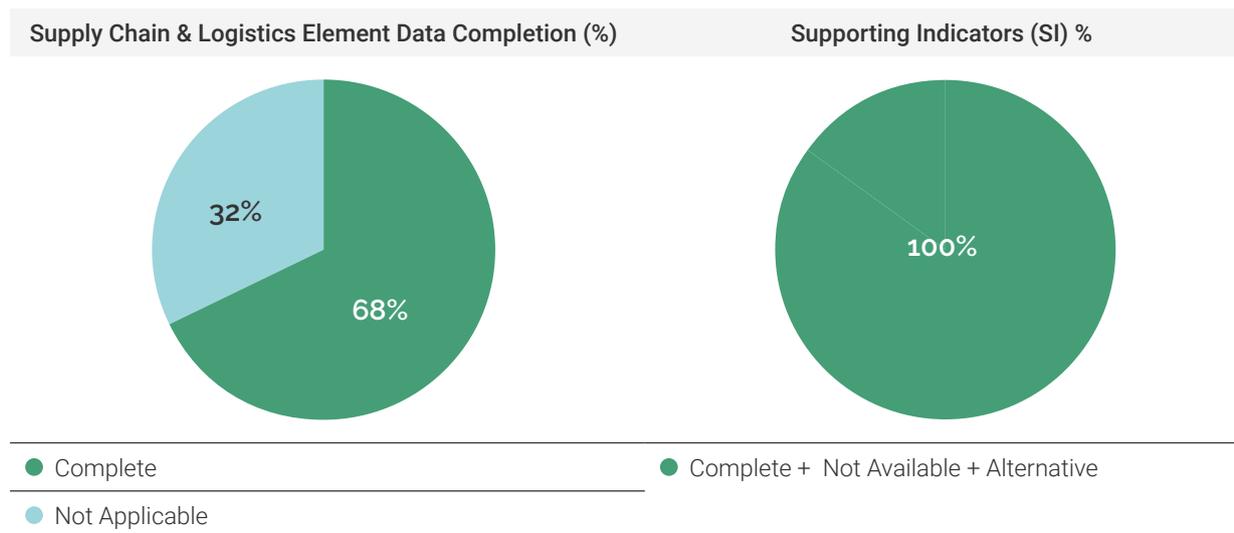
Figure 2: Indicator 1.2 and 1.3. Source: CRGP with SEMPLAN (2020).

2. Supply Chain & Logistics

The Supply Chain & Logistics Element is composed of four components: Water Resources, Energy Sources, Food Supply and Urban Logistics. It assesses the access, distribution and management of non-human resources such as supply of food and water, energy and logistics, especially the reliability of access during emergencies.

Data Collection

The total completion rate for data collection is 68% and 32% not applicable. Considering only the selected indicators, the completion rate was 100% for this element (including completed and alternative data).



Key Findings

There is a higher dependence on one water source kind, inland surface waters, but there are 3 different withdrawal points for 2 different water sources, this increases resilience to possible shocks due to droughts or water contamination. However, the city must consider put in place strategies for alternative sources in case of shocks.

Domestic usage is the main sector for water consumption in the city. Low proportion of water consumed by the industrial and commercial sectors. No data was available on water consumption by the agricultural sector.

There is a high consumption of non-renewable energy by the transport sector, mainly dependent on liquid fuels. The electricity supply is 100% from renewable sources (hydroelectric power). High dependence on a single energy source for electricity supply, that also has high supply instability.

Local food production value is low, and most of the food consumed comes from outside the city. No local measures were reported to prevent food waste.

Urban logistics has a high dependence on land transport (Trucks/LCV/HCV), representing 77,88% of goods, followed by cargo airplanes, both in stable increase. Land and air transport are overloaded due to high demand. According to the State Treasury Office, the primary entry points are Ponte Engenheiro Antônio Noronha, Rodovia BR-343/226/222, and Rodovia BR-316

No existence of integrated coordination body/ system for managing urban logistics operation.

Selected Indicators

2.1 Water Resources						
2.1.1 Water Resource Diversity						
Indicator Description	Main Value	%	Sec. Values (if any) Number of sources	Source	Date	
2.1.1.1 Proportion of water supplied from each source	Inland surface water	93,9	3	CRGP/PMT	2018	
	Sub basin Parnaiba		19,5			
	Sub basin Poti Direita		59,95			
	Sub basin Poti Esquerda		14,44			
	Reservoir/Dams		-			
	Shallow aquifers/ Groundwater	6,1		2		
	Deep aquifers/ Groundwater		-			
	Others, please specify		-			
2.1.1.1.1 Seasonal variability	Medium variability			ARSETE	2020	
2.1.1.1.2 Inter-annual variability	Low variability			ARSETE	2020	
2.1.1.3 Does the city have strategies in place for alternative resources in times of unavailability of primary water sources?	No			ARSETE	2020	
2.1.1.3.1 Frequency the city needs extra support from alternative sources.	Never			ARSETE	2020	
2.1.2 Water Balance						
Indicator Description	Main Value		Sec. Values (if any)	Source	Date	
2.1.2.1 Water consumption per capita (liters/day)	163 liters/day		170 liters/day (avg. jan – aug 2020)	ARSETE	2020	
2.1.2.1.1 Proportion of water consumed by sector	Domestic/Municipal	88 %		ARSETE	2020	
	Agricultural		-	ARSETE	2020	
	Industrial		1 %	ARSETE	2020	
	Commercial		7 %	ARSETE	2020	
	Public Sector		4 %	ARSETE	2020	
2.1.2.1.2 Trends in water consumption in the past 10 years	Stable Increase			ARSETE	2020	
2.1.2.1.3 Please describe the periods of occurrence and reasons for any spikes in consumption	Consumption peaks occur from September to December (B-R-O-BRÓ) due to high temperatures. (around 11.6%)			ARSETE	2020	

2.1.3 Water Resource Management						
Indicator Description	Main Value		Sec. Values (if any)	Source	Date	
2.1.3.1 Existence of Integrated Water Resource Management (IWRM) toolbox components in place (please specify degree of implementation, if possible)	Enabling environment	x	20/200	SEMAM/PMT	2019	
	Institutions and participation	x	220/600	SEMAM/PMT	2019	
	Management Instruments	x	280/800	SEMAM/PMT	2019	
	Financing	x	40/200	SEMAM/PMT	2019	
2.1.3.1.1 Are advocacy groups representing women and groups in vulnerable situations involved in the IWRM process?	No			SEMAM/PMT	2019	
2.1.3.2 If the city belongs to a transboundary basin area, is there an operational arrangement for water cooperation among relevant authorities?	No		Maybe with the implementation of the GEF an action will be taken in this direction	SEMPAN/PMT	2020	
2.1.3.3 Does the city have established and operational policies and procedures for participation of local communities in water management?	Yes, exists and operational		ARSETE performs election with representatives of residents' associations to compose to its sanitation advisory council	ARSETE	2020	
2.1.3.4 Is the city implementing water demand management strategies?	Yes, please specify		MUNICIPAL PLAN FOR WATER SUPPLY AND SANITARY SEWAGE IN TERESINA - PMAE / THE - Program and actions to achieve the goals	ARSETE	2019	

2.2 Energy Resources						
2.2.1 Energy Resource Diversity						
Indicator Description	Main Value		Sec. Values (if any)	Source	Date	
2.2.1.1 Proportion of energy consumed from each source, based on shares in total final consumption	Electricity (from electricity grid)	Non-renewable	Renewable	Equatorial	2020	
			0%	100%		
	Off-Grid Renewable Sources	Non-combustible	Combustible	Equatorial	2020	
			100%	0%		

2.2.2 Energy Efficiency and Clean Consumption					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
2.2.2.1 Proportion of Total Final Consumption by sector.	Buildings (inc. services and public spaces)	35%		Global Covenant of Mayors for Climate and Energy	2015
	Transport/Mobility	65%		Global Covenant of Mayors for Climate and Energy	2015
Energy Consumption disaggregation by Energy Typ	Liquid Fuels	65%		Global Covenant of Mayors for Climate and Energy	2015
	Gaseous Fuels	7%		Global Covenant of Mayors for Climate and Energy	2015
	Electricity	27%		Global Covenant of Mayors for Climate and Energy	2015
2.2.2.1.3 Trend in energy intensity in the past 10 years					
Buildings Electricity Consumption disaggregation *	Residential	86,2%	Trend +112%	Equatorial	2020
*Considering only Electricity Supply	Industrial	5,5%	Trend -31%	Equatorial	2020
	Agricultural	4,7%	Trend +122%	Equatorial	2020
	Others, please specify	.	Trend +76%		2020
2.2.2.2 Renewable energy share in the total final energy consumption (%)	27%*	*Considering Electricity Supply as 100% Renewable according to Equatorial.		Equatorial	2020
2.2.2.2.1 Trend in renewable energy share in the past 10 years.	-				
2.2.3 Energy Resource Management					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
2.2.3.1 Existence of energy efficiency regulations or incentives in place	Energy efficient building standards	x		Empresa de Pesquisa Energética	2019
	Efficient public lighting regulation	x		SEMCOP	2019
	Regulations for municipal energy management	x		Aneel	2020
	Promotion of renewable sources for heating/cooling	x	Equatorial promotes since 2018 efficient equipments with lower prices to the city of Teresina	Equatorial	2020
	Promotion of renewable sources for transportation				
	Regulations for efficiency in corporate procurement	x		Ministry of Mines and Energy	2019
	Price signals for permit fees for low-energy/ zero-energy activities				
	Partnerships, networks or alliances for energy efficiency	x		SEMCOP/PMT	2019
Other, please specify.					
2.2.3.1.1 Are advocacy groups representing women and groups in vulnerable situations involved in the energy efficiency process?	No, but the measures particularly consider the interests of groups in vulnerable situations				

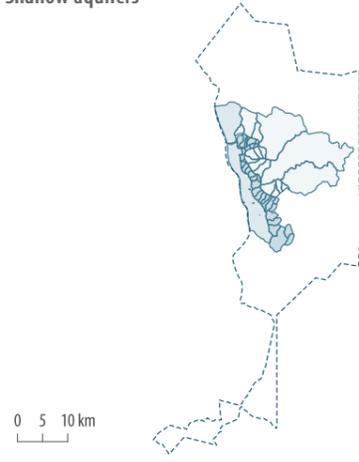
2.2.3.2	Does the local government finance clean/renewable energy transition and energy efficiency initiatives?	Yes			PMT	2020
2.3	Food supply					
2.3.1	Availability Of Food Supply					
	Indicator Description	Main Value		Sec. Values (if any)	Source	Date
2.3.1.2	Average value of food production per capita (disaggregated by basic food commodity groups, if possible)	National Scale	1102,45 R\$/capita	Low variability	IBGE	2018
		Regional Scale	889,35 R\$/capita	Low variability		
2.3.1.2.1	Food production variability. (Sec. Value column)	Functional Scale	22,23 R\$/capita	Low variability		
2.3.1.4	Cereal import dependency ratio	National Scale	-22%		FAO	2017
2.3.1.4.1	Trend in cereal import dependency in the past 10 years	Sharp decrease	2008-2010	-0.3%	FAO	2017
			2009-2011	-2.9%		
			2010-2012	-9.1%		
			2011-2013	-15.3%		
			2012-2014	-18.8%		
			2013-2015	-23.3%		
			2014-2016	-20%		
			2015-2017	-22.2%		
2.3.2	Availability Of Food Supply					
	Indicator Description	Main Value		Sec. Values (if any)	Source	Date
2.3.2.1	Are there existing measures in the local level to prevent food loss and waste?	No			CRGP	2020
2.3.2.2	Farm to market price differential	Farm price	-			
		Market price	348,67		CEPRO PI	2018
2.3.2.2.1	Please specify the food types comprising the typical food basket	Crystal sugar, rice, banana, powdered coffee, meat, manioc flour, beans, pasteurized milk, margarine, vegetable oil, bread, tomatoes			CEPRO PI	2018
2.3.3	Food Supply Chain Continuity					
	Indicator Description	Main Value		Sec. Values (if any)	Source	Date
2.3.3.1	What level of disruptions does the food supply chain face? (per stage, if possible)	No disruptions			Public Knowledge	2020

2.4 Urban Logistics						
2.4.1 Goods Transport Modal Share And Diversity						
Indicator Description	Main Value	Sec. Values (if any)	Source	Date		
2.4.1.1 Proportion of goods (tonnes) hauled by different transport modes.		To/From the city's functional area	SEFAZ/PI	2020		
		Percentage %	Trend			
		"Trucks/LCV/ HCV"	77,88 (1.548,501 t)	Stable Increase		
		Freight train	N.A.			
		Non-motorised modes	irrelevant			
		Light vessels	irrelevant			
2.4.1.1.1 Trends in dependence on each mode used within the functional area in the past 10 years. (Check Sec. Value Column)	Heavy vessels	irrelevant				
2.4.1.1.2 Trend in dependence on each mode used from or to the functional area in the past 10 years.(Check Sec. Value Column)	Cargo airplanes	22,11 (439,782 t)	Stable Increase			
2.4.2 Capacity Of Logistics Infrastructures						
Indicator Description	Main Value	Sec. Values (if any)	Source	Date		
2.4.2.1 Entry point significance in overall movement of goods, per critical entry point	Ponte Engenheiro Antônio Noronha	Primary	SEFAZ - PI	2020		
	Ponte da Amizade	Tertiary				
	Ponte Metálica	Tertiary				
	Aeroporto Senador Petrônio Portela	Secondary				
	Rodovia PI-112	Secondary				
	Rodovia PI-115	Tertiary				
	Rodovia PI-113	Secondary				
	Rodovia BR-343/226/222	Primary				
	Rodovia BR-316	Primary				
	Rodovia PI-130	Secondary				
	Ferrovias Transnordestina	-				
2.4.2.1.1 Is the entry point located in a hazardous area?	On the periphery of the airport is located a hazardous area		PMT and CRGP GIS analysis	2020		
2.4.2.2 Logistics facility capacity and complexity, per key logistics facility	Type	Modes Supported	CAU-PI	2019		
	Multi-modal logistic platform	Trucks	x			
		Freight rail	x			
		Non-motorised land	x			
		Light vessels				
		Heavy vessels				
Cargo planes		x				
2.4.2.2.1 Is the key logistics facility located in a hazardous area?	On the periphery of the airport is located a hazardous area		PMT and CRGP GIS analysis	2020		

2.4.3 Logistics Management And Continuity Of Operations					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
2.4.3.1	Existence of public policies at the local level aimed at encouraging more sustainable practices in urban logistics systems?	Yes	SPECIAL ZONES FOR SPECIFIC URBANIZATION PLAN areas designated to receive Specific Urbanization Plans, such as the current airport area and the areas benefited by the structuring projects, foreseen in the Territorial Planning Master Plan.	SEPLUR/PMT	2019
2.4.3.1.1	Are advocacy groups representing women and groups in vulnerable situations involved in setting logistics-related public policies?	Yes		SEPLUR/PMT	2019
2.4.3.2	What level of disruptions does the urban logistics network face? (per goods transport mode, if possible)	No disruptions		SEFAZ - PI	2019
2.4.3.2.1	If significant, please indicate reason(s)		There are occasional interruptions, usually political, related to strike movements.	SEFAZ - PI	2019
2.4.3.5	Existence of integrated coordination body/ system for managing urban logistics operation?	No		CRGP	2020

TERESINA | WATER RESOURCE DIVERSITY

Shallow aquifers



- Teresina's Perimeter
- Sub Basins**
- Sub basin Poti Esquerda
- Sub basin Parnaiba
- Sub basin Poti Direita

Health Facilities within the urban area of the city

- Teresina's Perimeter
- Shocks Areas
- Urban Perimeter
- Water Streams
- Sub Basins**
- Sub basins Susceptible to Flooding

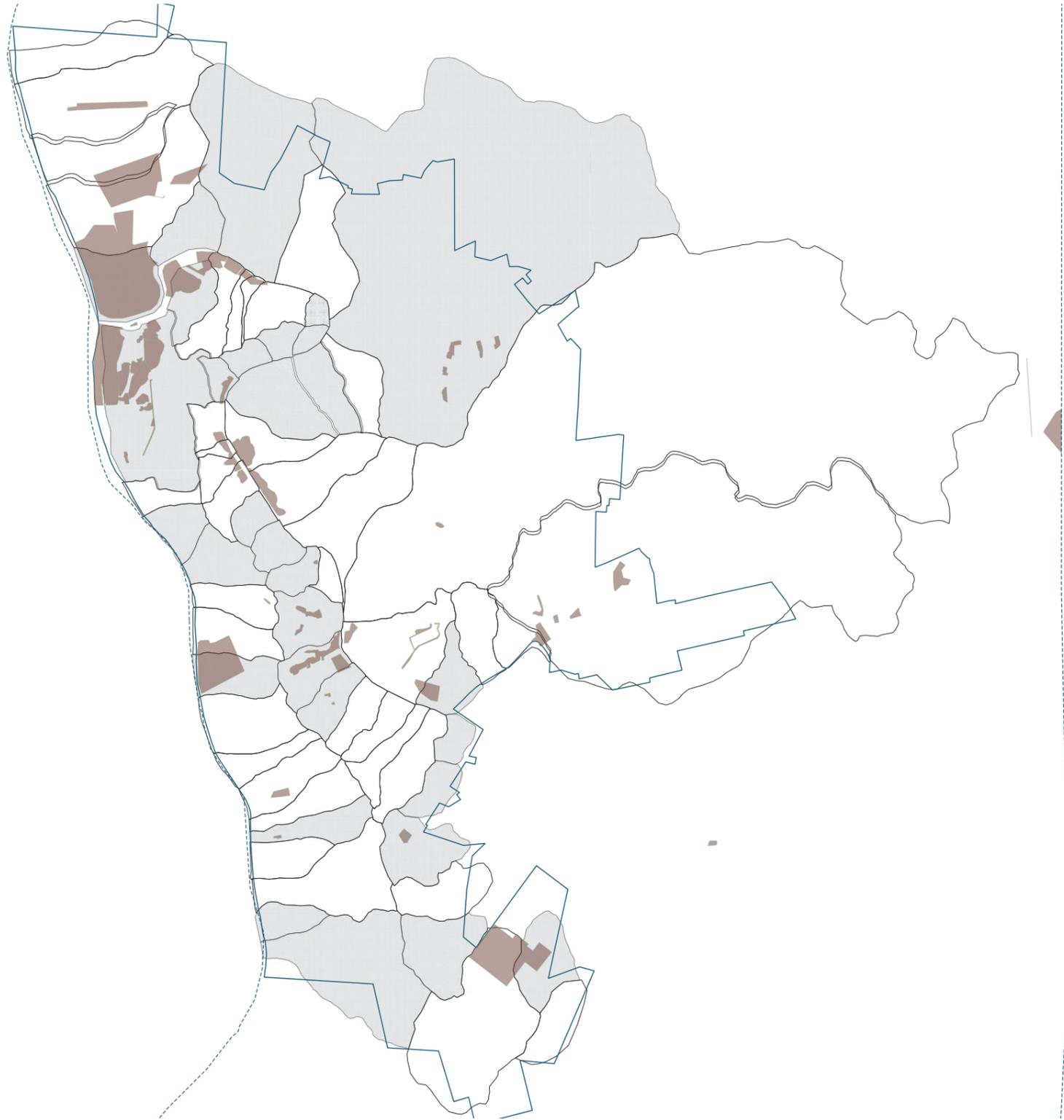


Figure 3: Indicator 2.1. Source: CRGP with SEMPLAN and HARD (2020).

TERESINA | REGIONAL CONNECTIVITY

Largest cities located between 200 and 500 km that have greater than 150,000 inhabitants



- Teresina's Perimeter
 - ▣ Urban Perimeter
- Road Junctions Significance**
- Primary
 - Secondary
 - Tertiary
 - Transnordestina Railway - São Luis, Teresina, Fortaleza
- Main Entry Points**
- ✈ Aeroporto Senador Petrônio Portella (Primary)
 - Ponte Engenheiro Antonio Noronha (Primary)
 - Terminal Rodoviário Governador Lucídio Portella (Secondary)
 - Ponte da Amizade (Tertiary)
 - Ponte Metalica (Tertiary)

Source: Municipality of Teresina, IBGE Brazil, Open Street Maps



Main railways, highways and entry points in the Municipality



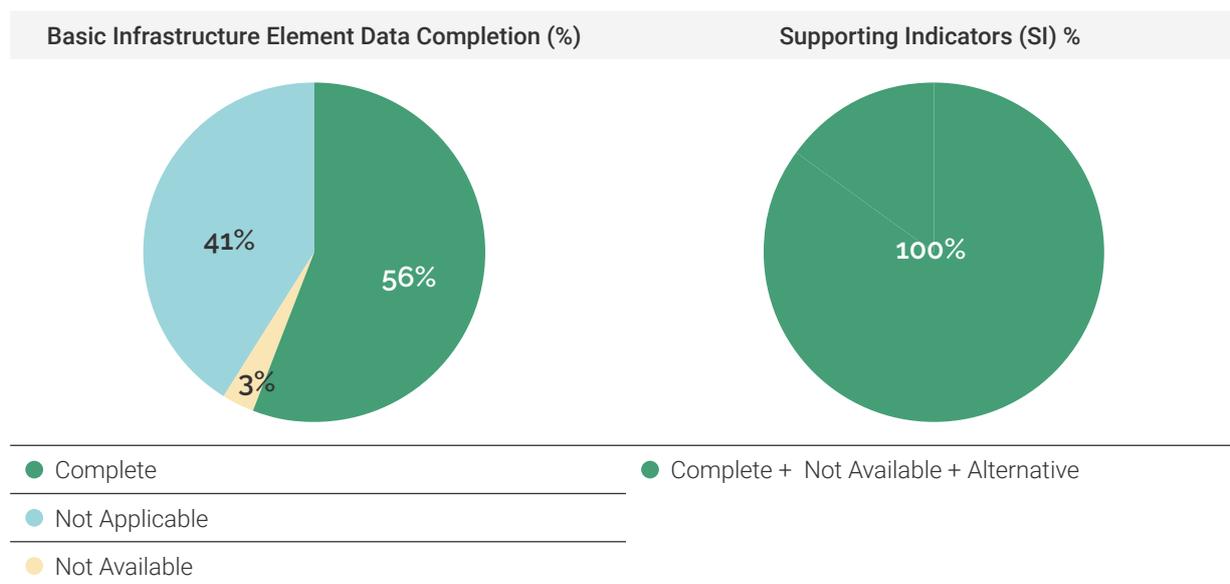
Figure 4: Indicator 2.4. Source: Municipality of Teresina, IBGE Brazil, Open Street Maps (2020).

3. Basic Infrastructure

The Basic Infrastructure Element is composed of six components grouped under three thematic groups. It analyses information related to energy supply in buildings and for mobility, water from its supply to sanitation and networks of wastewater and stormwater, and solid waste management in the city.

Data Collection

The total completion rate for data collection is 56%, also not applicable indicators represented 41%, and not available 3%. Considering only the selected indicators, the completion rate was 100% for this element (including completed and alternative data).



Key Findings

Although reaching 99,7% of the population, the electricity supply network does not yet have full coverage. The city is highly dependent on a single energy source, which faces significant disruptions. The network is also not able to cope with seasonal increase on demand.

The general consumption/capita of buildings sector have a good benchmark in the CRPT tool analysis. Public buildings have high energy consumption, and it is growing steadily, representing a considerable expense in the local budget (R\$20.000.000,00/month). A public-private partnership was signed to improve the energy efficiency of municipal public buildings and public lighting. The energy consumption by the transport sector is under stable decrease, with a total of 0,405 ToE/capita, however alternative low/non-carbon fuel share is only 4%.

In 2020, the city achieved the universalisation of water supply services, as 100% of the population has access to water services. However, water distribution has a high percentage of unaccounted for water - water losses - (44%). According to the water and wastewater concessionaire there are external disruptions in the service mainly caused by breakage of water mains by paving works.

Regarding sewage networks coverage, a low percentage of the households are connected to wastewater sewes. According to the water and wastewater concessionaire, the main barriers for coverage were from normative and institutional framework.

The city has insufficient data for accurate calculation of the drainage system coverage area, showing a data gap for the city 'urban planning activities. However, recurrent disruptions on road traffic due to waterlogging are reported.

Regarding protective structures, infrastructure has some deficiencies relative to 25-year flood scenario but designed to deal with 10-year flood scenario.

Teresina has a good coverage of the waste collection system and services are stable, but there are no pre-treatment methods and landfill remaining useful life is limited. Despite having a recycling collection system, there is low adherence among the population to the selective collection system and the municipality also has a low rate of recycled waste, but the recovery trend is under stable increase.

Selected Indicators

3.1.1 Energy - Energy Supply For Buildings					
3.1.1.1 Access to energy supply					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
3.1.1.1.1 Proportion of population with access to any means of electricity supply	99,7%	Male: 99.7% Female: 100%	PNAD/IBGE	2019	
3.1.1.1.1.1 Reasons for access being less than 100%	Socio-economic capacity, hydrological risks				
3.1.1.1.1.2 Proportion of population with alternative sources of electricity other than the public network	0,3%		PNAD/IBGE	2019	
3.1.1.1.2 Proportion of population with primary reliance on clean fuels and technology for heating/cooling, lighting and/or cooking	81,2%		PNAD/IBGE for the State of Piauí	2015	
3.1.1.1.2.1 Reasons for access being less than 100%	Socio-economic capacity		PMT	2015	
3.1.1.2 Coverage of energy supply services					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
3.1.1.2.2 Is the network able to cope with seasonal increase in demand?	No		https://g1.globo.com/pi/piaui/noticia/2019/10/08/procon-instaura-procedimento-contra-equatorial-por-conta-de-quebras-de-energia-em-teresina.ghtml	2019	
3.1.1.2.3 Is the network able to cope with the city tendencial growth scenario?	Yes		ELETRONBRAS Piauí-2017 Relatório de Administração e Demonstrações Financeiras de 2017	2020	
3.1.1.3 Efficiency in energy consumption					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
3.1.1.3.1 Buildings Sector (Residential + Services/Commercial) energy consumption per capita (ToE/cap)	0,25 ToE/cap		Equatorial	2019	
3.1.1.3.1.1 Trend in Consumption	Stable Increase	0,19 (Decrease in the number of consumers from 2016 to 2019. The building sector energy consumption per capita were 0,19)	Equatorial	2016	
3.1.1.3.3 Energy consumption of public buildings	94.861.968 kwh/ per year (AVG)	Municipal administration consumes, on average, 7.905.164 kwh in 1.494 consumer units, totaling a monthly expense of approximately R\$ 20.000.000,00 (twenty million reais). There is no information about public buildings sqm in Teresina.	SEMCOP/PMT	2019	
3.1.1.3.3.1 Trend in Consumption	Stable Increase		SEMCOP/PMT	2019	
3.1.1.4 Continuity of energy supply operations for building sector					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
3.1.1.4.1 Level of interruptions that the service faces, by source	Significant disruptions, Recurrent/ Seasonal disruptions		Equatorial	2019	

3.1.1.5 Maintenance and monitoring of supply network					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.1.1.5.1	Maintenance and monitoring measures are applied	Asset database for supply system network, operation and maintenance plan for supply management, regular monitoring of illicit connections.		Equatorial Website	2020
3.1.2 Energy - Energy Supply for Mobility					
3.1.2.2 Efficiency in fuel consumption					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.1.2.2.1	Transport energy consumption (ToE/capita).	Diesel	0,17 ToE/capita	Data Portal for Cities	2015
		Gasoline	0,23 ToE/capita		
		Total	0,405 ToE/capita		
3.1.2.2.1.1	Trend in Consumption	Stable decrease		SEFAZ/PI	2019
3.1.2.2.2	Alternative low/non-carbon fuels share (%)	4%		Data Portal for Cities	2015
3.2.1 Water - Water Supply					
3.2.1.1 Access to drinking water					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.1.1.1	Percentage of population with access to water services	Safely Managed Services = 100%		SNIS	2019
3.2.1.1.1.1	Barriers to accessing improved water services	No barriers			
3.2.1.2 Water supply network coverage					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.1.2.3	Is the capacity of the network able to cope with seasonal increases in water demand?	Yes		Águas de Teresina	2020
3.2.1.2.4	Is the network able to cope with the city tendencial growth scenario?	Yes	Interventions are in accordance with the Water Supply System Master Plan.	Águas de Teresina	2020
3.2.1.3 Efficiency of water supply operations					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.1.3.1	Percentage of unaccounted for water (water loss)	44%		Águas de Teresina	2020
3.2.1.3.4	What level of unplanned disruptions does the service face?	No major disruptions		Águas de Teresina	2020
3.2.1.3.4.1	Are majority of the disruption internal or external?	External	Breakage of water mains by paving works.	Águas de Teresina	2020

3.2.1.4 Monitoring and maintenance of water supply					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.1.4.1	What maintenance and monitoring measures are applied?	Asset database for water supply system, Operation and maintenance plan for water supply management, Regular maintenance of water supply network, Regular monitoring and replacing of ageing infrastructure, Regular monitoring of illicit connections		Águas de Teresina	2020
3.2.1.4.2	Is regular sampling of water in the supply network for compliance with water quality standards being conducted in the city?	Yes, regular sampling		Águas de Teresina	2020
3.2.2 Water - Wastewater and Sanitation					
3.2.2.1 Access to sanitation					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.2.1.1	Percentage of population with access to sanitation facilities	Safely Managed Services/ Transported through a sewer with wastewater and then treated off-site	14,8%*	Censo 2010	2010
		Safely Managed Services/Treated and disposed in situ	74%*	*The data for Safely Managed services is outdated, as it comes from the 2010 Census, and it is the only resource found for combined disaggregated data. However, data from the SNIS informs that Transported through a sewer with wastewater and then treated off-site is 33% in 2020.	
3.2.1.1.1.1	Barriers to access	-			
3.2.1.1.1.2	Please select and specify prohibitive costs associated with sanitation	-			
3.2.2.1.2	Percentage of population with access to handwashing facilities	Basic facility	97,2%	IBGE	2019
3.2.2.1.2.1	Barriers to access	No barriers		PMT	2020
3.2.2.1.2.2	Prohibitive costs associated with hygiene	No prohibitive costs		PMT	2020
3.2.2.2 Wastewater network coverage					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.2.2.1	Percentage of households connected to a wastewater network	35%	This number considers the inhabitants (287,521) with sewage collection and treatment.	Águas de Teresina	2020
3.2.2.2.1.1	If percentage is considered inadequate (or less than 60%), please indicate reason(s)	Normative and institutional frameworks		Águas de Teresina	2020
3.2.2.2.2	Is the network able to cope with seasonal increase in wastewater?	Yes		Águas de Teresina	2020
3.2.2.3 Wastewater treatment and discharge					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.2.3.1	Proportion of wastewater that is safely treated	34%		Águas de Teresina	2020
3.2.2.3.1.1	If percentage is considered inadequate (or less than 40%), please indicate reason(s)	Normative and institutional frameworks		Águas de Teresina	2020

3.2.2.3.2	Methods of treatment for hazardous wastewater				
3.2.2.5	Maintenance and monitoring of wastewater system				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
3.2.2.5.2	Is regular sampling of wastewater discharge for compliance with water quality standards being conducted in the city?	Yes, regular sampling		Águas de Teresina	2020
3.2.3	Water - Stormwater				
3.2.3.1	Stormwater collection				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
3.2.3.1.1	Percentage of urban area covered by stormwater collection system	Not covered	18.70% of the city covered with drainage system 70% of the basins have some drainage system *Road network with micro curb/sidewalk system connected to the macro sewage system.	CRGP/SEMPPLAN/SEPLUR/PMT	2019
3.2.3.1.1.1	If percentage is considered inadequate, please indicate reason(s)	Street network with curb/gutter system connected to wastewater system.	75,5%	CRGP/SEMPPLAN/SEPLUR/PMT	2019
3.2.3.1.2	Is the city's drainage system currently able to cope with seasonal increase in rain/stormwater?	Yes, for a 25-year recurrence interval		SECREM/PMT	2020
3.2.3.1.3	Is the city reusing rainwater collected stormwater and/or reclaimed water	No		SECREM/PMT	2020
3.2.3.2	Stormwater and flood management strategies				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
3.2.3.2.1	Is existing protective infrastructure well-designed and well-built based on flood risk information?	Infrastructure has some deficiencies relative to 25-year flood scenario but designed to deal with 10-year flood scenario.		SECREM/PMT	2020
3.2.3.2.2	Is the use of alternative water sensitive urban design solutions regularly and extensively being considered in the city?	No		SECREM/PMT	2020
3.2.3.2.3	Do zoning rules, building codes and standards that address water sensitive urban design and/or onsite stormwater solutions exist, are widely applied, properly enforced and verified?	Yes	Drainage Act/ Lei de Drenagem 4724 de 03/06/2015 LC3610	SECREM/PMT	2020
3.2.3.2	Stormwater and flood management strategies				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
3.2.3.3.1	Percentage of dwellings damaged by intense flooding (10 years)	-			
3.2.3.3.2	What level of disruptions on road traffic due to waterlogging does the service face?	Recurrent/ Seasonal disruptions (specify period of year)	First half of the year	SECREM/PMT	2020
3.2.3.3.3	What level of disruption of access to public services due to waterlogging does the service face?	No major disruptions		SECREM/PMT	2020

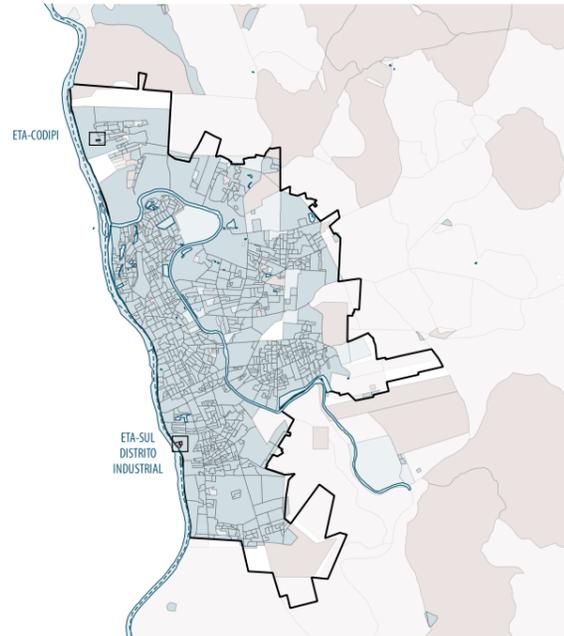
3.2.3.4 Monitoring And Maintenance Of Stormwater System					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.2.3.4.1	What monitoring and maintenance measures are applied?	Regular clearing of storm drains and street sweeping; Regular monitoring of illicit sewer connections and elimination; Regular monitoring and replacing of ageing infrastructure.		SECREM/PMT	2020
3.3 Solid Waste					
3.3.1 Solid waste collection coverage					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.3.1.1	Proportion of solid waste collected out of total solid waste generated by the city.	Total solid waste generated (all types of waste)	449,148,10 ton	SEMDOUH/PMT	2020
		Total solid waste collected formally	74,07%		
		Total solid waste collected informally	25,92%		
		Municipal Solid Waste	90%		
		Non-Municipal Solid Waste	10%		
3.3.1.1.1	If the proportion of solid waste collected is considered inadequate, please indicate reason(s), per category of waste	n.a			
3.3.1.1.2	If informal solid waste collection exists, please characterise the amount collected	116.434,71 ton		SEMDOUH/PMT	2020
3.3.2 Access to collection service					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.3.2.1	Percentage of population with regular municipal solid waste collection service (at least once a week)	99%		SNIS	2020
3.3.2.1.1	If percentage of population with regular municipal solid waste collection service is less than 100%, please indicate reason(s)	Socio-economic capacity, geospatial setting; social and cultural norms.		SEMDOUH/PMT	2020
3.3.3T Strategies for solid waste reduction					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.3.3.2	Main method(s) used for pre-treatment	No pre-treatment methods exist		SEMDOUH/PMT	2020
3.3.4 Treatment: recovery of solid waste					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.3.4.2	Characterise the recovery trend of solid waste in the last 10 years	Stable increase		SEMDOUH/PMT	2020
3.3.5 Treatment: disposal of solid waste					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.3.5.3	Characterise the trend of solid waste that has been landfilled in the last 10 years	Stable increase		SEMDOUH/PMT	2020
3.3.6 Continuity of operations of solid waste systems					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
3.3.6.1	What is the average number of days the solid waste systems are out of service per year?	For collection	0	SEMDOUH/PMT	2020
		For treatment	0		
3.3.6.1.1	For collection and for treatment, what is the level of impact of the disruptions?	No major disruptions		SEMDOUH/PMT	2020

3.3.7 Maintenance and monitoring of solid waste systems					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
3.3.7.1	For collection and for treatment, what maintenance and monitoring measures are applied?	Asset databases for solid waste, operations and maintenance plan for waste management, regular cleaning of collection points and drop of facilities (incl. within treatment sites), regular maintenance of vehicles and machineries of solid waste systems, regular monitoring and replacing of ageing infrastructure.		SEMДУH/PMT	2020
3.3.7.2	Remaining useful life of the site where the landfill is located (in years, based on capacity and municipal solid waste generation projections)	5		SEMДУH/PMT	2020

TERESINA | COVERAGE WATER SUPPLY

Indicator 3.2.1 - Water - percentage of Population Coverage

0 2,5 5 km



- Water Treatment Station (ETA - Estação de Tratamento de Água) in Teresina
 - Water Well
 - Water Mains
 - Water System Network
 - ▭ Water Streams
 - ▭ Teresina's Perimeter
 - ▭ Urban Perimeter
- Percentage of Population Coverage Water Supply in 2018**
- 0 - 20
 - 20 - 60
 - 60 - 85
 - 85 - 100

Source: CRGP with SNIS, 2018

0 2,5 5 km △ N

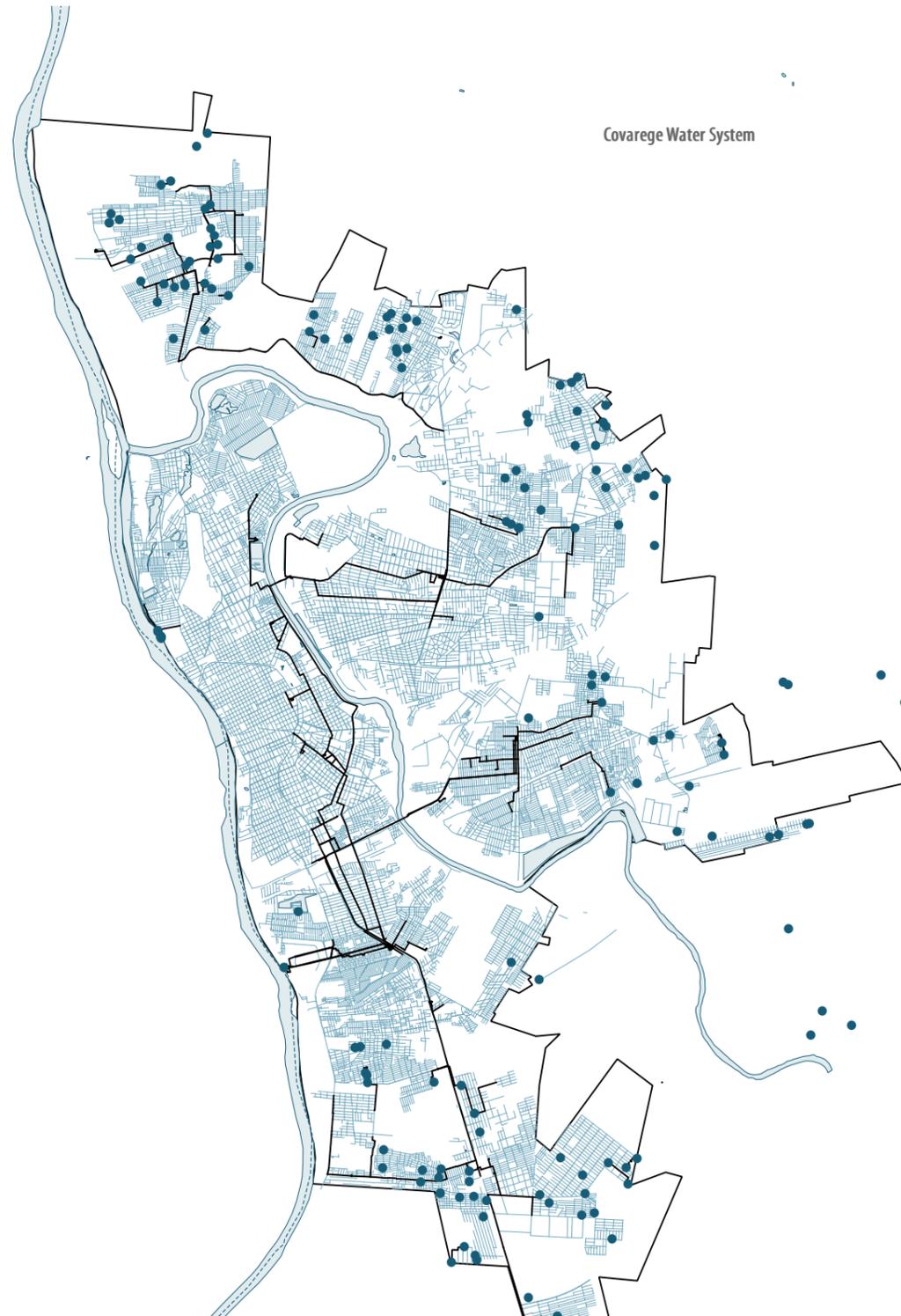
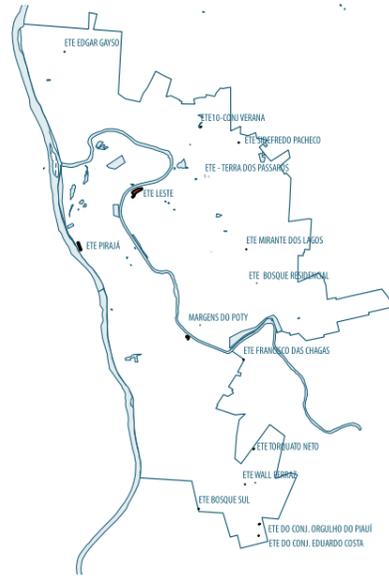


Figure 5: Indicator 3.2.1 Water Supply. Source: CRGP with SNIS (2018).

TERESINA | SOLID WASTE AND SEWAGE SYSTEM

Sewage Stations (ETE - Estação de Tratamento de Esgoto) in Teresina

0 2,5 5 km



Indicator 3.3: Solid Waste

- Sewage Pumping Station
- Selective Collection Points
- Sewage Station
- Outfall Sewage Pipeline
- Sewage Network
- TE_naturalwater_osm
- Sewage System
- Urban Perimeter

Source: CRGP with SEMPLAN, Open Street Maps, 2020

0 2,5 5 km

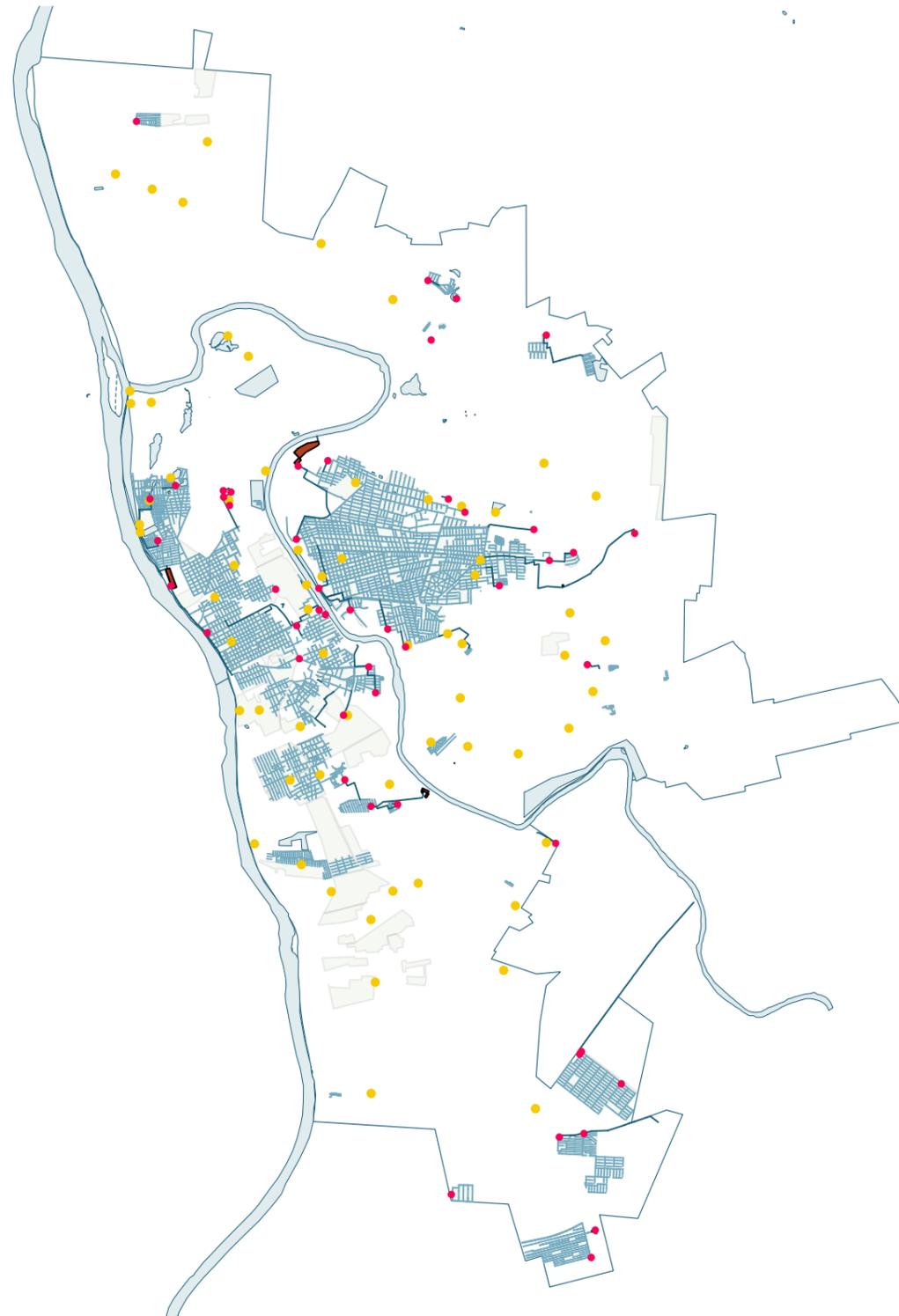


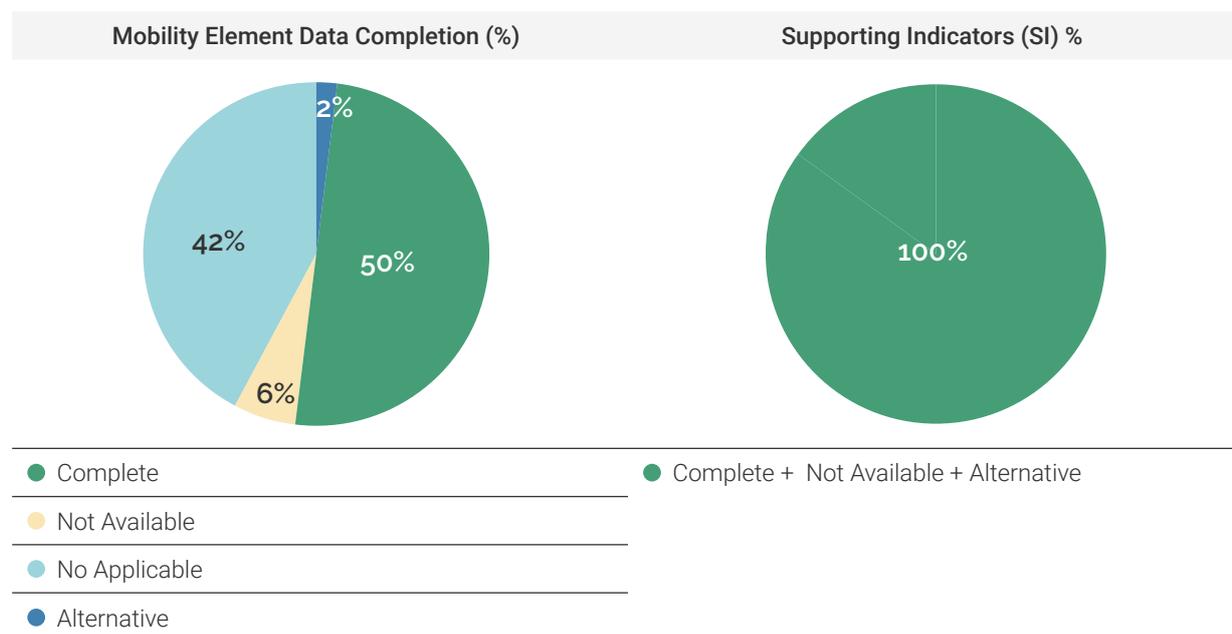
Figure 6: Indicator 3.3 Solid Waste Sewage System. Source: CRGP with SEMPLAN, Open Street Maps (2020).

4. Mobility

The Mobility Element consists of two components: Urban Mobility and Inter-regional/International Mobility. The element analyses information on the diversity of transport modes, coverage of infrastructure including networks and critical interchange facilities as well as potential vulnerabilities hindering the performance of the service and the consequent impacts while highlighting capacities.

Data Collection

substitute for: The total completion rate for data collection is 50%, also 42% not applicable and 6% not available. Considering only the selected indicators, the completion rate was 100% for this element (including complete and alternative data).



Key Findings

There is a lack of local updated data on origin-destination surveys, since the last available data is from 2008. As the city is conducting the new Sustainable Urban Mobility Plan, it is likely to have this data updated in the incoming year.

According to IBGE data, the main commuting mode is by Walking, representing 33,8%, the second most used mode to commute is by Bus, followed closely by individual cars. Cycling represents 12,2% of the commuting trips, while motorcycles 5,2%. It is relevant to highlight that private modes represents 28%

Regarding urban mobility network coverage, the road network density is still poor when marked against CRPT benchmarks, also there is a low density of cycle paths. Transit dedicated road density is considered good and 83,63% of the population lives within 500m from a public transport stop. Public transport is partially accessible to people with reduced mobility, but there is a specific system to serve this population (Transporte Eficiente). Low railway density.

The public transportation department doesn't have an operation control center, but it is under construction.

The city has great potential for water transportation however demand and accessibility should be evaluated to assess feasibility.

Male population are the main victims of transportation fatalities, representing almost 80% of the seriously injured victims and fatalities.

Regarding inter-urban mobility there is only one bus terminal in the city with regional / international destinations and one airport. However, there are also other smaller inter-city bus terminals serving as boarding/unboarding points.

Selected Indicators

4.1 Urban Mobility					
4.1.1 Diversity of Transport and Modal Share					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
4.1.1.1	Percentage of commuting trips using each one of the following modes	Private modes: 28%	Car = 22,25% (sharp decrease) Motorcycles = 5,2% (sharp increase) Trucks = 0,16% (stable decrease) Taxi=0,41% (stable increase)	IBGE CIDADES	2010 and 2018
		Public modes: 26%	Bus = 24,7% (stable increase) Metro = 0,04% (stable increase) Van = 0,35% (stable decrease) School transport = 0,66% Freight transport = 0,31%	IBGE CIDADES	2010 and 2018
		Sustainable modes: 46%	Bicycle private = 12,2% (stable increase) Bicycle public = 0% Walking = 33,8%	IBGE CIDADES	2010 and 2018
4.1.1.2	Percentage of population using paratransit modes of transportation		At least 9,23% based on 22% decrease of bus use due the paratransit "ligeirinho" comparing 2015 to 2018.	SETUT/PI	2018
4.1.1.2.1	For each mode of transport, characterise the growth rate				
4.1.2 Coverage of Urban Mobility Networks					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
4.1.2.1	Road network density (km/100000 population)	414,45 km/100 000 pop		Municipality Shape File and CRGP developed Shape File	2020
4.1.2.2	Road density dedicated for public transport only (km/100000 population)	4,48 km/100 000 pop		Municipality Shape File and CRGP developed Shape File	2020
4.1.2.3	Railway density (km/100000 population)	1,56 km/100 000 pop		CRGP developed Shape File	2020
4.1.2.4	Navigable water network density per population (km/100000 population)	21,45 km/100 000 pop		Municipality Shape file and GRGP developed Shape File	2020
4.1.2.5	Density of sidewalks and pedestrian paths (km / 100 000 population)		Less than two times the length of road network		
4.1.2.6	Bicycle lanes density (km/100000 population)	7,4 km/100 000 pop		CicloMapa Shape File and Local CRGP developed Shape File	2019
4.1.2.6.1	If coverage is less than 15km/100000 population please indicate reasons	Financial capacity		Cycling Master Plan and https://www.mobilize.org.br/noticias/12280/afinal-quantos-quilometros-de-ciclovias-existem-em-teresina.html	2020
4.1.3 Access to Urban Mobility Systems					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
4.1.3.1	Percentage of city population within 500m distance to nearest public transport stop	Bus stop Metro stop	83,63%	PMT	2017
4.1.3.4	Is public transport accessible to people with reduced-mobility?	Partially		STRANS/PMT	2020

4.1.3.5	Average commuting travel time using various modes of transport	Within the city		PDTMU/PMT	2008
		Public Modes	69 minutes	Plano Diretor de Transportes e Mobilidade Urbana de Teresina - 2008	
		Private Modes	21 minutes		
		Sustainable Modes	17 minutes		
4.1.3.6	Identify barriers to access per public transport mode (with particular attention to sex and groups in vulnerable situations)	Safety on transport vehicles; safety at transport stations, terminals, etc.; socio-cultural norms.		PMT	2020
4.1.4	Continuity of Urban Mobility Operations				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
4.1.4.0	Mode of transport	Public mode			
4.1.4.1	What level of disruptions does the service face?	Significant disruptions		STRANS/PMT	2020
4.1.4.2.1	What are the other modes of public transport that can be used, temporarily, as alternatives in case of a disruption in operations?	-			
4.1.4.3	What is the average passenger capacity during peak hours?	BUS: 35,15 passengers during peak hours 306,1 PPhPD	Can achieve 90 passengers per bus during peak hours	STRANS/PMT	2020
4.1.4.4	What is the average travel speed on major thoroughfares during peak hours?	35km/h		PDTMU/PMT	2008
4.1.4.5	Does this mode have a central control system?	No (Under Construction)	No (Under Construction)	PDTMU/PMT	2008
4.1.4.6	What is the average age of the transport fleet?	5,8 years		STRANS/PMT	2019
4.1.4.0	Mode of transport	Private model			
4.1.4.1	What level of disruptions does the service face?	Significant disruptions	Difficulty o car circulation, insecurity and evasion of the middle/higher class at the city center.	STRANS/PMT	2020
4.1.4.4	What is the average travel speed on major thoroughfares during peak hours?	35 km/h		PDTMU/PMT	2008
4.1.4.7	Transportation fatalities per 1000 population	fatalities	0,16/1000/pop	STRANS/PMT	2019
		Seriously injured and fatalities	2,93/1000pop		
		Seriously injured and fatalities	2,34/1000/pop		
		MALE			
		Seriously injured and fatalities	0,59/1000/pop		
	FEMALE				

4.2 Inter-Regional Mobility					
4.2.1 Diversity and Modal Share of Inter-Regional Mobility Systems					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
4.2.1.1	Percentage of trips using each one of following modes	Mid-distance inter-regional trips	Coach: 235174,4 trips per weekdays	Gov. Estado do Piauí	2020
			Airplanes: 13823 flights per year	Infraero Statistics	2018
		Long distance international trips	Coach: More than 300 bus services a day	Gov. Estado do Piauí	2020
4.2.1.2	Please select the growth rate of each mode.				
4.2.2 Coverage and Capacity of Entry Points and Inter-Regional transport Facilities					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
4.2.2.1	Number of major coach/bus terminal in city regional/international destinations	1		Gov. Estado do Piauí	2020
4.2.2.1.1	Characterise capacity	City coach station "Terminal Petrônio Portela"	2,000 pax / week	Gov. Estado do Piauí	2020
			5,000 pax / weekend		
4.2.2.2	Number of major train stations in city with regional/international destinations	0			
4.2.2.2.1	Characterise capacity	0			
4.2.2.3	Number of ports in city	0			
4.2.2.3.1	Characterise capacity	0			
4.2.2.4	Number of airports in city	1			
4.2.2.4.1	Characterise capacity	Petrônio Portela Airport	1.073.570 pax/year	INFRAERO	2018
4.2.4 Continuity of inter-regional mobility operations					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
4.2.4.0	Select mode of transport	-			
4.2.4.1	What level of disruptions does the service face?	-			
4.2.4.2.1	What is the most common cause of disturbance?	-			

TERESINA | PUBLIC TRANSPORTATION

Public Transports Stops, roads, buffer zone.

-  Teresina`s Perimeter
-  Teresina`s Urban Perimeter
-  Bus Stops
-  VLT Station
-  VLT road
-  Inthebra Stations
-  Inthebra road
- Road System**
-  Trunk
-  Primary
-  Secondary
-  Tertiary
-  Residential
-  Waterstreams
-  Buffer Zone of 500 m distance to nearest public transport stop

Source: CRGP with SEMPLAN, Open Street Maps, 2020

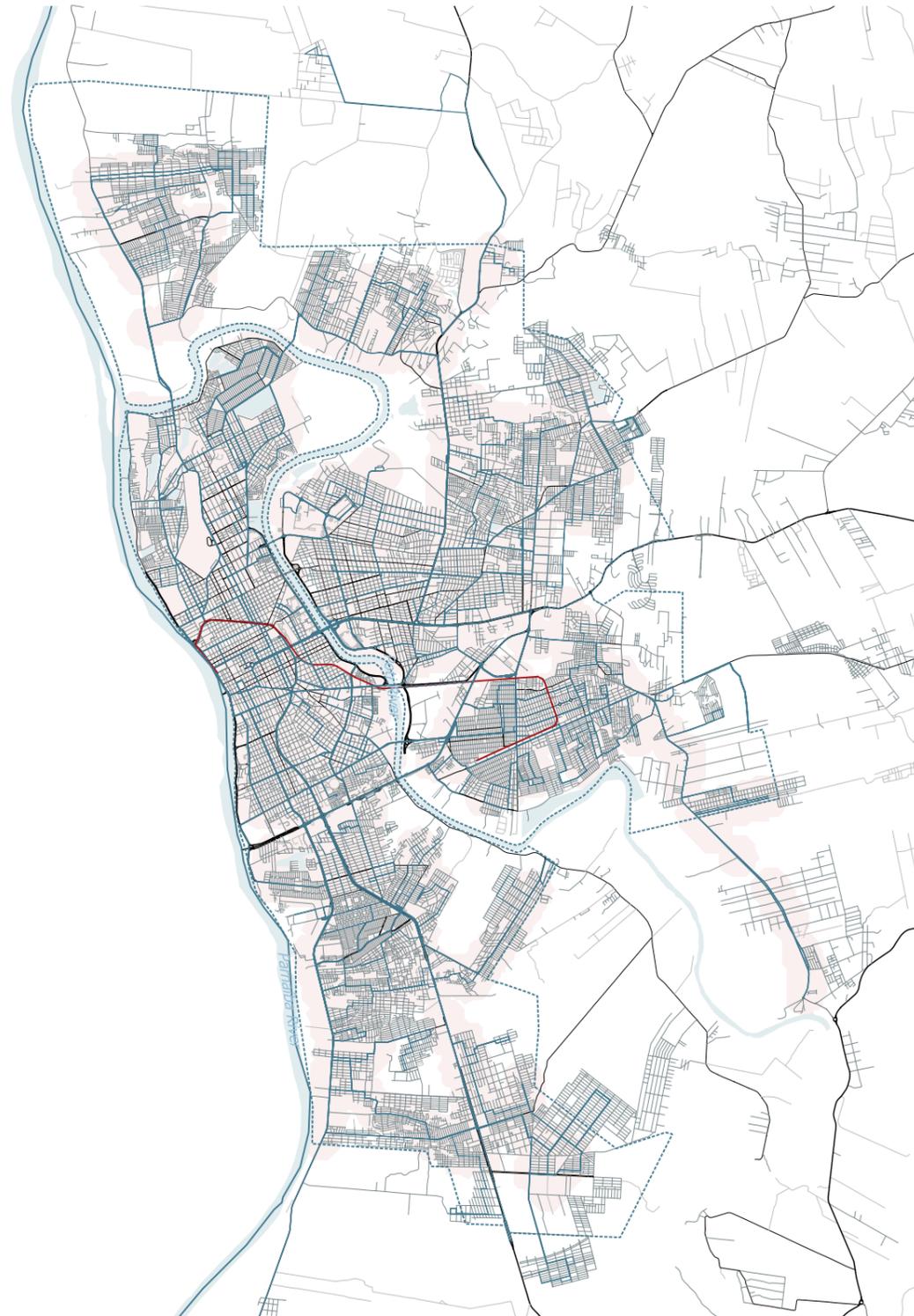
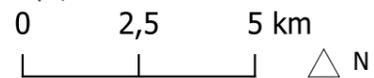


Figure 7: Indicator 4.1 - Urban Mobility. Source: CRGP with SEMPLAN, Open Street Maps (2020).

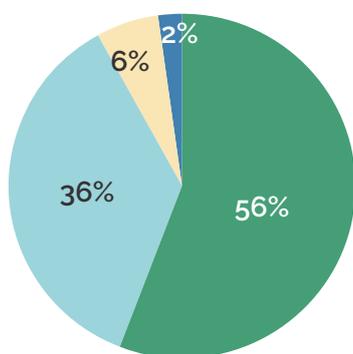
5. Municipal Public Services

The Municipal Public Services Element is composed of five components. It analyses information related to obligations commonly deployed by or under the expenses of the local governments as the public works; permits, monitoring and licensing activities; community welfare; local public security and law enforcement; and local emergency and rescue services.

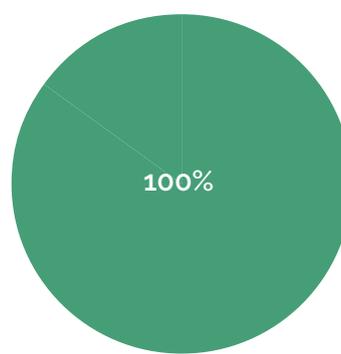
Data Collection

Substitute for this information: The total completion rate for data collection is 56%, also 36% of the data was considered not applicable, 6% not available and 2% alternative. Considering only the selected indicators, the completion rate was 100% for this element (including complete and alternative data).

Municipal Public Services Element Data Completion (%)



Supporting Indicators (SI) %



● Complete

● Not Available

● Not Applicable

● Alternative

● Complete + Not Available + Alternative

Key Findings

Data for street coverage demands calculations from CRGP and it will be updated soon and the cadaster of lighting fixtures were made available by the municipality. SEMDUH states that pedestrian and cycle paths, bridges and tunnels and transport hubs are 100% covered by public lighting. The majority of the lighting fixtures are High pressure sodium, displaying a large gap for investments in public lighting, 7.2% are LED.

Teresina does not use a night lighting schedule, but in the next 12 months, the lighting fixtures will be changed and telematic network equipment will be implemented so the municipality can dimerize 20% of the lights. Trends in energy consumption from public lighting are in sharp decline. The public lighting service represents 1,93% of local budget expenses, while maintenance 1,9% (in stable increase).

According to the municipality, 100% of public space has a regular cleaning schedule - daily for primary roads, every 3 months for residential roads, and alternative days for public spaces. According to the city's Finance Department, 6.21% of the municipal budget is spent on street cleaning. Despite the good coverage of cleaning and sweeping service, the service faces significant disruptions reported to be caused by the lack of awareness from the population in the maintenance of clean public spaces. Regarding buildings and engineering services, the municipality assesses that between 26-50% of services are completed on schedule, and less than 25% of projects are completed within estimated budget.

There is a local Animal Control and Communicable Disease agency, and its self-evaluating report shows good coverage and efficiency of inspection services. The service also has an early warning and rapid alert systems in case of disease outbreak through the basic health system. The most relevant emergency events occurred are chome COVID-19, Dengue, Zika, Chikungunya and leishmaniose disease outbreaks.

There is a data gap regarding the activities, development, buildings and engineering works permits and monitoring in the city's data collection. The city also lacks proper mapping of cultural and community welfare facilities. There is a good rate of sport facilities per habitant, but the city lacks a better cultural offer for citizens.

There is a high prevalence of urban crime in the city, being markedly robberies. According to SMPM/PMT, 12,25% of the female population experienced some type of domestic violence in the previous year (2016), and in total 27,11% experienced any type of domestic violence in their lifetime. The city has a Local Security Body - Guarda Municipal, responsible for security and protection of municipal assets, however operational capabilities are inadequate.

No data on Emergency and Rescue Services were available.

Selected Indicators

5.1 Public Works					
5.1.1 Public Lighting					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.1.1.1	Percentage of public space covered by public lighting.	Public lighting		SEMDUH/PMT and CRGP shapefiles	2020
		General Coverage	74,92%		
		Lighting of primary roads	73,8%		
		Lighting of secondary roads	48,9%		
		Lighting of pedestrian paths and bicycle lanes	99,4%		
		Lighting of public open spaces	100%		
		Lighting of outdoor sports facilities	No data		
		Lighting of cultural heritage sites	No data		
		Lighting of bridges and tunnels	100%		
		Lighting of transport hubs	100%		
5.1.1.2	What level of disruption does the public lighting service face?	Seasonal disruptions	Considering that disturbance is the demand for correcting public lighting problems	SEMDUH/PMT	2020
5.1.1.2.1	Does the municipality use a night lighting schedule?	No	In the next 12 months, the park luminaires will be changed and remote management equipment will be implemented and the city hall will be able to dim 20% of the luminaires installed in Teresina.	SEMDUH/PMT	2020
5.1.1.2.2	Does the municipality switch off lighting for the entire city during the specified	Yes		SEMDUH/PMT	2020
5.1.1.3	Proportion of different lighting types installed from the total public lighting infrastructure in the city	Mercury vapour lighting	0,2%	SEMDUH/PMT	2020
		Metal halide lighting	10,65%		
		High pressure sodium (HPS) lighting	81,65%		
		LED lighting	7,1%		
		Fluorescent and mixed lamps	0,58%		
5.1.1.4	Trends in energy Consumption/capita from public lighting	Sharp decrease	Considering the PPP that come into force in Sep/20, the goal is to reduce the electricity consumption of the public lighting network by 50% in up to 21 months	SEMDUH/PMT	2020
5.1.1.4.1	Percentage of municipal budget spent on public lighting energy consumption last 5 years	2015	-	SEMDUH/PMT	2020
		2016	-		
		2017	-		
		2018	-		
		2019	1,93%		
5.1.1.5	What operation and maintenance measures are applied	Asset database for public lighting system, Operation and maintenance plan for public lighting infrastructure, Regular maintenance of all public lighting infrastructure, Regular monitoring and replacing of ageing infrastructure, Regular monitoring and replacing of non-functional infrastructure		SEMDUH/PMT	2020

5.1.1.5.1	Percentage of municipal equipped with telematic network	0%	Not relevant, 50 points with telematic network still in testing phase .	SEMduh/PMT	2020
5.1.1.5.2	Percentage of municipal budget spent on public lighting maintenance	2016	1,29%	SEMduh/PMT	2020
		2017	1,43%		
		2018	1,65%		
		2019	1,92%		
		2020	n.a.		

5.1.2 Public spaces quality, maintenance and cleaning

Indicator Description		Main Value	Sec. Values (if any)	Source	Date
5.1.2.1	Please select the choice that best suits primary space furniture quality assessment	Street & public spaces litter bins coverage	medium	SDU Sudeste/PMT	2020
		Street & public spaces benches coverage	medium		
		Street name signing coverage	good		
		Public lavatories coverage	good		
		Street & public spaces litter bins maintenance	good		
		Street & public spaces benches maintenance	good		
		Street name signing maintenance	good		
		Public lavatories maintenance	good		
5.1.2.2	Percentage of public space with regular cleaning schedule	100%		SDU Sudeste/PMT	2020
5.1.2.2.1	What is the sweeping cycle for arterial and residential streets?	Primary road	daily	SDU Sudeste/PMT	2020
		Residential roads	Every 3 months		
		Public spaces	Alternative days		
5.1.2.2.2	Percentage of municipal budget spent on street cleaning	6,21%		SEMF/PMT	2020
5.1.2.3	What level of disruption does the public spaces cleaning service face?	Significant disruptions	Greater population awareness is needed to maintain the cleanliness of public spaces.	SDU Sudeste/PMT	2020
5.1.2.4	Percentage of public spaces in need of significant repairment	0-25%	Only periodic maintenance done regularly is necessary	SUS Sudeste/PMT	2020
5.1.2.5	What operation and maintenance measures are applied?	Operation and maintenance plan for public spaces and furniture maintenance, Regular maintenance of all public spaces and furniture, Regular monitoring and replacing of ageing infrastructure, Regular monitoring and replacing of non-functional infrastructure.	The plan is applied to squares. There is no plan for the other spaces, as maintenance is carried out on demand.	SDU Sudeste/PMT	2020
5.1.2.2.2	Percentage of municipal budget spent in public spaces maintenance	0,05%		SDU Sudeste/PMT	2020
5.1.3 Public buildings maintenance and engineering services					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
5.1.3.1	Percentage of buildings demanding maintenance that is currently being addressed (under project, bidding, implementation phase)	0-25%		SDU Sudeste/PMT	2020
5.1.3.2	Assessment of Buildings and Engineering Services Operations	Projects completed on schedule	26-50%	SDU Sudeste/PMT	2020
		Projects completed within budget	0-25%		

5.2 Permits, Monitoring and Inspection					
5.2.2 Animal control and communicable diseases					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.2.2.1	Is there any local Animal Control and Communicable Diseases agency to drive the coordination work to ensure public safety?	Animal Control and Communicable Diseases		FMS/PMT	2020
5.2.2.2	If answer to 5.2.2.1 is Yes, please select the choice that best suits Animal Control and Communicable Diseases inspection and monitoring quality assessment	Coverage Routine Inspection	good	FMS/PMT	2020
		Coverage Risk-Based Inspection	good		
		Coverage Complaint-based	good		
		Coverage Acute Events	good		
		Efficiency Routine Inspection	For Leishmaniasis, rabies:good. For animal collection: average		
		Efficiency Risk-Based Inspection	good		
		Efficiency Complaint-based	good		
		Efficiency Acute Event	good		
5.2.2.3	Presence of notification mechanism on communicable disease occurrence or outbreaks	Yes	Colab, sinan, telephone exchange	FMS/PMT	2020
5.2.2.4	Existence of early warning and rapid alert systems in case of diseases outbreak	Yes, general public	Basic health system	FMS/PMT	2020
5.2.2.5	Existence of awareness-raising activities as means of prevention and control of communicable diseases	Yes, general public	Schools and churches	FMS/PMT	2020
5.2.2.5.1	Please specify the five most relevant emergency events occurred in the last five years	2020 - COVID 2019 - Dengue, zika, chikungunya, leishmaniose		FMS/PMT	2020
5.2.2.6	What operation and maintenance measures are applied?	Regular surveillance of communicable diseases, Regular surveillance of immunisation and vaccination programmes, Investigation and control of communicable disease, Epidemiological research, Teaching/training in communicable diseases epidemiology, 24h Animal Shelter to receive sick or injured animals, Immediate response to call in case of aggressive animals endangering human life.		FMS/PMT	2020

5.2.2.7	Frequency of surveillance activities	Type of disease(s): Active surveillance Frequency of data collection: Passive surveillance Frequency of data collection:	Raiva, Leishmaniose, Arboviroses (dengue, zika, chikungunya, febre amarela, febre do Nilo), Malária, Leptospirose Daily Daily	FMS/PMT	2020
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5.2.3 Activities, development, buildings and engineering works permits and monitoring

Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.2.3.1 Is there any local agency responsible for Buildings and Engineering Works Permits and Monitoring?	Activities, Development, Buildings and Engineering Works Permits: SDUs (Urbanism Managements)	CREA - Conselho Regional de Engenharia e Agronomia do Piaui	CREA-PI	2020
	Activities, Development, Buildings and Engineering Works Inspections and Monitoring: SDUs (Inspection Managements)	Tribunal de Contas do Estado do Piaui, SEMPLAN, Corpo de Bombeiros	TCE-PI, PMT, Corpo de Bombeiros	2020
5.2.3.2 If answer to 5.2.3.1 is Yes for any, please select the choice that best suits Buildings and Engineering Works Permits and Monitoring quality assessment	Licensing (new development), Licensing (new activity).Routine Inspection, Complaint-based, Emergency Even		CAU-PI	2020
5.2.3.2.1 If coverage/response efficiency is less than "Good", please identify barriers (for each item)	-			
5.2.3.4 Diversity of submission/following-up/notification mechanism for licensing and inspection services	Diversity of submission/following-up/notification mechanism for licensing and inspection services Digital Service for irregular construction or activity; Digital service to submit and follow-up development licensing; Digital service to submit and follow-up activity licensing		CAU-PI	2020
5.2.3.5 Percentage of Development services delivered on the basic level of service	-			
5.2.3.6 What operations measures are applied?	-			
5.2.4.7 Does the Local Authority dispose of municipal funds for emergency intervention on protected built heritage?	Yes	Lei Orçamentária Anual do Município - Fundação Cultural Monsenhor Chaves	SEMPPLAN/PMT	2020

5.3 Community Welfare

5.3.1 Cultural and community facilities and activities

Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.3.1.1 Coverage of Community Facilities. Please inform rate of community facilities per capita				
Public libraries	10	1,15 facilities per 100 000pop	FMC/PMT	2020
Museums of all disciplines	7	0,80 facilities per 100 000pop	FMC/PMT	2020
Archives and documentation centres	2	0,23 facilities per 100 000pop	PMT	2020
Performing arts centres	3	0,35 facilities per 100 000pop	FMC/PMT	2020
Community and civic centres	3	0, 35 facilities per 100 000pop	PMT	2020
Child recreation spaces	12	1,38 facilities per 100 000pop	SEMEL/PMT	2020
Sports Complex and Facilities	181	20,85 facilities per 100 000pop	SEMEL/PMT	2020

5.3.1.1.1	If number of facilities are considered inadequate, please identify barriers				
5.3.1.1.2	Does the local authority maintain an updated georeferenced database of community facilities?	Yes			Teresina Geo/PMT
5.3.1.4	Does the municipality regularly perform participatory processes to decide on community facility offers and regular activities developed?	Yes	Orçamento participativo		SEMPPLAN/PMT

5.4 Local Public Security and Law Enforcement

5.4.1 Violence and security

Indicator Description	Main Value	Sec. Values (if any)	Source	Date		
5.4.1.1 Crimes against property per 100 000 inhabitants	Burglaries	2303,64/100000hab	SSP-PI (Secretaria de Segurança Pública)	2019		
	Motor vehicle thefts	380,64/100000hab	Estatísticas Criminais)			
5.4.1.2 Violent crimes per 100000 inhabitants	Total	2336,02/100000hab	SSP-PI,SEMPPLAN, Fórum Brasileiro de Segurança Pública	2018-2019		
	Robberies	2303,64/100000hab				
	Rapes	29,83/100000hab				
	Aggravated assaults	2,55/100000hab				
5.4.1.3 Homicide per 100 000 inhabitants (Please disaggregate by sex, age and groups in vulnerable situation, if possible)	Intentional Homicide per 100 000 inhabitants	27,63/100000hab	SSP-PI	2019		
	Male	26,24/100000hab				
	Female	1,5/100000hab				
5.4.1.6 Percentage of inhabitants who experienced domestic violence. (Please disaggregate by sex, age and groups in vulnerable situation, if possible)Last year	Type	%	SMPM/PMT	2016		
	Last year	All types of domestic violence (Female)	12,25%			
		Physical (female)	4,38%			
		Psychological (female)	10,28%			
		Sexual	2,19%			
	Last 5 years	n.a.				
		Lifetime	All types of domestic violence (Female)		27,13%	
			Physical (female)		14,22%	
			Psychological (female)		22,11%	
	Sexual		6,35%			

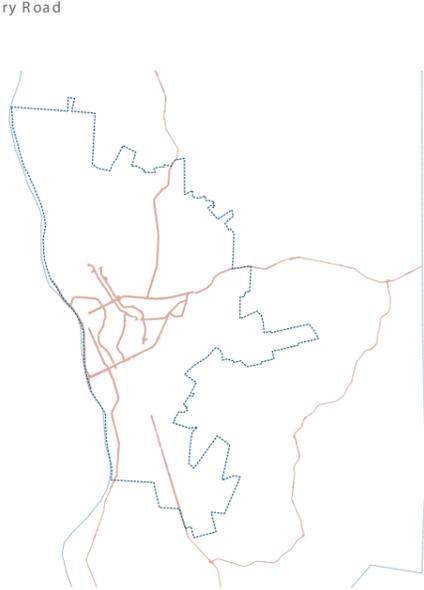
5.4.2 Local public security bodies

Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.4.2.1 Does the city has any Local Public Security Body?	Yes		PMT	2020
5.4.2.2 If answer to 5.4.2.1 is Yes, please select the applicable areas of activity being carried by the authority	Name of unit	Guarda Civil Municipal	PMT	2020
	Area(s) of responsibility	Security and protection of municipal assets		
	Spatial scale(s) of interventions	Local		
	Operational capabilities	Inadequate		

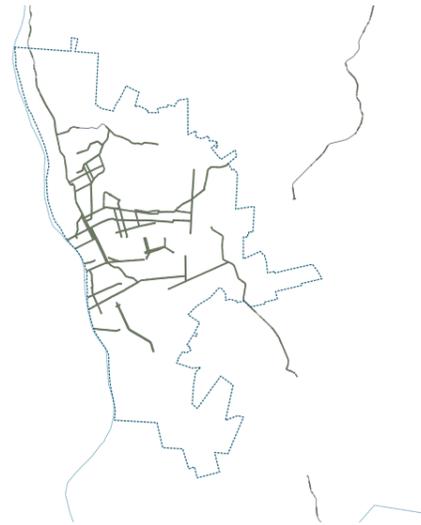
5.4.2.3	Does the Local Public Security Body also implement preventive policies?		Add here: Public Security Secretariat of the State of Piauí (Secretaria de Segurança Pública do Estado do Piauí)		
5.4.3	Traffic control and enforcement				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.4.3.1	Does the city have any local authority in charge of traffic control and enforcement?	Yes	STRANS has traffic guards in charge of traffic control	PMT	2020
5.4.4	Law enforcement and justice				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.4.4.2	Is any informal crime-watch organisation in place?	-			
5.5	Emergency and Rescue Services				
5.5.1	Diversity and typology of emergency and rescue services				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.5.1.1	Fire emergency services operating in the city, with respective capacities	Public Private Charity/ Non-profit	Defesa Civil (Civil Defense) e Corpo de Bombeiros (Firefighters) (not available) (not available)	Defesa Civil e CBM	2020
5.5.1.2	Public works units available in the city, with capacities.	-			
5.5.1.3	Emergency services available in the city, with respective staffing and equipment capacities	-			
5.5.2	Continuity of emergency and response operations				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
5.5.2.1	Operational schedule of emergency and response services	-	Working Hours Specific schedule		2020
	Fire emergency services	Fire Department (Corpo de Bombeiros)	24h/7d On-demand	CBM	
	Public works uni	Civil Police (Polícia Civil)	24h/7d Field operations	Polícia Civil	
	Specialised Emergency Services	Mobile Emergency Service (SAMU)	24h/7d Field operations	SAMU-PI	
	Civil Emergency Services	Civil Defense (Defesa Civil)	24h/7d On-demand	Defesa Civil	
5.5.2.2	Modality that emergency and rescue services can be contacted	-			
	Fire emergency services	Fire Department (Corpo de Bombeiros)	Free Number: 193	CBM	
	Public works uni	Civil Police (Polícia Civil)	Free Number: 197	Polícia Civil	
	Specialised Emergency Services	Mobile Emergency Service (SAMU)	Free Number: 192	SAMU-PI	
	Civil Emergency Services	Civil Defense (Defesa Civil)	Free Number: 199	Defesa Civil	
5.5.2.3	Response time of emergency and rescue services	SAMU: 13,6 minutes (urban zone) 32,8 minutes (rural zone)-		SILVA, 2012	2012
5.5.2.4	Existence of a public management body that is responsible for inter-agency preparedness and response coordination	-			

TERESINA | PUBLIC LIGHTING
Indicator 5.1: Public Lighting

Primary Road



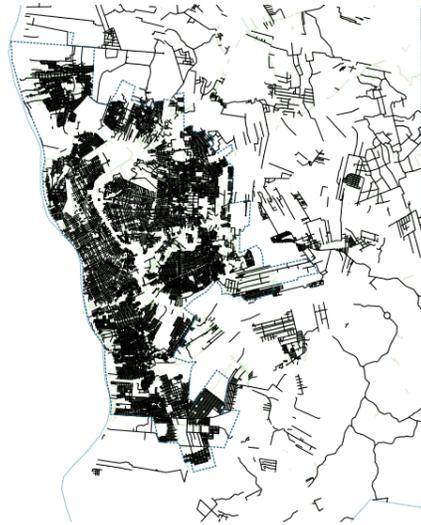
Secondary Road



Tertiary Road



Residential and Others



Public Lighting 50m Radius Buffer

- Primary
- Secondary
- Tertiary
- Residential and Others

Road

- Primary
- Secondary
- Tertiary
- Residential and Others

- Teresina's Perimeter
- Urban Perimeter

Source: CRPG and Municipality of Teresina, 2020



Figure 8: Indicator 5.1. Source: CRGP with Municipality of Teresina (2020).

TERESINA | CULTURAL AND COMMUNITY FACILITIES AND ACTIVITIES

Indicator 5.3: Coverage of Community Facilities

- Esportes
- Library
- Museums
- Theaters
- Open Popular Gyms
- Urban Perimeter
- City Blocks
- Teresina's Perimeter

Source: CRGP with Open Street Maps, 2020

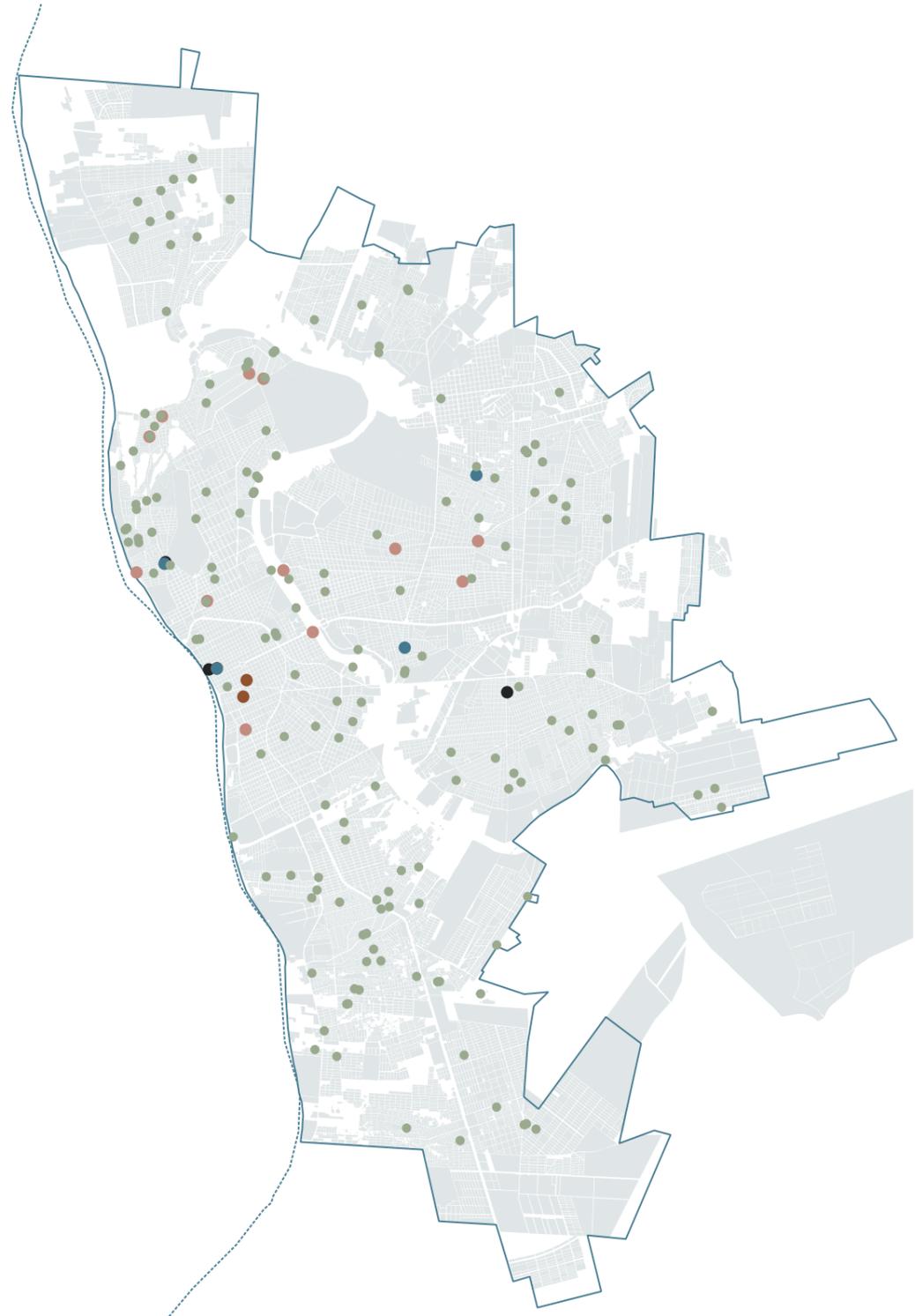
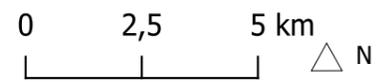


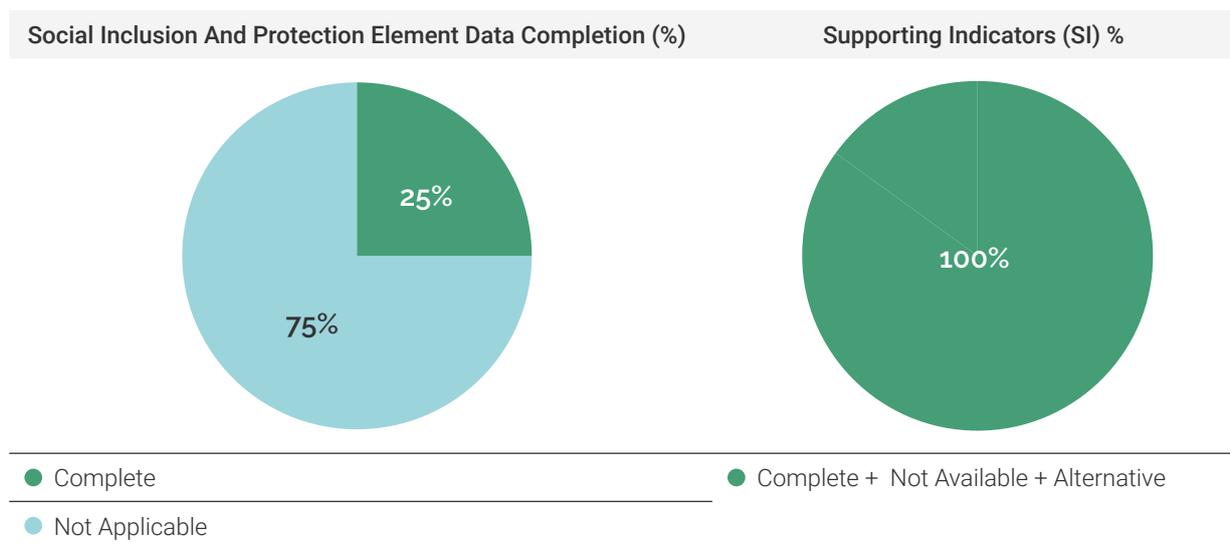
Figure 9: Indicator 5.3. Source: CRGP with Teresina Geo/PMT (2020).

6. Social Inclusion And Protection

The Social Inclusion and Protection Element (SIP) Element is composed of three macro-components, gathering data on Social Accountability, Social Protection Floors and Basic Social Services – such as education, health, social care and food provision. The chapter is designed to assess the availability of the aforementioned services in the city, mapping accessibility barriers that different population groups may face.

Data Collection

Replace here by: The total completion rate for data collection is 25% and 75% is not applicable. Considering only the selected indicators, the completion rate was 100% for this element (including complete and alternative data).



Key Findings

The municipality has several mechanisms of citizen consultation in the development of public interventions, with a diversity of methods as workshops, public meetings, online consultations, and regular mechanisms as a participatory budget.

Regarding social protection floors, there is a 100% universal basic health insurance coverage, offered by the national health insurance system SUS, and more than 17% of the households benefit from a guaranteed minimum income (Bolsa Família).

Regarding the access to social basic services, enrolment rate is 97,3% for early childhood, 98,7% in primary education, and 61% on Secondary education, being this the most concerning sector. Drop-out rate is low in early years, but considerably high in secondary education. The capacity of public education facilities of the services surpass the demand.

Hospital beds per 1.000 inhabitants are double the national values, nursing personnel and physicians are considerably higher than national figures. The operations of healthcare systems are facing significant disruptions. There are protocols in place to monitor infectious diseases.

No data on social care services were provided by the conclusion of the report.

Selected Indicators

6.1 Social Accountability					
6.1.1 Consultation of citizens in development intervention					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
6.1.1.1 Does the local government consult citizens regarding its development interventions?	Yes	Teresina Participativa, Also there are several sectoral councils composed by the public sector + civil society, in areas such as Urban Development, Health, Culture, Women rights, Environment, Public Transportation, Social Services, Employment, etc.	SEMPPLAN/PMT	2020	
6.1.1.1.1 If yes, does the local government consider the balanced consultation of male and female citizens as well as of citizens in vulnerable situations?	No data available, but this one line of action of the Municipal Plan of Public Policy for Women.	According 'to the Plan: "1.1.1 Implement a policy of equal participation and equal pay for men and women in public and private service. Therefore, a diagnosis of the current situation must be made, with a view to building an adequate and consistent policy".	SEMPPLAN/PMT	2020	
6.1.1.1.2 Select the topics of interest when organising consultations, and specify the number of citizens reached by the process:	Development of utilities infrastructure	x	SEMPPLAN/PMT	2020	
	Development of basic social services	x	SEMPPLAN/PMT	2020	
	Development of land and housing	x	SEMPPLAN/PMT	2020	
	Development of mobility infrastructure	x	SEMPPLAN/PMT	2020	
	Development of ecology-related projects	x	SEMPPLAN/PMT	2020	
6.1.1.1.3 What method is used for public consultation and what is the number of citizens reached by each method?	"Small groups/ roundtables/ workshops"	x	SEMPPLAN/PM	2020	
	Public call/meeting	x	SEMPPLAN/PMT	2020	
	Mail/telephone/online questionnaire		SEMPPLAN/PMT	2020	
	Other(s)	x - Online Consultation; Popular Budget	SEMPPLAN/PMT	2020	
6.2 Access to Social Protection Floor for All					
6.2.2 Access to health care (primary, secondary and tertiary healthcare) through appropriate insurance					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
6.2.2.1 Coverage of basic universal healthcare insurance, total population, sex disaggregated	Yes	100 %	FMS/PMT	2019	
6.2.4.3 Coverage with Guaranteed Minimum Income (GMI) type of benefits	24,17 %		Transparent Portal	2019	
6.2.4.3.1 If less than 100%, what are the barriers them prevent them from benefiting from this measures	Financial capacity	x	Public Knowledge	2019	
6.3 Access to Basic Social Services					
6.3.1 Access to Basic Social Services - Education					
6.3.1.1 Coverage of Public Education Services					
Indicator Description	Main Value	Sec. Values (if any)	Source	Date	
6.3.1.1.1 Physical Capacity of Public Education Facilities	Early Childhood (age 3-5)	62,18 % of effective coverage	INEP/DataSUS	2019	
	Primary (age 6-11)	177,78 % of effective coverage	INEP/DataSUS	2019	
	Secondary (age 12-18)	25,51 % of effective coverage	INEP/DataSUS	2019	

6.3.1.1 Access to public education							
Indicator Description		Main Value		Sec. Values (if any)	Source	Date	
6.3.1.2.1	Indicate the enrolment rate (%) (disaggregate by sex when data is available)	Early Childhood (age 3-5)	97,3 %	Kindergarten 27,48% (51,10% M/ 48,90% F) *Municipal schools	INEP/SEMEC	2019	
		Primary (ages 6-11)	98,7 %	Elementary School 70,48% (51,50% M/ 48,50% F) *Municipal schools	INEP/SEMEC	2019	
		Secondary (ages 12-18)	61 %	Youth and Adult Education 1,93% (46,60% M/ 53,40%F) *Municipal schools	INEP/SEMEC	2019	
6.3.1.2.1.1	If enrollment rate is not universal, what factor(s) most contribute(s) to this limitation?	Other, please specify	x	Address change; Family (has no one to leave children with); Job; Pregnancy; Lack of interest; Violence	SEMEC/PMT	2020	
6.3.1.2.2	What is the drop-out rate per education level (%) (disaggregate by sex when data is available)?	Early Childhood (age 3-5)	0,2%		INEP	2018	
		Primary (ages 6-11)	2%		INEP	2018	
		Secondary (ages 12-18)	11%		INEP	2018	
6.3.2 Access to Basic Social Services - Health							
6.3.2.1 Coverage of Basic Health Services							
Indicator Description		Main Value		Sec. Values (if any)	Source	Date	
6.3.2.1.1	Physical Capacity of Health Facilities	Number of Hospitals	123	0,14 per 1.000 pop.	FMS/PMT	2020	
		Physicians	Hospital beds	3.246	3,74 per 1.000 pop.	Ministério da Saúde	2020
		Nursing Personnel	6.127	70,58 per 1.000 pop.	CRM-PI	2020	
			23512	71,65 per 1.000 pop.	COFEN	2020	
6.3.2.1.2	Capacity of Emergency Response	Emergency responders	252	2,9 per 1.000 pop.	SEMPPLAN/PMT	2018	
		Emergency response vehicles	15	0,17 per 1.000 pop.	SEMPPLAN/PMT	2018	
		Facilities for emergency response purposes	3	0,03 per 1.000 pop.	SEMPPLAN/PMT	2018	
6.3.2.1.3	Do local or national early warning systems for disease control exist (e.g. Ebola outbreak)?	Yes			SEMPPLAN /PMT	2018	
6.3.2.1.4	Are there protocols in place for monitoring infectious diseases	Yes			SEMPPLAN /PMT	2018	

6.3.2.3 Continuity of Operations of Basic Health Services							
	Indicator Description	Main Value	Sec. Values (if any)		Source	Date	
6.3.2.3.1	What level of disruption is faced in the healthcare system?	Significant			SEMPPLAN /PMT	2018	
6.3.2.3.1.2	If disruptions in provision of health service are significant, please describe the cause(s) of the disruption(s)	Unknown			SEMPPLAN /PMT	2018	
		Seasonal/Environmental Disruption					
		Fiscal/Budgetary Constraints or Mismanagement	x				
		Administrative/Health Provider Disruption	x				
		Other Disruptions					

6.3.3 Access To Basic Social Services - Social Care And Protection						
6.3.3.1 Coverage of Social Care Services						
	Indicator Description	Main Value	Sec. Values (if any)		Source	Date
6.3.3.1.1	Existence of preventive measures per each of the following category and subcategory of people in vulnerable situations, sex disaggregated	Existence of Preventive Measures (Yes/No)	Total	[%] of population covered	SEMPPLAN/PMT	2019
6.3.3.1.1.1	Children without parental care	Yes	45 Units of Preventive Measures	41,03%	SEMPPLAN/PMT	2019
6.3.3.1.1.2	Poor people	Yes	77 Units of Preventive Measures		SEMPPLAN/PMT	2019
6.3.3.1.1.3	Lone and dependent elderly	Yes	8 Units of Preventive Measures	28,13%	SEMPPLAN/PMT	2019
6.3.3.1.1.4	Ethnic minorities	Yes			SEMPPLAN/PMT	2019
6.3.3.1.1.5	Persons with disabilities	Yes	3 Units of Preventive Measures		SEMPPLAN/PMT	2019
6.3.3.1.1.6	People living in marginalised communities	Yes			SEMPPLAN/PMT	2019
6.3.3.1.1.7	Other categories of people in vulnerable situations - Facilities for emergency response purposes	Yes	11 Units of Preventive Measures		SEMPPLAN/PMT	2019
		Homeless	2			
		LGBTI	4			
		Women	5			
6.3.3.1.2	Existence of protective measures per each of the following category and subcategory of people in vulnerable situations, sex disaggregated	All the protective measures are the same as the preventive measures of people in vulnerable situations			SEMPPLAN/PMT	2019

TERESINA | EDUCATION

Indicator 6.3.1 Access to Basic Social Services - Education Facilities

- Education Facilities
- City Blocks
- ▭ Teresina`s Perimeter
- ▬ Water Streams
- ▭ City Zones

Source: CRGP with SEMPLAN, 2020

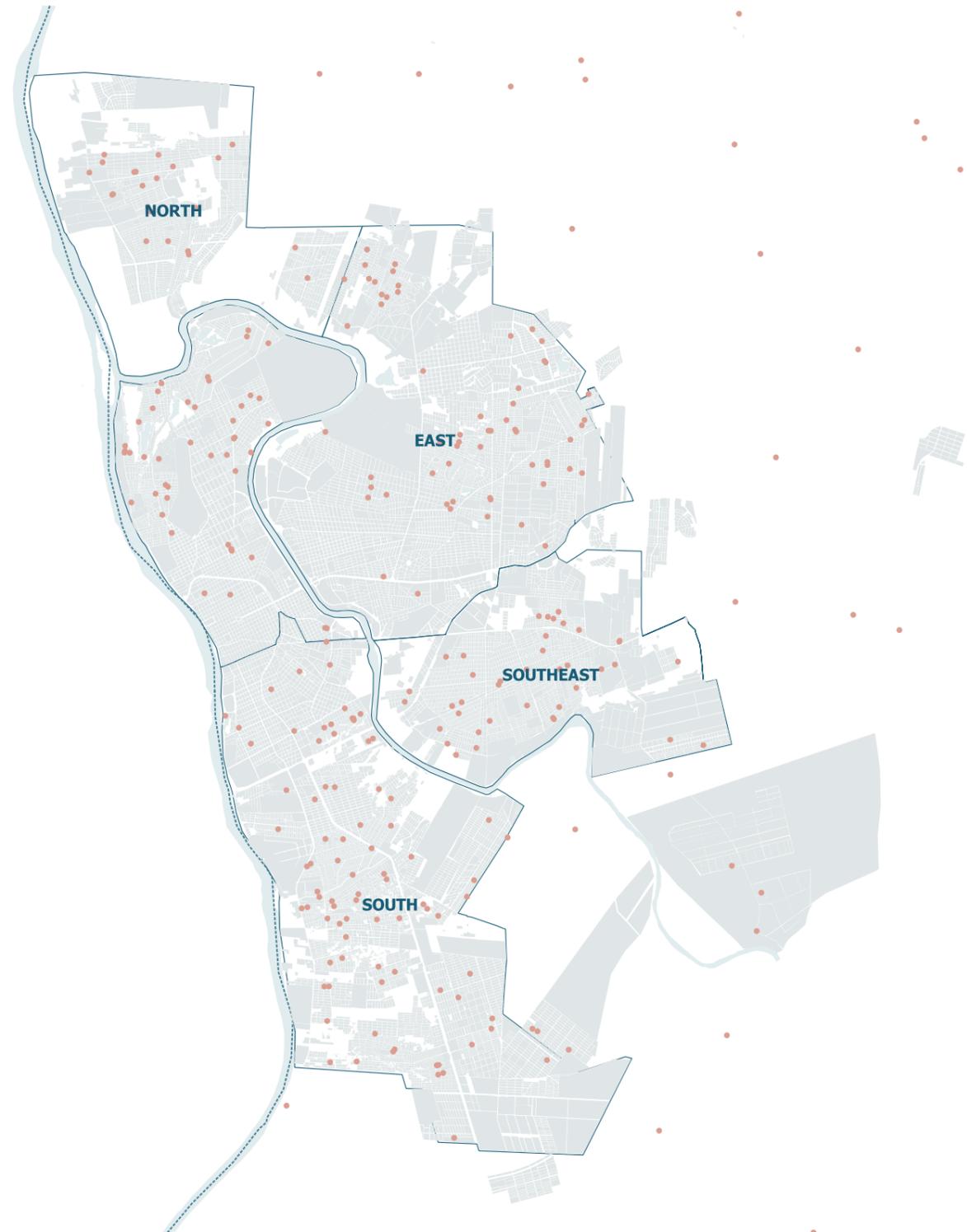
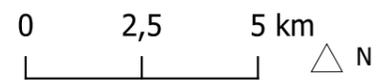


Figure 10: Indicator 6.3.1 - Education . Source: CRGP with Open Street Maps (2020).

TERESINA | HEALTH

Indicator 6.3.2: Access to Basic Social Services - Health Facilities

- Saúde
- City Main Zones
- Teresina's Perimeter
- City Blocks
- Water Streams

Source: CRGP with Open Street Maps, 2020

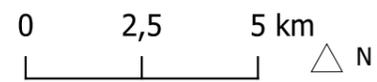


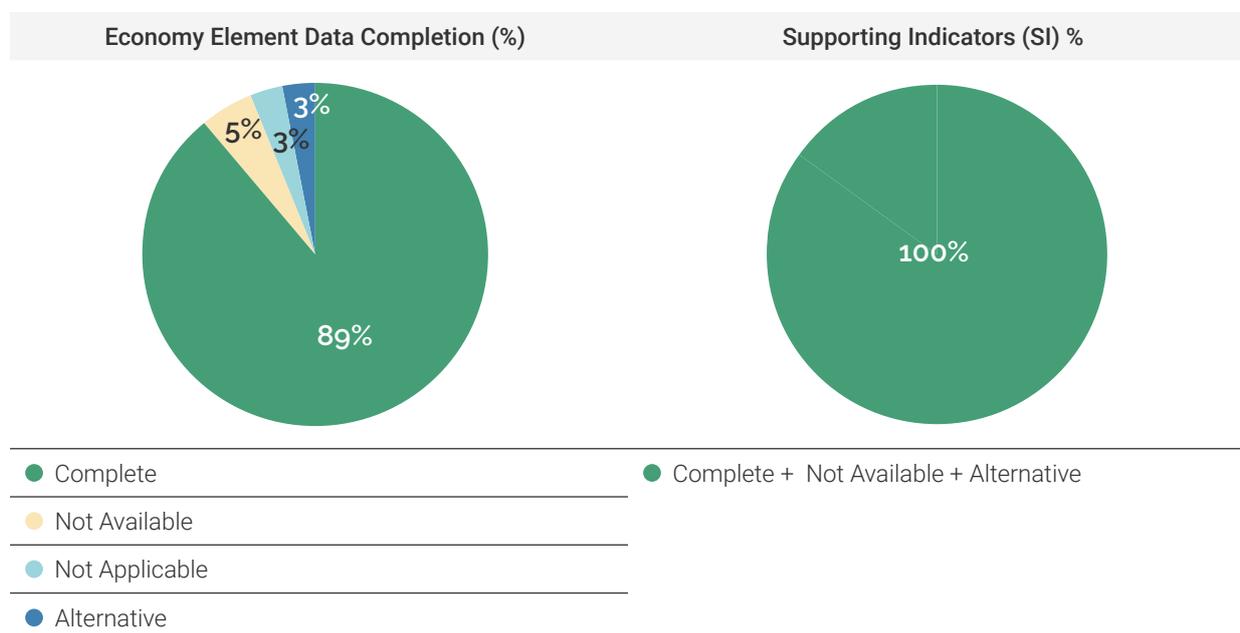
Figure 11 : Indicator 6.3.2 - Health. Source: CRGP with Open Street Maps (2020).

7. Economy

The Economy Element comprises three components and analyses information related to the local economic structure, municipal fiscal stability and market connectivity. Analysing information related to the economic composition of a city such as its municipal finance and fiscal mechanisms, and the degree to which the local economy is connected to other markets, can provide an understanding of factors that influence economic resilience. While there are many ways to analyse urban economies, the three components have been selected to highlight vulnerabilities and capacities within the economic aspects of a city.

Data Collection

Replace this by: The total completion rate for data collection is 89%, also 5% not available, 3% alternative and 3% not applicable. Considering only the selected indicators, the completion rate was 100% for this element (including complete and alternative data).



Key Findings

Public Administration is the main industry sector responsible for 37% of city product share. Other relevant industry sectors are Retail (11%), Administrative Activities (8%), Education (8%) and Human Healthcare and Social Services (7%). Manufacturing share of the city's GDP is low (5,7%). City's GCP/capita in local currency (BRL) had a considerable average growth rate in the past decade, but figures are low with values in USD (current prices). Industrial diversity is low.

Business diversity is average. The retail sector represents 41% of total business, the second sector in number of business is Administrative Activities (8%), Processing Industries (8%), and Lodging and Food (8%). However, the informal economy represents around half the economy.

Regarding employment, 26% of jobs are under the Public administration, 17% in Administrative activities, and 13% in the Retail sector. Employment diversity is considered low. Self-employed share was around 31%, and informal employment rate 44,7%. In 2019, the unemployment rate was 13,7%, being 24% among the youth (age under 29 years old).

According to SIS /PNAD data, 29.3% of families below the poverty line. The income gap between women and men was 21% higher for men. There are considerable inequalities in local income distribution.

Regarding fiscal stability, the main revenue sources are current transfers from the national government. The proportion of local government revenues that is won-source is 22,5%, with an increasing trend in the last 5 years. Diversity index in municipal income is considered low. The diversity index in municipal expenses is considered on average. The main expense shares in local government are for Health services (43,66%), followed by education (18%) and Urban Development (18,27%).

Access to financial services is still of concern, 87,10% of the population has a bank account, and there are 6,13 commercial banks per 100 000 inhabitants. Market connectivity is low, there are only 2 large cities located between 200 and 500km. Imports and Exports are low.

Selected Indicators

7.1 Local Economic Structure											
7.1.1 Industrial Composition											
Indicator Description	Main Value	Sec. Values (if any)							Source	Date	
7.1.1.1	Industrial diversity using composition by city product sector shares	Industry sector	Product my sector	Employment by sector	Emp. by sector	Emp. Ratio	City product by sector	City product share by sector	City Product Share ^2	RAIS	2017
		Public administration	1706595,534	9250000	76900	1%	14187,8050	36%	0,1268992		
		Retail sector	808387,3582	9160000	49600	1%	4377,29399	11%	0,01207924		
		Administrative activities	371259,3793	4200000	37800	1%	3341,33441	8%	0,0070383		
		Human healthcare and social services	281438,5617	2290000	22000	1%	2703,77657	7%	0,0046086		
		Education	371259,3793	2040000	17600	1%	3203,02209	8%	0,00646767		
		Processing industries	856291,7942	6750000	15900	0%	2017,04289	5%	0,00256483		
		Construction	131737,1991	1960000	15200	1%	1021,63542	3%	0,00065799		
		Lodging and food	191617,7442	1890000	10200	1%	1034,12750	3%	0,00067418		
		Transport and postal services	275450,5072	2310000	8740	0%	1042,18070	3%	0,00068472		
		Others	107784,9811	740000	19277	3%	2807,79875	7%	0,00497004		
		Specialized services	149701,3626	1020000	4940	0%	725,02246	2%	0,00033138		
		Agriculture	119761,0901	1390000	843	0%	72,6320855	0%	0,00000332		
		Electricity and gas	41916,38154	125000	2330	2%	781,321351	2%	0,00038484		
		Domestic Services	0	3300	3	0%	0	0%	0		
		Extractive industry	59880,54505	212000	204	0%	57,6209018	0%	0,00000209		
		Information and communication	161677,4716	338000	2330	1%	1114,52221	0%	0,00078307		
		Arts, entertainment and recreation	23952,21802	254000	943	0%	88,9249669	3%	0,00000498		
		Real estate activities	11976,10901	143000	1040	1%	87,0989746	0%	0,00000478		
		Financial activities	251498,2892	870000	3340	0%	965,522167	2%	0,00058769		
		Water supply, sewerage, waste management and remediation activities	5389249055	333000	1230	0%	199,062352	0%	0,00002498		
		Total	5976078,396	43000000	290420	1%	39827,7466	100%			
		HHI Diversity Index	0,1687720								
7.1.1.1.1	Manufacturing share of Local City Product	5,7%								RAIS	2017

7.1.1.2	Gross City Product (GCP) and GCP per capita for the past 10 years	GCP (US\$ current prices)	GCP/capita (US\$ current prices)	GCP (R\$)	GCP/capita (R\$)	IBGE	2017
		2010	5987261,83	7412,997784	10539377	13049,1	
		2011	6808069,254	8838,191045	11403516	14803,97	
		2012	6296312,289	8225,156042	12306772	16076,89	
		2013	6861158,231	8174,958287	14803635	17638,29	
		2014	7478541,684	8984,945186	17600000	21145,17	
		2015	5294070,854	6270,775927	17637197,05	20891,09	
		2016	5490264,643	6478,722673	19161572,63	22611,39	
		2017	5988054,505	7043,129699	19113869,98	22481,67	
		Average Growth Rate	0,00%	-0,64%	7,73%	7,04%	

7.1.2 Business Composition						
	Indicator Description	Main Value	Sec. Values (if any)		Source	Date
7.1.2.1	Diversity of businesses based on ICIS industry sector categorisation	Industry sector	Number of businesses	% of total businesses	RAIS	2017
		Public Administration	98	1%		
		Retail sector	5690	41%		
		Administrative activities	1110	8%		
		Human Healthcare and social services	987	7%		
		Education	429	3%		
		Processing industries	1110	8%		
		Construction	685	5%		
		Lodging and food	1130	8%		
		Transport and postal services	366	3%		
		Others services activities	736	5%		
		Specialized services	554	4%		
		Agriculture	95	1%		
		Domestic services	2	0%		
		Electricity and gas	7	0%		
		Extractive industry	29	0%		
		Information and communication	206	2%		
		Arts, entertainment and recreation	178	1%		
		Real estate activities	112	1%		
		Financial activities	158	1%		
		Water supply, sewerage, waste management and remediation activities	36	0%		
		Total	13718	100%		
		HHi Diversity Index	0,2064986837			
7.1.2.2	Total number of business establishments per square kilometre	77,61634506			IBGE	2018
7.1.2.3	Proportion of total businesses that can be classified as informal	58,80% of informal workers in Piauí, in the 1st semester of 2020			Censo IBGE	2020

7.1.2.4	Number of new businesses (by sector if possible)	45311			
7.1.3	Employment Composition				
	Indicator Description	Main Value	Sec. Values (if any)		Source Date
7.1.3.1	Diversity index for local employment using local employment composition by sector	Industry Sector	Total Employment	Employment share (%)	RAIS 2017
		Public administration	76900	26%	
		Retail sector	49600	17%	
		Administrative activities	37800	13%	
		Human Healthcare and social services	22000	8%	
		Education	17600	6%	
		Processing industries	15900	5%	
		Construction	15200	5%	
		Lodging and food	10200	4%	
		Transport and postal services	8740	3%	
		Others services activities	19277	7%	
		Specialized activities	4940	2%	
		Specialized services	843	0%	
		Agriculture	2330	1%	
		Domestic services	3	0%	
		Electricity and gas	204	0%	
		Extractive industry	2330	1%	
		Information and communication	943	0%	
		Arts, entertainment and recreation	1040	0%	
		Real estate activities	3340	1%	
		Financial activities	1230	0%	
		Water supply, sewerage, waste management and remediation activities	0	0%	
		All sectors	290420	100%	
		HII Diversity index			0,1385152983
7.1.3.1.1	Manufacturing job share	5%			RAIS 2017
7.1.3.1.2	Local government job share	40%			RAIS 2017
7.1.3.1.3	Self-employed job share	31%			RAIS 2017

7.1.3.2	Unemployment rate	Category	Unemployment rate			SIS/IBGE	2019
		TOTAL (all groups)	Total	Female	Male		
			13,7	13,8	13,6		
		Education level					
		Without instruction or incomplete elementary					
		Complete elementary school or incomplete high school					
		Complete high school or incomplete higher education					
		Complete higher education					
		Age group					
		<29	24%				
30-49	10,6%						
>50	7,2%						
7.1.3.3	Informal employment rate (please disaggregate by sex and vulnerable groups, if possible)	Total	44,7		SIS/IBGE	2018	
		Male	50,1				
		Female	49,9				
7.1.3.4	Youth unemployment rate (please disaggregate by sex and vulnerable groups, if possible)	Total	24%		SIS/PNAD	2018	
		Male					
		Female					
7.1.3.5	NEET Rate (please disaggregate by sex and vulnerable groups, if possible)	Total	19,3%		SIS/PNAD	2018	
		Male					
		Female					
7.1.3.6	Are worker training and retraining programs available for city inhabitants?	Yes			SENAC website	2020	
7.1.4	Income and equality						
	Indicator Description	Main Value	Sec. Values (if any)		Source	Date	
7.1.4.1	Local income distribution (disaggregate by sex and vulnerable groups, if possible)	Income group	Proportion of population (%)			SIS/PNAD	2018
			Total	Women	Men		
		Lowest earning 20%	3,5				
		21-40%	7,6				
		41,60%	12,6				
		61-80%	20,4				
		Highest earning 20%	55,9				
All income groups	100						
7.1.4.2	Proportion of the households below the poverty line	29,3%			IBGE	2018	

7.1.4.3	Provide GINI Coefficient at local level the last year available	0,511						SIS/ PNAD	2018
7.1.4.4	Gender pay gap	Median income		Income Gap				SIS/ PNAD	2018
		Women		Men					
		R\$ 398		R\$ 505		21,2%			
7.1.5	Housing Affordability								
	Indicator Description	Main Value	Sec. Values (if any)				Source	Date	
7.1.5.1	Residential real estate market trends in relation to income	Year	Median home sale price (R\$)	% change in home price	Median household income (R\$)	% change in income	CRECI PI and IBGE	2020	
		2016	253000		1367				
		2017	269000	6,33	1290	-5,63			
		2018	284000	5,58	1781	38			
		2019	290000	2,11	1420	-20,27			
		2020	302000	4,14	1999	40,77			
		5-year chance		19,37		46,23			
7.1.5.3	Average proportion of a household's budget spent on rental housing		36%					IBGE POF - Pesquisa de orça- mento familiar	2017- 2018
7.1.5.4	Housing tenure composition (rental/mortgage/owed outright)	Item	All housing	Rental	Owned outright	Other	IBGE Censo	2010	
		Number of housing units	222154	30013,01	176945,66	2865,79			
		Proportion of total (%)		13,51	79,65	1,29			
7.1.5.5	Existence of taxes, subsidies, and/or regulations targeting access to, and security within, housing for low and middle-income households	Subsidies	Minha casa minha vida					PMT	2020

7.2 Fiscal Stability and Municipal Finance							
7.2.1 Municipal revenue composition							
Indicator Description	Main Value	Sec. Values (if any)			Source	Date	
7.2.1.1 Revenue diversity	Revenue category	Total revenue (R\$)	% share	% share ^	SEMPLAN /PMT-	2020	
	Current transfers	2.245.963.222,00	61%	0,3661320085			
	Land/property tax	99.994.000	3%	0,0007257388735			
	Other local taxes	489.217.000	13%	0,01737143051			
	Grants and subsidies	202.141.000	5%	0,002965796326			
	Patrimonial revenue	88210000	2%	0,0005647654849			
	Services revenue	78.460.000	2%	0,000468164058			
	Other current revenue	101.816.000	3%	0,0007524273362			
	Credit operations	324.520.000	9%	0,007643907761			
	Amortization of loans	3.020.000	0%	0,0000006619823177			
	Capital transfers	144907000	4%	0,001524092177			
	Intra-budgetary contributions	158340000	4%	0,001819758616			
	Revenue patrimonial	400000	0%	0,000000011611321552			
	Services revenue intra-budgetary	27185000	1%	0,0000536402975			
	Current transfers deduction	252380000					
	Total revenue	R\$ 3.711793.000,00	100%	1			
Diversity Index	0,40						
7.2.1.2 Proportion of total local government revenue that is own-source	22,5%				SEMPLAN/PMT	2020	
7.2.1.3 Trends in own-source revenue (last 5 years)	Increased			45%	SEMPLAN/PMT	2020	
	Increased slightly/remained the same						
	Decreased						
7.2.1.4 Percentage of inhabitants paying land/property tax	0%-50%	*38,03%			PMT *In 2019, Teresina registred 329 .000 proprieties tax with the Property and Urban Property Tax (IPTU)	2019	
	51%-70%						
	71%-90%						
	Greater than 90%						
7.2.1.4.1 How is land/property assessed	Assessed by government official based on established criteria						

7.2.2 Municipal expenditure composition						Source	Date
Indicator Description	Main Value	Sec. Values (if any)					
7.2.2.1	Expenditure diversity of the local government	Government division	Total expenditures (R\$)	% share	% share ^	SEMPPLAN/PMT	2020
		01 - Legislative	77.192.000	0,02	0,00		
		02 - Essential to justice	1.206.000	0,00	0,00		
		03 - Administration	422.939.000	0,11	0,01		
		04 - Public security	13.369.000	0,00	0,00		
		05 - Social assistance	67.550.000	0,02	0,00		
		06 - Municipal Pensions	348.524.000	0,09	0,01		
		07 - Health	1.280.859.000	0,35	0,12		
		08 - Work	2.982.000	0,00	0,00		
		09 - Education	649.675.000	0,22	0,03		
		10 - Culture	7.648.000	0,00	0,00		
		11 - Citizenship rights	14.517.000	0,00	0,00		
		12 - Urbanism	535.970.000	0,14	0,02		
		13 - Housing	23.910.000	0,01	0,00		
		14 - Sanitation	45.743.000	0,01	0,00		
		15 - Environmental management	36.597.000	0,01	0,00		
		16 - Science and technology	2.425.000	0,00	0,00		
		17 - Agriculture	3.634.000	0,00	0,00		
		18 - Industry	301.000	0,00	0,00		
		19 - Services and retail	4.311.000	0,00	0,00		
		20 - Transportation	6.040.000	0,00	0,00		
		21 - Leisure	6.905.000	0,00	0,00		
		22 - Special Charges	135.528.000	0,04	0,00		
		23 - Contingency reserve	23.968.000	0,01	0,00		
		Total expenditures	R\$2.933.412.000,00	1			
		HHI	0,31		0,10		
7.2.2.2	Percentage of total expenditures that are discretionary or fixed for each Local Government Division	Local Government division	Discretionary Exp.	Fixed Expenditures	Total expenditures	SEMPPLAN/PMT	2020
		01 - Social and Personal Charges		44.32%			
		02 - Debts interest and charges		1.37%			
		03 - Other current expenses		33.85%			
		04 - Investments	18%				
		05 - Financial Inversion	0.88%				
		06 - Debt Amortization		1.88%			
		Total expenditures	18.57%	81.43%	100%		
	*The Budgetary Law doesn't express the proper discretionary and fixed expenditures it was subdivided as fixed the Social and Personal Charges, Debts interest and charges and Debt Amortization. The Law establishes only the difference of current and capital expenditures.						

7.2.2.3	Existence of performance indicators and goals for tracking budget execution	Yes and results from performance indicators and goals are incorporated into the following budget		SEMPPLAN/PMT	2020
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7.3 Market Connectivity

7.3.1 Access to financial services

	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
7.3.1.1	Proportion of the population with a bank account (%) (Please disaggregate by sex and groups in vulnerable situations, if possible)	87,1%		PMT	2020
7.3.1.2	Commercial banks per 100000 inhabitants	6,13	Total = 53	BACEN	2020
7.3.1.2.1	ATMs per 100000 inhabitants	10,62	Total = 91	Multiple Banks website	2020

7.2.3 Investment context and market integration

	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
7.3.2.1	National Business Freedom measure according to the Index of Economic Freedom	63.8		Heritage Institute	2020
7.3.2.1.1	Trade Freedom measure	73.9		Heritage Institute	2020
7.3.2.3	Currency volatility over the past decade	Year	Year-over-year inflation % / value of currency	IBGE	2011/2020'
		2011	7,1		
		2012	6,75		
		2013	6,49		
		2014	7,73		
		2015	12,08		
		2016	6,69		
		2017	3,25		
		2018	4,08		
		2019	4,53		
		2020	1,34		
		Total 2011-2020	68,71		
7.3.2.4	Largest cities located between 200 and 500 km that have greater than 150,000 inhabitants	City name	Population and distance	IBGE	2020
		Parnaíba-PI	153.482hab - 340km		
		Sobral-CE	210.711hab - 360km		
		São Luís-MA	958.545hab - 439km		

7.3.2.5	Top 5 import and export partners (domestic and international) by value (cities with from which city receives imports/exports)	Import	DataViva	2018
		Country	Annual Import Value	
		China	46,1M	
		USA	13,6M	
		Ukraine	11,6M	
		Canada	6,57M	
		Russia	3,42M	
		Exports		
		Country	Annual Import Value	
		Venezuela	763 mil	
		China	480 mil	
		Hong Kong	25,7 mil	
		Angola	5,14 mil	
		Egito	2,76 mil	
7.3.2.6	Five largest import and export commodities (by value)	Imports / Industrial sector	DataViva	2018
		Value / % of total imports / product type		
		1 Produtos laminados de ferro revestidos / metais	21900000 / 02,2013809%	
		2 Produtos laminados a frio de ferro / metais	15100000 / 0,1737629459%	
		3 Produtos laminados a quente de ferro metais	14900000 / 0,1714614499%	
		4 Petróleo refinado / produtos minerais	9030000 / 0,1039125432%	
		5 Trigo / produtos de origem vegetal	6570000 / 0,07560414269%	
		All imports	86900000	
		Exports / Industrial sector	Value / % of total imports / product type	
		1 Fertilizantes mistos minerais ou químicos / Produtos químicos	466000 / 0,03612403101%	
		2 Resíduos de cobre / Metais	480000 / 0,03720930233 %	
		3 Soja / Produtos de origem vegetal	297000 / 0,02302325581 %	
		4 Maquiagens / Produtos químicos	25700 / 0,001992248062 %	
		5 Produtos para cabelo / Produtos químicos	8900 / 0,0006899224806 %	
		All Exports	12900000	

TERESINA | LOCAL ECONOMIC STRUCTURE

Indicator 7.1

- Public Administration
 - Rede Estadual e Federal
 - Retails
 - Healthcare
 - Social Services
 - Food
 - Agriculture
 - Economy Support
 - Arts , entertainment and recreation
 - Education
 - Water supply, sewerage, waste management and remediation activities
- ▭ Neighborhoods
 - ▭ Water Streams
 - ▭ City Blocks
 - ▭ Teresina's Perimeter
 - ▭ Urban Perimeter

Source: CRGP with SEMPLAN, Open Street Maps, 2020

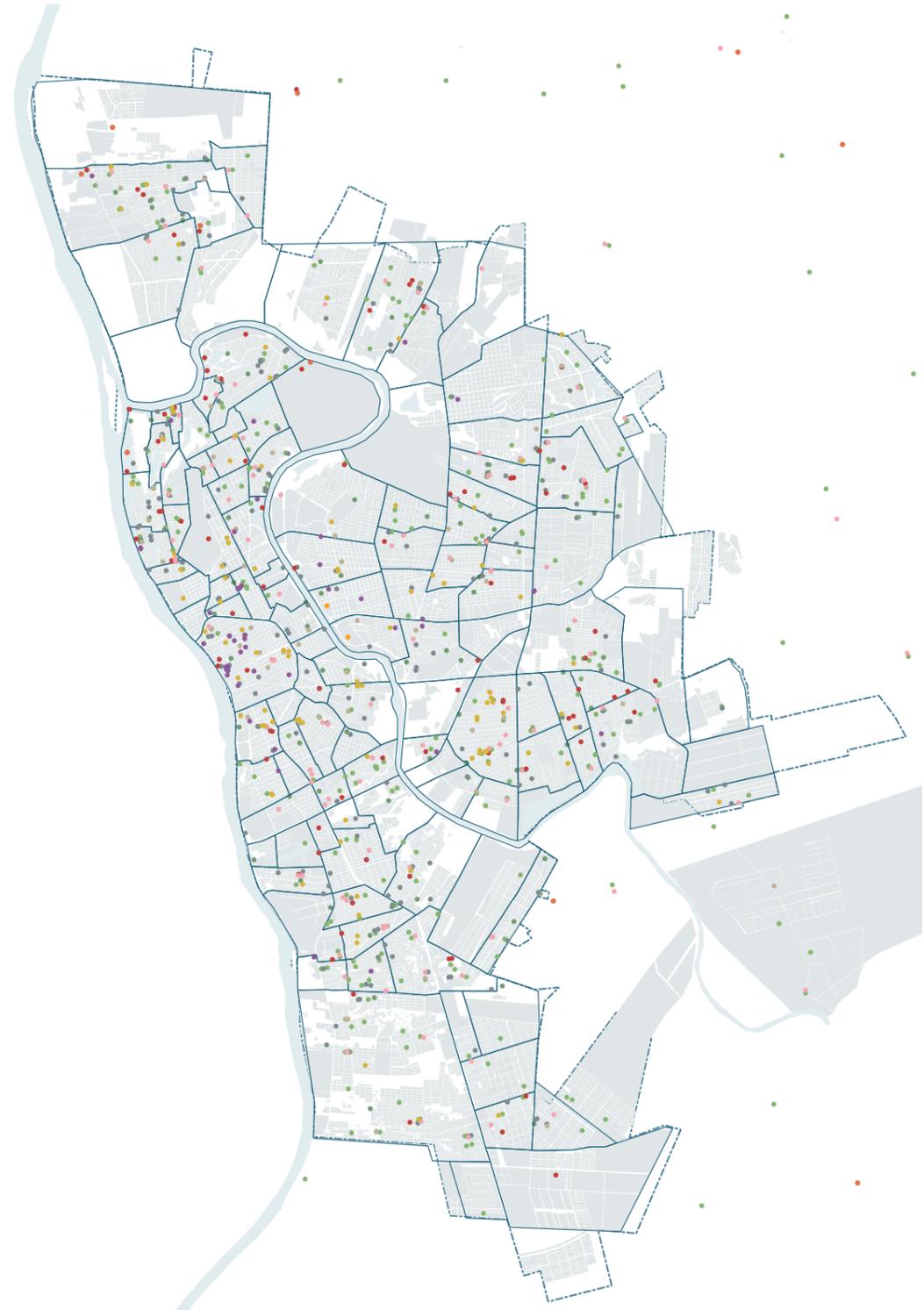
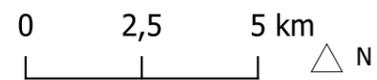


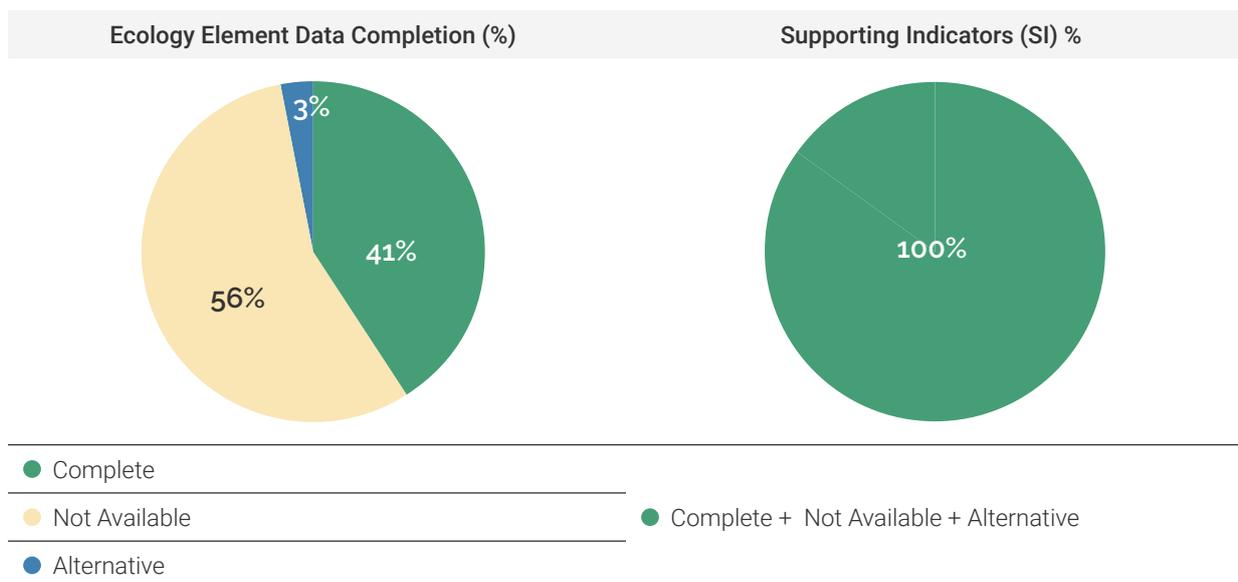
Figure 12: Indicator 7.1 . Source: CRGP with Open Street Maps (2020).

8. Ecology

The Ecology Element adopts the ecosystem services approach to assess how the city and its surrounding region interact with and impact its ecosystems – essential in providing resources for consumption, regulating the environment, and serving cultural and recreational purposes –, and by further analysing its ecological footprint, its biodiversity and green infrastructure, and its environmental quality.

Data collection

The total completion rate for data collection is 41%, also 56% not available and 3% is alternative. Considering only the selected indicators, the completion rate was 100% for this element (including complete and alternative data).



Key Findings

There is a large data gap in environmental data in the city. The local government doesn't take an ecosystem services approach or a different environmental approach into consideration in local policy and planning. The main services provided by the surrounding ecosystems and taken into account in local policies, plans and initiatives are Fresh Water Provision, Climate Regulation, Water Regulation, Water Purification and Waste Treatment, Disease Regulation and Natural Hazards Regulation.

There is no data for local biocapacity and ecological footprint (national level provided). National figures for ecological footprint of production and consumption were both considered inadequate according to CRPT benchmarks.

There is little data on local green infrastructure and biodiversity. Proportion of natural areas (which are not, no longer, or only slightly influenced by human actions) is low, however it is estimated that 73,94% of these areas are protected under legal instruments.

There are strong environmental regulation mechanisms at the municipal level, but it is reported an overlap of competences over environmental legislation, involving local, state and federal governments.

No data was available to inform local environmental quality. Relevant master plans (open data, greenhouse gas inventory, afforestation) are under development to support the production of quality environmental data.

Selected Indicators

8.1 Ecosystem Services					
8.1.1 Ecosystem Services Condition & Trends					
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
8.1.1.1	Indicate the level of preservation (good, bad) of the provisioning services the inhabitants are obtaining from the ecosystem, as well as the trend (enhanced, stable, degraded) over the past 10 years.				
8.1.1.2	Indicate the level of preservation (good, bad) of the regulating services the inhabitants are obtaining from the ecosystem, as well as the trend (enhanced, stable, degraded) over the past 10 years.				
8.1.1.3	Indicate the level of preservation (good, bad) of the cultural services the inhabitants are obtaining from the ecosystem, as well as the trend (enhanced, stable, degraded) over the past 10 years.				
8.1.2.1/ 8.1.2.2	Please select the services the local government obtains from the surrounding ecosystems and identify the policies or plans that the local government developed to preserve the selected ecosystem services				
			The local government does not produce food, but supports local producers with inputs, equipment and logistics.	SDR/SEMAM	2020
Provisioning of services	Raw materials	x	The National government has done an analysis of raw materials, minerals reserves of each Region in Brazil. It compared prices, production.	DNPM	2014
	Genetic resources	-			
	Biochemical, natural medicines and pharmaceuticals	-			
	Ornamental resources	-			
	Fresh water	x	The production and distribution of treated water in the municipality is carried out by the Águas de Teresina concessionaire.	ARSETE	2020
	Others				

Regulating Services	Air quality regulation	-			
	Climate regulation	x	Creation of programs to encourage the public and private sectors to plant trees in the municipality, improving thermal comfort in the most diverse points of the city. Creation of the project "A tree in my life", which planted 192 seedlings between 2019 and 2020. Joint efforts of planting in municipal parks, 210 seedlings in Parque Matias Matos, 200 seedlings in Lagoas do Norte Project, 70 seedlings in Parque Potycabana and 100 seedlings around UFPI. All only in 2019.		
	Water regulation	x	Federal Law No. 9.433-1997 - Institutes the National Water Resources Policy, creates the National Water Resources Management System.	Arsete	2020
	Erosion	-			
	Water purification and Waste treatment	x	Municipal Plan Of Basic Sanitation And Municipal Plan For Integrated Solid Waste Management In Teresina.	SEMPPLAN	2018
	Disease Regulation	x	Municipal Health Plan	SEMPPLAN	2018
	Pest Regulation	-			
	Pollination	-			
	Natural hazard regulation	x	Risk Plan And Mapping In Teresina	SEMPPLAN	2014
	Other(s)				
8.1.2.2.1	Does the local government involve advocacy groups representing women and groups in vulnerable situations in the development of measures to preserve ecosystem services?	Yes	Workshop Women for Climate 2019	SEMPPLAN	2019
8.1.2.2.2	Please identify if educational and awareness measures (e.g. global citizenship education, education for sustainable development) exist to encourage a lifestyle in harmony with nature, for all sexes, ages and groups in vulnerable situations	Yes	Municipal Plan For Environmental Education	SEMPPLAN	2020
8.1.2.2.3	Existence of educational and awareness measures that consider climate change mitigation, adaptation, impact reduction and early warning	Yes	All the themes found in the SDG indicator 4.7.1 (education for global citizenship and sustainable development) are present in the New Teresina 2018 Curriculum and, consequently, are part of teacher training as well as student assessment.	SEMPPLAN	2020
8.1.2.3	Does the local government take the ecosystem services approach or a different environmental approach into consideration in local policy and planning?	No		SEMPPLAN	2020
8.1.2.4	Is the local government involved in transboundary agreements or collaborations to enable policy and planning for the implementation of ecosystem services approaches?	No (Under Development)	Sustainable RIDE Great Teresina Project / Funded by the Global Environmental Facility - GEF 7	SEMPPLAN	2020

8.2 Ecological Footprints

8.2.1 Biocapacity

Indicator Description	Main Value	Sec. Values (if any)				Source	Date
		Area size in 2008 (in ha)	Biocapacity in 2008 (in gha)	Area size in 2017 (in ha)	Biocapacity in 2017 (in gha)		
8.2.1.1 What is the biocapacity of the region over the last 10 years? Please specify the area size (in hectares) of each land use type present in the region, in order to calculate the area's biocapacity (in global hectares) for 2008 and 2017.	Land use type					Data Footprint Network	2020
	Built-up	0,09	6,52	-	5,8		
	Cropland	-					
	Grazing land	-					
	Forest land	-					
	Fishing ground	-					

8.2.2 Ecological Footprint of Consumption					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
8.2.2.1	Ecological Footprint of Production (10 year trend)		EFP [gha]	Data	2019
		2020	-	Footprint	
		2019	-	Network	
		2018	-		
		2017	-		
		2016	8,7		
		2015	8,88		
		2014	8,93		
		2013	9,02		
		2012	9,04		
		2011	9,17		
2010	9,2				
8.2.2.2	Ecological Footprint of Consumption (10 year trend)		EFP [gha]	Data	2019
		2020	-	Footprint	
		2019	-	Network	
		2018	-		
		2017	-		
		2016	2,81		
		2015	2,91		
		2014	3,1		
		2013	3,1		
		2012	3,09		
		2011	3,13		
2010	2,99				
8.3 Biodiversity and Green Infrastructure					
8.3.1 Native biodiversity in the city					
Indicator Description		Main Value	Sec. Values (if any)	Source	Date
8.3.1.1	Specify the change in number of native species over the past ten years. If data is available, please disaggregate further, particularly into those species on the Red List of Threatened Species.		* 586 species on the Red List of Threatened Species, which 2 are classified as Endangered and 8 as Vulnerable. The others are classified as Near Threatened (12), Least Concern (554) and Data Deficient (10)	IUCN	2019
8,3,1,2	Proportion of invasive alien species as percentage of all species				
8.3.1.2.1	Please, provide a full list of invasive alien species and, if available, information regarding areas in the city where these species concentrate				
8.3.1.2.2	Does the local government take measures (regulation, monitoring, enforcement) to prevent or control invasive alien species?	Yes		ICMBio	2019
8.3.1.3	Proportion of natural areas and urban green spaces in the city as a percentage of the urban area	Type %		CRGP & PMT	2020
Urban green space	Natural areas		1,26%		
		44,19%			

8.3.1.4	Specify the urban green space per capita and disaggregate, if possible, by sex, age and groups in vulnerable situation.		13,43 ha/1000pop	CRGP	2020
8.3.1.4.1	Select barriers that may reduce access to the urban green spaces	Socio-economic		PMT	2020
8.3.1.5	Proportion of urban green space cover (including vegetation canopy cover and blue areas), as percentage of the size of the functional area.	76,88%		CRGP	2020
8.3.2	Protected natural areas in the region and connectivity				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
8.3.2.1	Please, specify the proportion of natural areas in the region that is protected	21,4%		CRGP & PMT	2020
8.3.2.2	Please specify whether expenditure (public and private) per capita spent on the preservation, protection and conservation of natural heritage is increasing, stable, or decreasing.				
8.3.2.3	Please specify the total size of the number of areas (in ha) that connect protected natural areas and urban green spaces in the city, using the Green Infrastructure Index as measure.				
8.3.2.4	Does the city take the biodiversity in these corridors, and in their green spaces and blue areas in general, into consideration?	Yes	Master Plan for Urban Afforestation for Teresina	SEMAM	2020
8.4	Environmental Quality				
8.4.1	Native biodiversity in the city				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
8.4.1.1	CO2 emissions	2.23		Our World in Data	2017
8.4.1.2	CO2 Intensity				
8.4.2	Air quality				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
8.4.2.1	Particulate matter (PM10) concentration (24-hour average)				
8.4.2.1.1	Exceedance days (above 50µg/m3)				
8.4.2.2	Fine particulate matter (PM2.5) concentration (1-year average)				
8.4.2.2.1	Exceedance days (above 25µg/m3)				
8.4.2.3	Nitrogen dioxide (NO2) concentration (1-hour average)				
8.4.2.3.1	Annual average concentration				
8.4.2.3.2	Exceedance days (above 200µg/m3)				
8.4.3	Water quality				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
8.4.3.1	Select the pollutants present in groundwater that have transgressed the established limit				
8.4.3.1.1	Specify additional pollutants of concern: primary pollutants, their characteristics and other factors that affect groundwater				
8.4.3.1.2	Please describe the source of pollution, if applicable				
8.4.3.2	Select the pollutants present in inland surface water that have transgressed the established limit				
8.4.3.2.1	Specify additional pollutants of concern: primary pollutants, their characteristics and other factors that affect inland surface water bodies				

8.4.3.2.2	Please describe the source of pollution, if applicable.				
8.4.4	Additional pollution				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
8.4.4.1	Are there areas in the city with significant land pollution (e.g. brownfield sites, riverbeds, agricultural sites etc.)?				
8.4.4.1.1	Specify additional pollutants of concern: primary pollutants, their characteristics and other factors that affect inland surface water bodies				
8.4.4.2	Are there currently areas in the city with significant thermal pollution (e.g. heat island effect)?				
8.4.4.2.1	Please describe the source/origin of pollution, if applicable.				
8.4.4.3	Are there currently areas in the city with significant radioactive pollution (e.g. nuclear power plants, industrial sites, hospitals etc.)?				
8.4.4.3.1	Specify additional pollutants of concern: primary pollutants, their characteristics and other factors that affect inland surface water bodies				
8.4.4.4	Are there currently areas in the city with significant noise pollution?				
8.4.4.4.1	Please describe the source/origin of pollution, if applicable.				
8.4.4.5	Are there currently areas in the city with significant light pollution?				
8.4.4.5.1	Please describe the source/origin of pollution, if applicable.				
8.4.4.6	Other types of pollution not included in this report [+]				
8.4.4.6.1	Please describe the source/origin of pollution, if applicable.				
8.4.5	Monitoring of environmental quality				
	Indicator Description	Main Value	Sec. Values (if any)	Source	Date
8.4.5.1	Existence and monitoring of a greenhouse gas inventory	No (Under Development)	The city has already launched a second bidding process (previous one was deserted) for its GHG Inventory within the Climate Action Plan.	Agenda2030/ PMT	2020
8.4.5.2	Existence, monitoring and enforcement of air quality regulations	Ineffective regulations, no monitoring or enforcement		PMT	2020
8.4.5.3	Existence, monitoring and enforcement of water quality regulations	Approved regulations, adequate monitoring, adequate enforcement		SEMAM	2019
8.4.5.4	Existence, monitoring and enforcement of regulations regarding the additional types of pollution identified in Indicator 4.4.4 [+]				

TERESINA | GREEN INFRASTRUCTURE

Indicator 8.3: Native biodiversity in the city

-  Teresina's Perimeter
-  Urban Footprint 2019
-  Tree Cover
-  Water Streams

Source: CRGP with SEMPLAN and Global Forest Watch, 2020

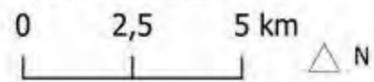


Figure 13: Indicator 8.3. Source: CRGP with Global Forest Watch (2020).

Annex III

Inventory of Policies, Plans and Initiatives in Teresina

List of Tables

- Table 1** Priority Matter 1: Water Cycle Management.
- Table 2** Priority Matter 2: Ecosystem Imbalance.
- Table 3** Priority Matter 3: Economic Underperformance.

Priority Matter 1: Water Cycle Management

Water Cycle Mis Water Cycle Mismanagement management				
		Name	Status	Areas
National	Policy	[2001] City Statute - National Urban Policy	Approved	Urban Development/ Sprawl
		[2012] National Civil Defense and Protection Policy	Approved	DRR
		[2010] National Civil Defense System	Approved	DRR
		[2017] National Policy for the Recovery of Native Vegetation	Approved	Natural Buffers Protection
		[2017] National Policy for Land Regularization	Approved	Housing Tenure/ Accessibility
	Plan	[2017] National Plan for the Recovery of Native Vegetation (Planaveg)	Approved	Natural Buffers Protection
		[1997] National Water Resources Plan	Approved	IWRM
	Initiative	[2020] Pro-housing (PRÓ-MORADIA)	Under implementation	Housing Tenure/ Accessibility
		[2019] Advancing Cities - Sanitation	Implemented	IWRM, Flood Prevention, DRR
		[xxxx] S2iD (Integrated Disaster Information System)	Implemented	DRR
		[2012] National Civil Defense and Protection System	Approved	DRR
		[2020] National Housing Programme (Minha Casa Verde Amarela)	Under implementation	Housing Tenure/ Accessibility
Supra Local	Policy	[2000] State Water Resources Policy	Approved	IWRM
		[2019] Urban Land Regularization Policy in Piauí	Approved	Housing Tenure/ Accessibility
	Plan	[2010] State Water Resources Plan	Approved	IWRM
	Initiative	[2020] Minha Casa Legal (Tenure Formalisation). Already finished	Implemented	Housing Tenure/ Accessibility
		[2020] Integrated and sustainable Piauí (Inside Piauí PPA)	Approved	Housing Tenure/ Accessibility, DRR Natural buffers protection, IWRM
		[2019] Moradia para Todos (Micro Credit for Housing Improvement)	Approved	Housing Tenure/ Accessibility

Water Cycle Mis Water Cycle Mismanagement management				
		Name	Status	Areas
Local	Policy	[2019] Teresina Urban Land Regularization Policy	Approved	Housing Tenure/ Accessibility
		[2015] Urban Perimeter Act	Approved	Urban Development/ Sprawl
	Plan	[2013] PLHIS - Local Social Housing Plan	Approved	Housing Tenure/ Accessibility
		[2015] Drainage Act	Approved	Flood Prevention
		[2015] Urban Drainage Plan	Approved	Flood Prevention
		[2016] Municipal Basic Sanitation Plan	Approved	IWRM
		[2019] Land Tenure Regularization Plan		Housing Tenure/ Accessibility
		[2020] Teresina's Urban Development Master Plan	Approved	Urban Development/ Sprawl Natural Buffers Protection
	Initiative	[2020] Teresina Natural Based Solutions Strategies	Under development	Natural Buffers Protection Flood Prevention
		[2019] Advancing Cities - Sanitation - Teresina (Avançar Cidades)	Under development	IWRM, Flood Prevention, DRR
		[OnGoing] Land Regularization Project	Under implementation	Housing Tenure/ Accessibility
		[2019] REURB	Under implementation	Housing Tenure/ Accessibility
		[2013-Ongoing] Teresina Mais Verde Program	Under implementation	Natural Buffers Protection
		[2013-Ongoing] Vila da Paz Urbanisation Project	Under implementation	Natural Buffers Protection Flood Prevention
		[2019] Drainage System at Portal da Alegria (residential Torquato Neto)	Under development	Flood Prevention, DRR
[2020] PPP Drainage Systems		Under development	Flood Prevention	
[2006-Ongoing] Northern Lagoons Programme	Under implementation	Flood Prevention, DRR, Natural Buffers Protection		

Priority Matter 2: Ecosystem Imbalance

Ecosystem Imbalance				
		Name	Status	Areas
Na-tional	Policy	[2010] National Solid Waste Policy	Approved	Solid Waste
		[2015] PAN-Brasil	Approved	Desertification, Droughts
		[2007] National policy for basic sanitation	Approved	Water Contamination
		[2009] National Policy on Climate Change	Approved	Heat waves, Climate Action
	Plan	[1997] National Water Resources Plan	Approved	Water Contamination
		[2015] Contingency plan for public health emergency due to drought	Approved	Droughts
	Initiative			
Supra Local	Policy	[2011] State Policy on Climate Change and Combating Poverty	Approved	Climate Action, Droughts
	Plan			
	Initiative	Ongoing] Ecological ICMS	Implemented	Environmental Action
		[2010] PAE Piauí	Under implementation	Desertification, Droughts

Ecosystem Imbalance				
		Name	Status	Areas
Local	Policy	[2009] Disposal of technological waste	Approved	Solid Waste
		[2014] Law 4555/2014 Obligation of afforestation in low-density urban developments	Approved	Vegetation Loss
	Plan	[2016] Municipal Basic Sanitation Plan	Approved	Solid Waste, Wastewater
		[2018] Municipal Plan for Integrated Solid Waste Management	Approved	Solid Waste
		[2020] Municipal Afforestation Plan	Under development	Vegetation Loss
		[2020] Teresina's Urban Development Masterplan	Approved	Land Consumption
	Initiative	[2020] Women for Climate - Recycling	Under development	Solid Waste
		[2013] Zero Waste Programme	Implemented	Solid Waste
		[Ongoing] Teresina Recycling Programme	Implemented	Solid Waste
		[2019] Restructuring and creation of environmental parks	Under development	Green Infrastructure, Heat Waves, Climate Action
		[2020] Teresina Natural Based Solutions Strategies	Under development	Vegetation Loss, Low Emission, Green Infrastructure, Heat Waves, Climate Action
		[2020] GEF RIDE Great Teresina	Under development	Vegetation Loss, Low Emission, Green Infrastructure, Heat Waves, Climate Action
		[2014] Adopt the Green Program	Implemented	Vegetation Loss, Heat Waves
		[2020] Women for Climate - Urban Gardens	Under development	Green Infrastructure, Heat Waves, Climate Action
		[2020] Teresina Climate Action Plan	Under development	Heat Waves, Low Emissions, Green Infrastructure, Climate Action
[xxxx] Project A Tree in My Life	Implemented	Vegetation Loss, Low Emission, Climate Action		

Priority Matter 3: Economic Underperformance

Economic Underperformance				
		Name	Status	Areas
National	Policy	[2012] National Urban Mobility Policy	Approved	Mobility
		[2008] National Microentrepreneurs Act	Approved	Informal Economy
	Plan	[2019] Industry 4.0 Action Plan	Approved	Supply Chain Management, Attractiveness
		[2019] PRDNE (Northeast Regional Development Plan)	Approved	Supply Chain Management, Attractiveness
	Initiative	[2007] REDESIM	Implemented	Public Services Efficiency
		[2017] Efficient Brazil	Implemented	Public Services Efficiency
		[2020] PRONAMPE	Implemented	Business and Employment
		[2020] BNDES Small Business Credit Line	Implemented	Business and Employment
		[2017] Advancing Cities - Mobility	Implemented	Mobility
[2017] REFROTA	Implemented	Mobility		
Supra Local	Policy			
	Plan	[2016] Piauí 2050 (State-level Economic Development Plan)	Approved	Supply Chain Management, Attractiveness
		[2020] PPA/Piauí 2020-2023	Approved	Supply Chain Management, Attractiveness
Initiative	[2016] Piauí Digital	Implemented	Public Services Efficiency	
Local	Policy	[2015] Teresina Municipal Employment Council - COMETE	Approved	Business and Employment
	Plan	[2017] Municipal Plan for Public-Private Partnerships	Approved	Public Services Efficiency
		[2011] Integrated Development Plan for Sustainable Tourism (PDITS)	Approved	Economic Diversification, Business and Employment
		[2015] Cycling Master Plan	Approved	Mobility
		[2020] Sustainable Urban Mobility Plan	Under development	Mobility

Economic Underperformance				
		Name	Status	Areas
Local	Initiative	[2018-2020] INTHEGRA (BRT System)	Implemented	Mobility
		[2018] Euroclima + Innovation for better Mobility	Under implementation	Mobility
		[2019] IDB/Brazil DOT Technical Cooperation	Under implementation	Mobility, Urban Development/Sprawl
		[2015-OnGoing] "Gestão Cidadã" Programme	Implemented	Municipal Finance
		[2018-Ongoing] Sustainable Teresina Program	Under implementation	Mobility, Urban Development, Public Services Efficiency
		[Ongoing] Empresa Fácil (Easy Business)	Implemented	Public Services Efficiency
		[2018-Ongoing] Construa Fácil (Easy Building)	Implemented	Public Services Efficiency
		[2020] Teresinense Digital (Digital Teresina)	Implemented	Public Services Efficiency
		[Ongoing] Colab Teresina	Implemented	Public Services Efficiency
		[2018-On Going] Municipal Training Program (CAF)	Under development	Public Services Efficiency
		[2018-On Going] Teresina Open Data Plan	Under development	Public Services Efficiency
		[OnGoing] Popular Bank of Teresina (BP)	Implemented	Economic Diversification, Business and Employment
		[2019] Empreende Bairro Project	Implemented	Economic Diversification, Business and Employment
		[2019-OnGoing] THEch Programme	Under implementation	Economic Diversification
		[2015] Competitive Teresina (Teresina Competitiva)	Under development	Economic Diversification, Business and Employment
		Promotion and Attraction of Private Investments	Implemented	Business and Employment
		[2020] Active Teresina (Covid-19 Economic Recovery)	Under development	Business and Employment
		[2020] Commercial and Creative Technology	Under implementation	Business and Employment
[On-Going] Professional Training Programs at FWF	Under implementation	Business and Employment		

Annex IV

Covid-19 Municipal Budget Impacts Report

Annex IV

Covid-19 Municipal Budget Impacts Report

Municipality of Teresina

Report 29/2020 - ASS-TEC-SEMF
Teresina, 27th October 2020

In attention to the request through the Office NO 1355/2020 - GAB-SEMPPLAN (1212460) issued in the SEI Case No. 00046.002668/2020-18, and the order 714/2020 - CERM-SEMF (1254824), follow the data regarding the financial impact of the COVID-19 pandemic on the economy of the Municipality of Teresina explaining about the revenue projections for the year 2020.

In the current world situation, the economic crisis related to the pandemic of the new coronavirus (Covid-19) makes revenue projections more uncertain. The SEMF seeks to carry out analysis with the objective of measuring in a technical way the impact on revenue projection at the municipal level by observing the factors that touch the revenue of the municipality of Teresina. This projection aims to establish criteria and rules to give reliability and consistency to the estimates of revenues with Own Resource.

The methodology used for the projection of the revenue involves the use of conjunctural indicators published by the Central Bank, via Focus Bulletin, as well as by other national and international institutions. The Gross Domestic Product (GDP) and the Broad Consumer Price Index (IPCA) are the main makers, besides the analysis of elasticity of each revenue in relation to these indicators. However, the impacts resulting from SEMF actions, regulatory changes, and the peculiarities inherent to each of the revenues are projected.

The current year (2020) also includes some exceptional measures adopted at the municipal, state and federal levels to try to mitigate the negative impact on the economy, such as the delayment of the Property Taxes payment due dates, thus maintaining the taxpayer's opportunity to obtain the discount for the single quota payment. And, at the Federal level, through the Recomposition of the FPM - Municipal Participation Fund - (MP 938/2020) and Financial Aid to Municipalities by the Act no 173/2020, due to the public health emergency. Below, the scenarios projected before and during the pandemic, in the latter, considering more conservative and more optimistic circumstances.

- 1. Scenario 1:** The first scenario projected for the 2020 collection, elaborated in July 2019, had as indicators, the GDP growth of 2.3% and the IPCA in 4%, which resulted in a predicted value in the order of R\$1,710,185,635.67.
- 2. Scenario 2:** The second scenario was elaborated in May 2020, during the pandemic. Taking in consideration the economic conjuncture, in the end of 2020 it would have a retraction of 7% in its production and with an inflation (IPCA) of 1.59 0 0. This would result in an estimated amount of R\$1,530,128,092.40 and consequently a reduction of 10.5% in relation to the previously projected.
- 3. Scenario 3:** The third scenario, elaborated at the same time as the partial reopening of the economy, shows a situation of recovery, which aims an improvement in the indicators, with the GDP pointing to -4.8% and IPCA with an expectation of 3.4% resulting in a revenue expectation of around R\$ 1,568,050,953.63

The table "2020 Revenue Projection" shows each scenario described added to the extra resources, which served to soften the negative effect of the pandemic on the economy of states and municipalities. For the municipality of Teresina in specific, there is an amount of R\$ 111,326,219.44 of extraordinary resources. Being R\$ 39,610,331 through the Recomposition of the FPM (MP 938/2020) and Financial Aid to Municipalities by national Act.

Revenue Projection 2020			
Scenarios	Projected	Extra Resources	Total in each scenario
Scenario 1	1.710.185.635,67	---	1.710.185.635,67
Scenario 2	1.530.128.092,40	111.326.219,44	1.641.454.311,84
Scenario 3	1.568.050.953,63	111.326.219,44	1.679.377.173,07

* This document has been translated from Portuguese to English by the CRGP.
The original document in Portuguese is annexed and signed in the following pages.

28/10/2020

SEI/PMT - 1296775 - Despacho



ESTADO DO PIAUÍ
 Prefeitura Municipal de Teresina
SEMF - Secretaria Municipal de Finanças

Despacho 29/2020 - ASS-TEC-SEMF

Teresina, 27 de outubro de 2020.

Ao Gabinete SEMF

Em atenção ao solicitado através do Ofício N° 1355/2020 - GAB-SEMPPLAN (1212460) proferido no Processo SEI n° 00046.002668/2020-18, e ao despacho 714/2020 - CERM-SEMF (1254824), seguem os dados referente ao impacto financeiro da pandemia de COVID na economia do Município de Teresina explanando sobre as projeções de receita para o ano de 2020.

Tendo em vista a atual conjuntura mundial, onde se vive uma realidade de crise econômica, relacionada à pandemia do novo coronavírus (Covid-19) tornando mais incerta as projeções de receita, a SEMF busca realizar análise com o objetivo de mensurar de forma técnica o impacto na arrecadação a nível municipal observando os fatores que tangem a receita do Município de Teresina. O trabalho de Projeção, visa estabelecer critérios e regras com o intuito de dar confiabilidade e consistência as estimativas de receitas com Recurso Próprio.

A metodologia utilizada para a projeção da receita envolve o uso de indicadores conjunturais divulgados pelo Banco Central, via Boletim Focus, bem como por outras instituições nacionais e internacionais, tendo como principais balizadores da projeção, o Produto Interno Bruto (PIB) e o Índice de Preços ao Consumidor Amplo (IPCA), além da análise de elasticidade de cada receita em relação a estes indicadores. Não obstante, são projetados os impactos resultantes de ações desenvolvidas no âmbito da SEMF, alterações normativas, e as peculiaridades inerentes a cada uma das receitas.

O ano corrente (2020) conta ainda com algumas medidas excepcionais, adotadas tanto pela esfera municipal, como pela esfera estadual e federal para tentar amenizar o impacto negativo na economia, como a prorrogação da data de vencimento do pagamento do IPTU e do IPVA, mantendo assim a oportunidade de o contribuinte obter o desconto do pagamento pela cota única. E, em âmbito Federal, através da Recomposição do FPM (MP 938/2020) e auxílios Financeiro aos Municípios pela LC n°173/2020, em razão da emergência de saúde pública. Abaixo, os cenários projetados antes e durante a pandemia, neste último, considerando circunstâncias mais conservadoras e mais otimistas.

1. Cenário 1 - O primeiro cenário projetado para a arrecadação de 2020, elaborado em julho de 2019, tinha como indicadores, o crescimento do PIB 2,3 % e o IPCA em 4% que resultou em um valor previsto na ordem de **R\$1.710.185.635,67**.
2. Cenário 2 - O segundo cenário foi elaborado em maio de 2020, já durante a pandemia, considerando que a conjuntura econômica teria ao final do ano, uma retração de 7% na sua produção e com uma inflação (IPCA) de 1,59%, que resultaria no montante previsto em **R\$ 1.530.128.092,40**, que resultando numa redução de 10,5% frente ao projetado anteriormente.
3. Cenário 3 - O terceiro cenário, elaborado concomitantemente a reabertura parcial da economia mostra uma situação de recuperação, tendo em vista uma melhoria dos indicadores, com o PIB apontando para -4,8% e IPCA com expectativa de 3,4% resultando uma expectativa de receita na ordem de **R\$ 1.568.050.953,63**

O quadro “Projeção de Receita 2020” mostra cada cenário descrito somado aos recursos extras, que serviram para suavizar o efeito negativo da pandemia na economia dos Estados e Municípios. Para o município de Teresina em específico, foram repassados até outubro de 2020 o montante de R\$

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111.326.219,44 de recurso extra. Sendo R\$ 39.610.331,32 através da Recomposição do FPM (MP 938/2020) e R\$ 71.715.888,12 de auxílios Financeiro aos Municípios pela LC nº173/2020.

Projeção de Receita 2020			
Cenários	Projetado	Recurso Extra	Total em cada Cenário
Cenário 1	1.710.185.635,67	-	1.710.185.635,67
Cenário 2	1.530.128.092,40	111.326.219,44	1.641.454.311,84
Cenário 2	1.568.050.953,63	111.326.219,44	1.679.377.173,07



Documento assinado eletronicamente por **Taffarel Francisco Oliveira Soares, Assessor Técnico**, em 27/10/2020, às 12:44, com fundamento no Decreto nº 18.316/2019 - PMT.



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Referência: Processo nº 00046.002668/2020-18

SEI nº 1296775

Praça Mal. Deodoro, 860 - Bairro Centro - Palácio da Cidade - CEP 64000-160 - Teresina - PI
- <http://semf.teresina.pi.gov.br/>

Annex V

Climate Change Projections for Teresina

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Annex V

Climate Change projections for Teresina

Future climate change and expected impacts and vulnerability in the Teresina city (Brazil) by the end of the 21st century

The Teresina City (the capital of Piauí Province, Brazil), located at 72 m a.s.l., in NE part of South-America, has a tropical climate (AW - according to the Koeppen-Geiger classification), with distinct seasons: a dry season (with sweltering weather) between May and December and a wet season between December and May; a hot season between August and November and a cool season between January and June. The city has multiple stressors derived by anthropic activity related to e.g. land use change or exacerbated by the recent climate variability and change. Overall, the city is located in the northeastern part of South-America, a region which experienced an increasing frequency of warm days, warm nights and heavy precipitation and a decrease in dry spell duration and dryness (e.g. Dai, 2011; Donat et al., 2013). Air temperature is already rising in the city due to both climate change and the urban heat island effect.

Methodology

In order to provide a realistic projected climate change signal for a certain local area (i.e. a city), the selected climate models should be able to reproduce the local climate patterns. This implies that commonly used global circulation models (GCM) used in the IPCC report, with a typical spatial resolution smaller than 1° (>100km) cannot be directly used on impact assessments. Instead, regional circulation models (RCM) simulate the climate for a certain part of the globe, usually a continent, with a much higher spatial resolution. This higher resolution allows a more accurate reproduction of the surface elevation and in turn a more realistic simulation of the small-scale climate patterns of specific locations on Earth. Still, RCMs require GCMs as boundary conditions for their simulations. Thus, each climate projection is generated by a regional model driven by a global model. The combination of different RCMs and GCMs provides a broad ensemble of plausible future projections which in turn allows the computation of robust statistics for the estimation of the climate change signal.

Here, we use a multi-model ensemble of 4 regional climate projections from the South-America CORDEX domain with a spatial resolution of 0.22° (~22km) and a daily temporal resolution (see Table 1). Projected changes describe the possible future evolutions of the local urban climate for the next 80 years, over three time horizons (near future - 2011-2040; mid-future - 2041-2070; and far-future - 2071-2100), relative to the 1980-2000 baseline climate. The projections cover the expected changes in air temperature (mean, maximum and minimum), precipitation and some associated extremes defined below.

The output of any climate model should be always adjusted with observations in order to assure it represents the observed statistics of the past climate and thus gain confidence on the projections for the future climate. In this assessment we have corrected the annual mean bias of each of the climate models before generating the multi-model ensemble. We have used as observational reference the commonly used ERA5 reanalysis from the ECMWF.

Projection	Driving global circulation model	Regional circulation model
1	MOHC-HadGEM2-ES MetOffice Hadley Center, UK	REMO2015 Climate Service Center, Germany
2	NCC-NorESM1-M Norwegian Climate Centre, Norway	REMO2015 Climate Service Center, Germany
3	NCC-NorESM1-M Norwegian Climate Centre, Norway	RegCM4-7 National Center for Atmospheric Research, USA
4	MPI-M-MPI-ESM-LR Max Planck Institute for Meteorology, Germany	REMO2015 Climate Service Center, Germany

Table 1: List of the regional climate models used in this assessment together with the scientific developing institutions. Each climate projection is generated by a specific RCM driven by a specific GCM.

Two different emission scenarios are considered corresponding to the marginal IPCC-AR5 Representation Concentration Pathways (RCPs): On the one hand, the RCP2.5 represents a stringent mitigation scenario which implies a major change in the global socio-economical system in order to reduce net global CO₂ emissions to 0 by year 2050. RCP2.5 aims to maintain mean global warming below 2°C. On the other hand, the business as usual scenario is represented by RCP8.5 accounting for a pathway without additional efforts to constrain emissions.

While average values of temperature and precipitation show a significant change in climate projections, it is the change in the occurrence and intensity of climate extremes (within daily time scales) where the future projections show a more drastic alteration relative from the historic period. Climate extreme indices used in this assessment follow the next definitions.

- Tropical nights (TR): It is the average number of days per season which daily minimum temperature is above 20°C.
- Heat wave (HW): A heat wave is defined for each season as a persistent warm event of consecutive days having maximum temperature above the percentile 90th of the corresponding season from the reference period (here during 1980-2000).
- Heat wave duration (HWD90): It is the average duration in days of heat waves per season - Heat wave number (HWN90): It is the average number of heat waves events per season. - Dry spell duration or Consecutive dry days (CDD): It is the number of consecutive days with daily precipitation below 1mm/day per season.
- Wet spell duration or Consecutive wet days (CWD): It is the number of consecutive days with daily precipitation above 1mm/day per season.
- Heavy precipitation (R10mm): It is the number of days with daily precipitation above 10mm/day per season.
- Very heavy precipitation (R20mm): It is the number of days with daily precipitation above 20mm/day per season.
- Maximum seasonal daily precipitation (Rx1day / Rx5day): It is the maximum amount of daily precipitation during 1 or 5 consecutive days per season.

Air Temperature and Temperature Extremes

Annual mean temperatures are expected to increase significantly for both scenarios (RCP2.6 and RCP8.5) although with a clear distinction between them (figure 1). In the most favorable scenario (RCP2.6) a consistent temperature increase is observed until mid-century where the maximum positive change around

slightly above 1°C is observed. Note that this maximum in mean temperature matches the moment where the greenhouse emissions are imposed to remain neutral under this scenario. A weak temperature decrease is observed during the second half of the XXI century ending with a mean temperature change just below 1°C. On the contrary, under the RCP8.5 scenario, a constant warming is clearly evident during this whole century. The change in the annual mean temperature by 2100 reaches 4°C with the multi-model ensemble minimum around 3°C.

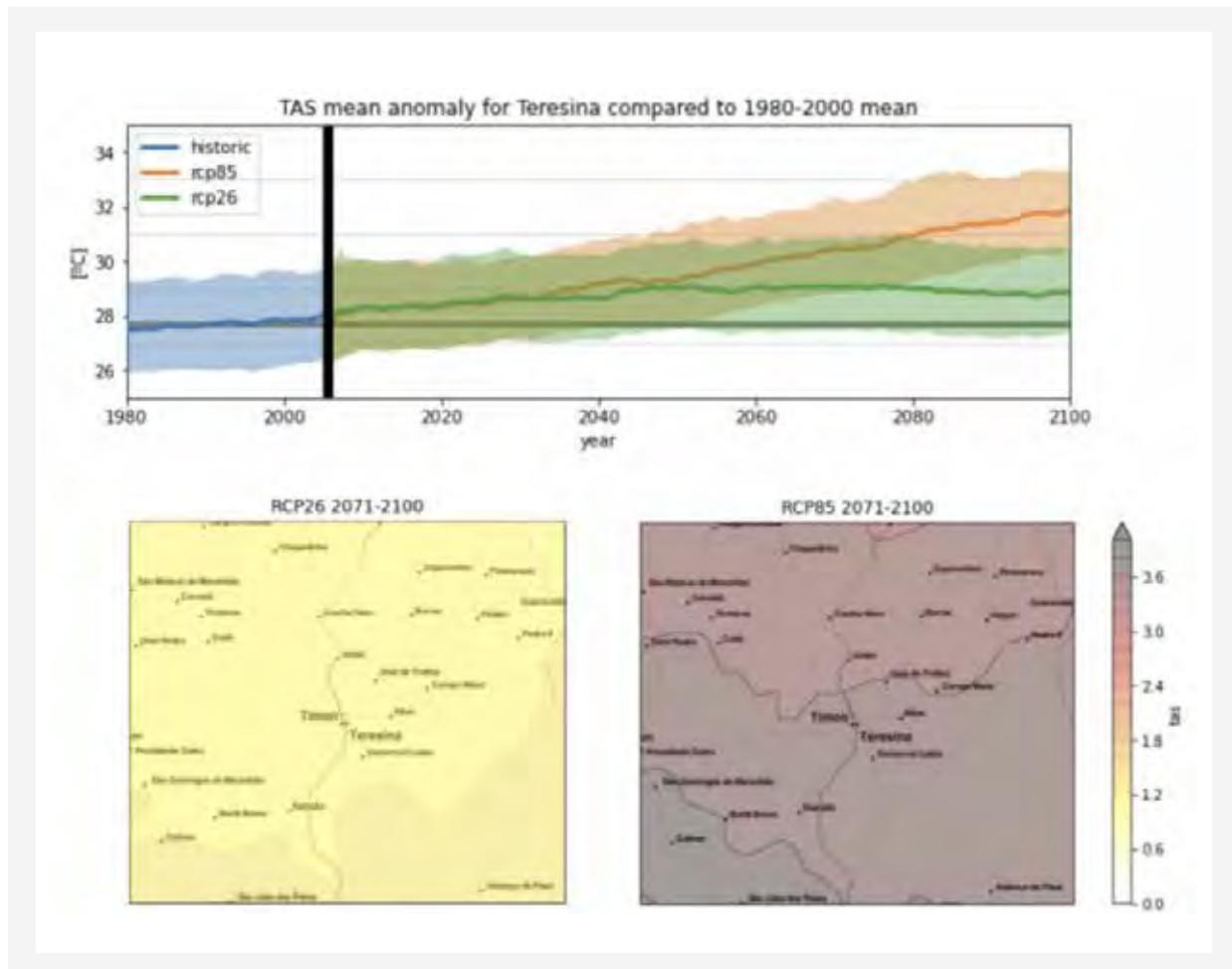


Figure 1: Top panel: Time series of the projected annual mean surface temperature [°C] in Teresina during XXI century for the two scenarios (RCP2.6 and RCP8.5). Shaded coloured area represents the region between the minimum and maximum values within the multi-model ensemble. This interval provides an estimation of the uncertainty related to the natural variability, i.e. the interannual variation for a given year may fall within this shaded area. Horizontal grey line indicates the average annual temperature for the historical period. Bottom panel: Projected annual mean change in surface temperature [°C] for period 2071-2100 with respect to the reference period (1980-2000) for the two scenarios. Positive values indicates an increase in temperature in the future. Source: Lobelia.

Monthly mean temperatures in Teresina are projected to increase slightly throughout the year under the low emission scenario (RCP2.6) by 0.6°C to 1.1°C by the 2040s, 0.9°C to 1.8°C by the 2070s and 0.8°C to 1.4°C by the end of 2100. The climate projections forced by RCP2.6 indicate that the largest warming in the Teresina area is expected in the mid-future (2041-2070). Under the high emission scenario (RCP8.5), mean temperatures are projected to increase dramatically, especially in the mid- (2041-2070) and far-future (2071-2100), by 1.7° to 2.9°C and 2.6° to 4.8°C, respectively. Regardless of the selected scenario, largest warming is projected between June and December in the target area (especially in November and December), making the hot season of the year longer and even hotter than in the present climate (Fig. 2). The days and the nights in the city are expected to become particularly hot exacerbating the heat stress and bioclimatic discomfort. Daytime heat stress is projected to increase considerably at the end of the hot season in the area, due to an estimated increase in the maximum temperatures of up to 2.0°C under RCP2.6 in December (2041-2070) and up to 4.7°C under RCP8.5 in November (2071-2100). Comparatively, during nighttime, the augmentation of future heat stress is also important especially in November, in response to an estimated increase in minimum temperatures of 1.5°C under RCP2.6 (2041-2070) and 4.6°C under RCP8.5 (2071-2100).

An additional indication of heat stress augmentation with climate change is provided by the record maximum monthly temperatures which are projected to increase notably under the high emission scenario (RCP8.5), especially in the far-future time horizon (2071-2100). The interval between June and December (overlapping most of the hot season under present climate conditions) is projected to experience the largest increases, from 4.1°C in June and September to 4.6°C in December, which will determine record daytime temperatures of over 36° (July) or even 40°C (August to December), well-above those in the historical period.

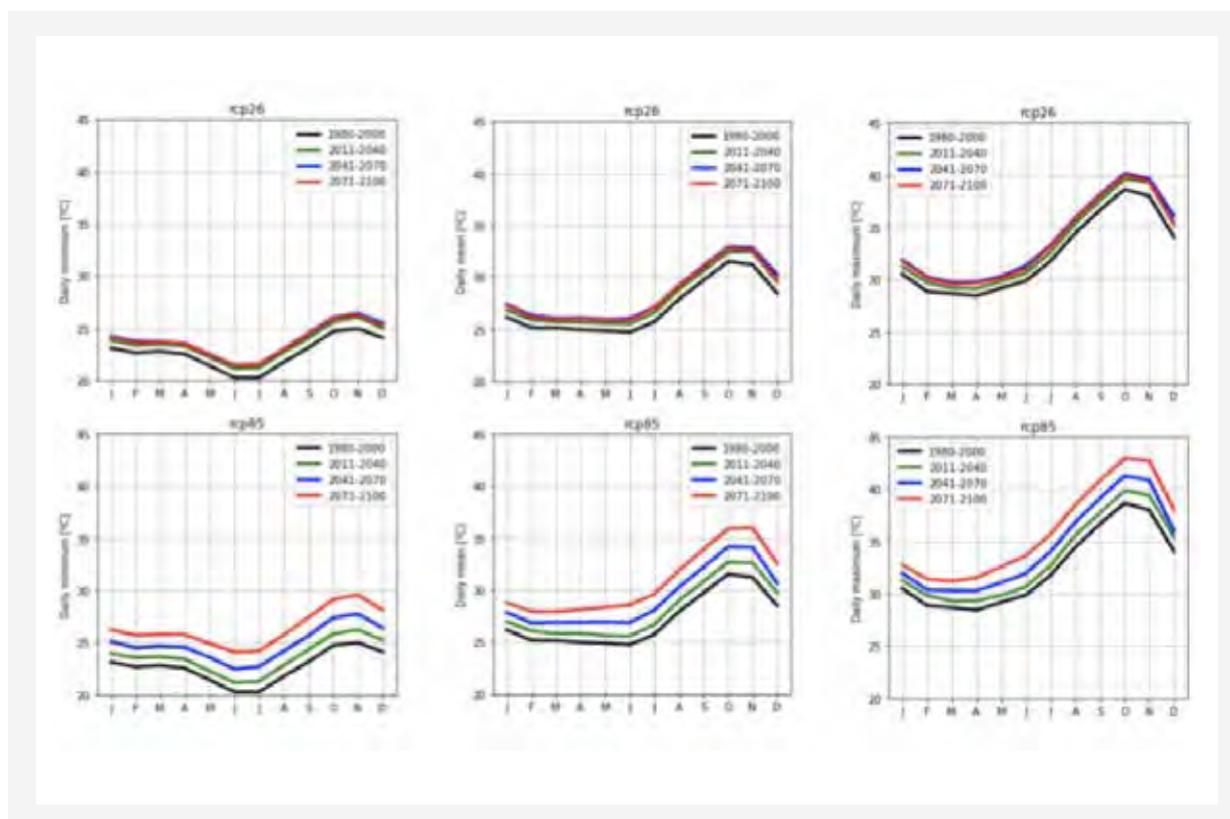


Figure 2: Projected change of the seasonality for the surface temperature daily minimum (left), daily mean (center) and daily maximum (right) for different periods and scenarios. Source: Lobelia.

Over the June-August interval (the best tourist visiting period of the year), mean temperature will rise up to 1.4°C under the low emission scenario and up to 3.8°C under the high emission one and increasing exposure to hotter-humid weather is expected both daytime and nighttime. By the end of the 21st century, mean monthly temperatures of October (the warmest month of the year) are projected to reach values of up to 33°C under RCP2.6 and 36°C under RCP8.5. For the coldest month of the year (February), mean temperature rise is projected to increase moderately, up to values of 26°C under RCP2.6 and about 29°C under RCP8.5.

A dramatic increase in the frequency and duration of hot weather extremes is expected in the area of Teresina city.

The frequency of tropical nights (daily minimum temperatures over 20°C) in Teresina will increase at the beginning of the hot season (between June and August) with 12-13% (corresponding to an average increase of 12-14 tropical nights more during the hot season) under the low-emission scenario and between 12 to 18% (corresponding to 12-18 nights) under the high-emission scenario (Fig. 3). This change is expected to contribute to the increase of nighttime heat stress and bioclimatic discomfort across the city already augmented by the heat island effect. Throughout the rest of the year, tropical nights will also become more.

frequent but the change signal is visibly weaker under both emission scenarios: 1.4-1.6% between March and May, about 1.2% from December to February and about 0.1% between September and November over the last two thirds of the century (RCP2.6); 0.8 to 2.2% between March and May, 1.2% between December and February over the same future time horizons (RCP8.5). It worth mentioning, that under both emission scenarios, the frequency of tropical nights in Teresina is projected to increase the least over the March-May interval (0.2% under RCP2.6 and 0.8%, under RCP8.5) or even to decrease slightly in the far-future (with no more than 1.4%) between December and February (at the end of the cool season) and from September to November (at the end of the hot season).

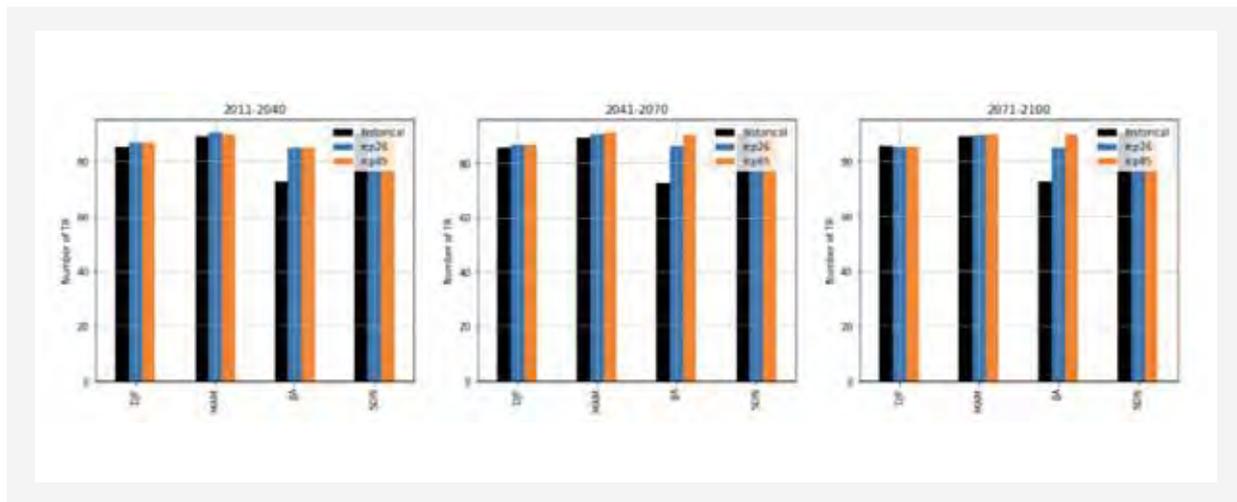


Figure 3: Average number of tropical nights per season for different periods and scenarios. A tropical night is defined as a day with a minimum temperature above 20°C. It can be seen that for Teresina, climate projections show a quasi permanent occurrence of tropical nights along the whole year. Source: Lobelia.

Heat waves events represent one of the more evident impacts of global warming. As described in the methodology, heat waves are defined as persistent warm episodes that surpass a certain threshold defined from the historical period (1980-2000) climate. In a warmer climate, this constant threshold will be exceeded systematically as clearly shown in figure 4. The occurrence of heat waves during the reference period was below 0.3 events per season with a weak seasonality. For the projected future the huge increase of extreme warm events is alarming. The number of heat waves will grow up to an occurrence of 0.5 to more than 2 events per season. This represents an increase factor between 2 to 10 times with respect to the reference period. Interestingly this increase will happen under the two scenarios. The number of heat waves (persistent time intervals of extreme daytime heat) is on a slight increase by the end of the 21st century, with no evident changes between the two scenarios. The projected change in heat wave frequency is of +1-2 cases per season in both scenarios. Largest increases are expected over the September-November interval (at the end of the hot season), in all the three future time-horizons (RCP2.6), as well as from December to August by 2070s and by the end of 2100 and from September to November by 2041-2070 (RCP8.5).

But the most dramatic change related to heat waves can be seen from the duration of these events. Figure 4 shows that heat waves will last from an average of a few days at the end of the last century to far beyond 10 days during the hot season in the second half of the XXI century. Actually, under the rcp8.5 from 2040 onwards, more than half of the hot season (from June to November) will become a permanent heat wave considering the definition of what a heat wave was in the XX century. Climate projections suggest that heat waves in the city of Teresina will increase considerably in duration. Most visible upwards are expected at the end of the hot season, from September to November, under both scenarios, in the range of 10 to 21 days under RCP2.6 and of 17 to 75 days under RCP8.5 (Fig. 4). As previously shown, the 2041-2070 (RCP2.6) and 2071-2100 (RCP8.5) are the future time-horizons in which the change in heat wave duration is projected the largest. Heat waves will become more persistent throughout the entire year, but the expected change is lower than that estimated for the September-November interval. Under RCP2.6 these changes are generally below 12 days under RCP2.6. The high emission scenario shows a different picture especially for the mid- (2041-2070) and far-future (2071-2100), when the increasing rates of heat wave duration maintain large enough also during the cool season of the year, covering the January-June interval (14 to 28 days in the mid-future and 30 to 62 days in the far-future).

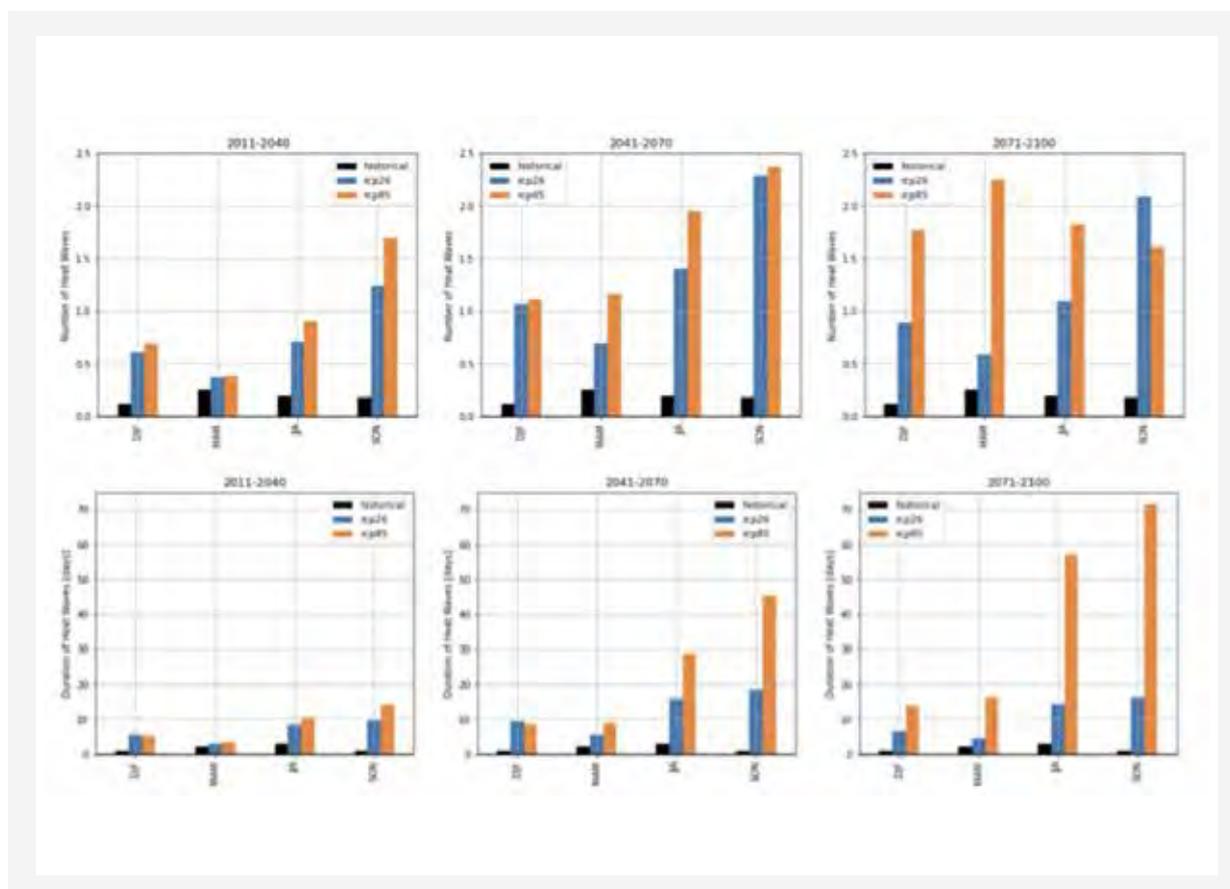


Figure 4: Average number (top) and duration in days (bottom) of heat waves for different periods and scenarios. Source: Lobelia.

Precipitation and Precipitation Extremes

Projected changes for precipitation are not as significant as for temperature in the area of Teresina (figure 5). show in general a reduction on the average daily precipitation in both scenarios. However this reduction mainly occurs during the dry season while the projected change during the wet season especially under the RCP8.5 precipitation shows a positive sign and a larger absolute value (figure 6). By 2100, change in precipitation intensity range between -33.6% to +6.6% under RCP2.6 and between -93.7% and +23.3% under RCP8.5.

In the future, Teresina will face less precipitation throughout most of the year under both emission scenarios. Under RCP2.6, the wet season in the area (December to May) will accumulate less precipitation than in the present-day conditions, especially at its onset with peak decreases over 2041-2070 (December -22.8%). In this scenario, some small increases are also expected, but only in the near-future (2011-2040), which are less than 10%: in March (+6.6%) and January (+2.0%). The dry season of the year (generally lasting from May to December) is expected to grow even drier, particularly in June (with a peak decrease of -30.6% over 2041-2070) and toward its end in September-October (e.g. the peak decrease for September is of -44.3% over 2071-2020, while that of October is of -41.5% over 2041-2070).

The projections under RCP8.5 scenario indicate a different picture of future precipitation evolution in the target area. The dry season is expected to become considerably dry in the mid- and far-future, with peak precipitation decreases in June (44 to 53%) and October (73 to 94%). During the wet half of the year (December to May) precipitation is projected to increase between January and March in the near-future (2.9 to 4.2%) and mid-future (0.9 to 16.4%) and over January-February interval in the far-future (11.8 to 23.3%). In other words, the mid part of the wet season in Teresina is expected to become wetter under RCP8.5, especially over the last two thirds of this century.

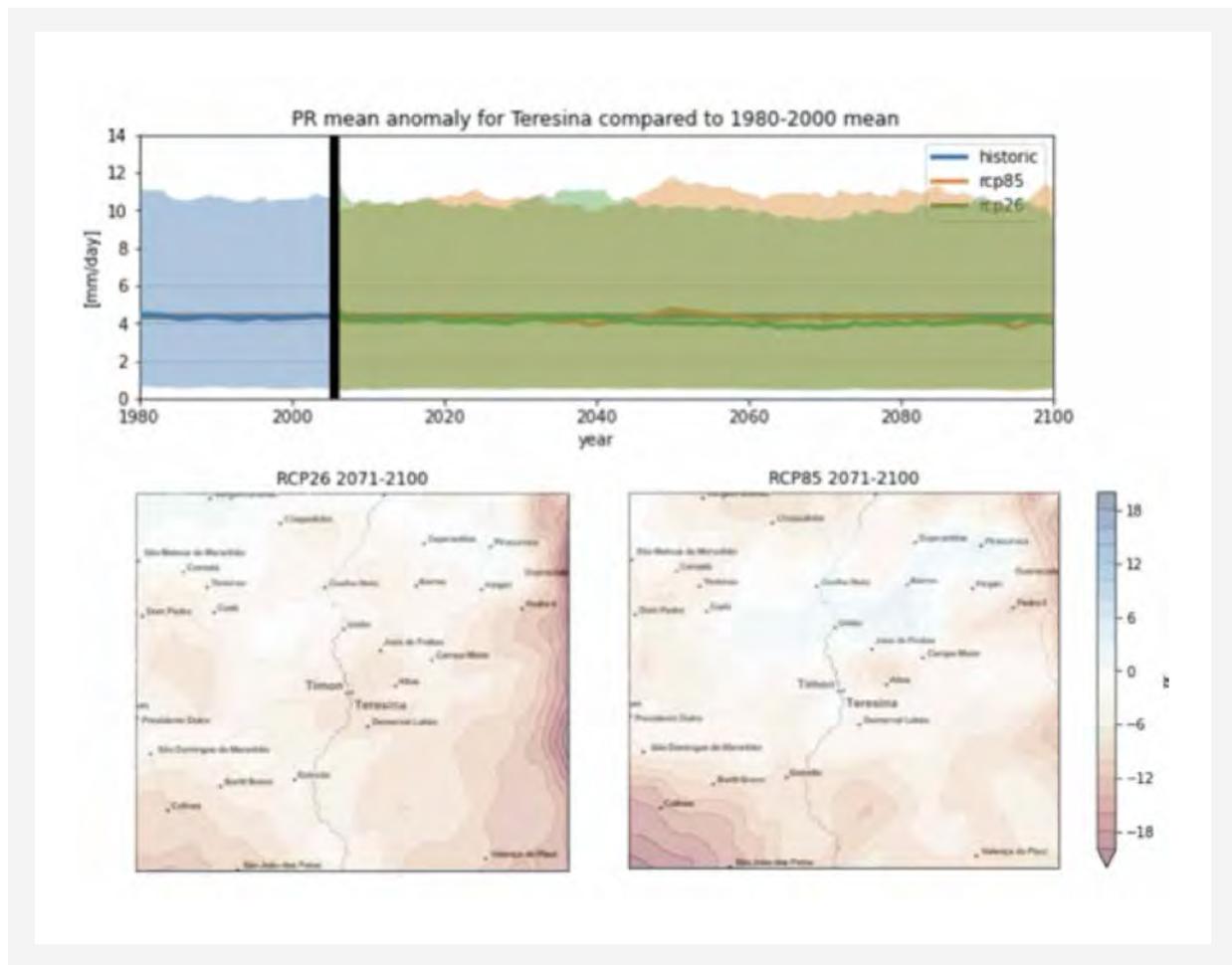


Figure 5: Top panel: Time series of the projected annual mean daily precipitation [mm/day] in Teresina during XXI century for the two scenarios (RCP2.6 and RCP8.5). Shaded coloured area represents the region between the minimum and maximum values within the multi-model ensemble. This interval provides an estimation of the uncertainty related to the natural variability, i.e. the interannual variation for a given year may fall within this shaded area. Horizontal grey line indicates the average annual precipitation for the historical period. Bottom panel: Projected annual mean percentual change in precipitation [%] for period 2071-2100 with respect to the reference period (1980-2000) for the two scenarios. Negative values indicates less precipitation in the future. Source: Lobelia.

Again, the climate average projected changes described for the average daily precipitation (figure 5 and 6) contrast with the significant expected changes for extreme precipitation events. An increase in the duration of dry spells (resulting from time-spans of consecutive days without precipitation) is expected in the area throughout the entire year, under both scenarios (Fig. 7). Largest positive changes are expected from December to May (the dry season) in the mid-future (2041-2070) under RCP2.6 (19 to 26%) and far-future (2071-2100) under RCP8.5 (27 to 30%). A slight increase in dry spells is also projected during the wet season, between September and November, of about 5% under RCP2.6 and in the range of 10 to 12% under RCP8.5. Further indication regarding this future drying climate trend is given by the future evolution of wet spell duration (time-spans of consecutive days with rainfall) by the end of the 21st century (not shown). Teresina will experience a generalized decrease in the maximum number of consecutive wet days over the year, with up to 10-20% in the mid-future (RCP2.6) and 10-46% in the far-future (RCP8.5). Largest changes are expected from September to November under both scenarios.

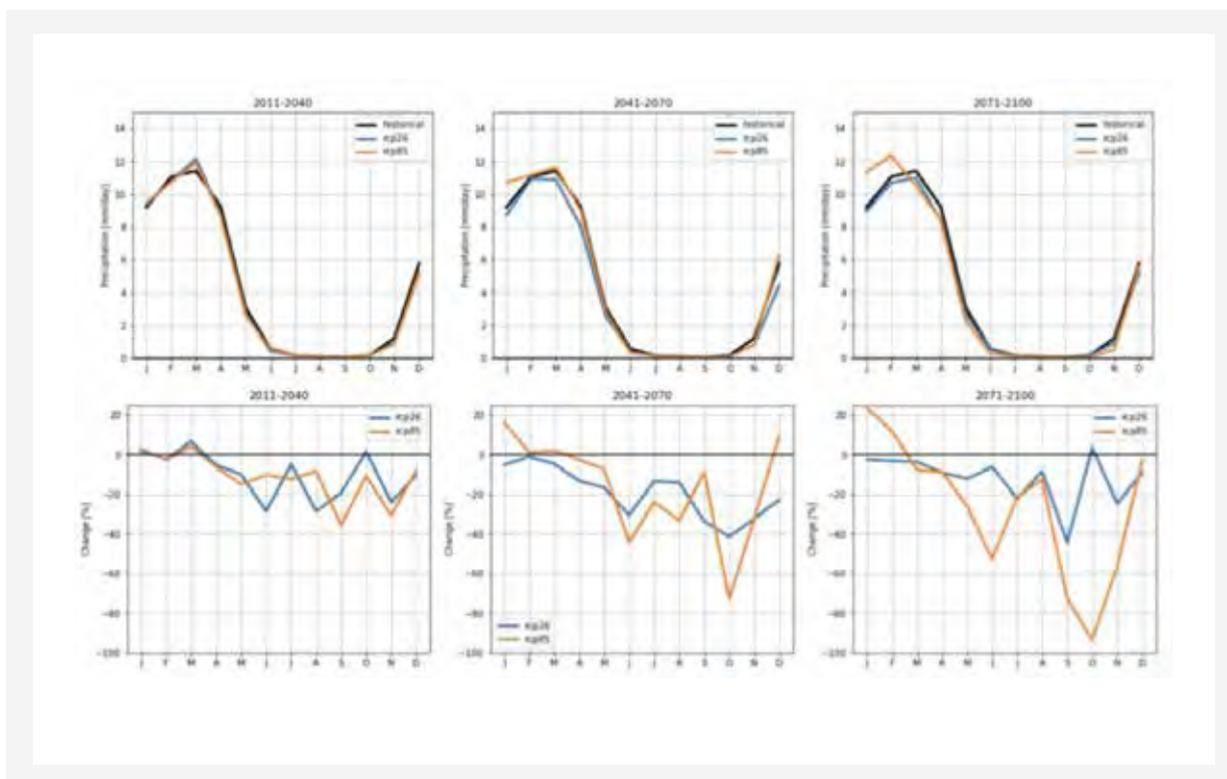


Figure 6: Seasonal cycle of the projected daily precipitation [mm/day] in Teresina (top) and relative change [%] with respect to the historical period [bottom] for the two scenarios (RCP2.6 and RCP8.5) and different periods. Source: Lobelia.

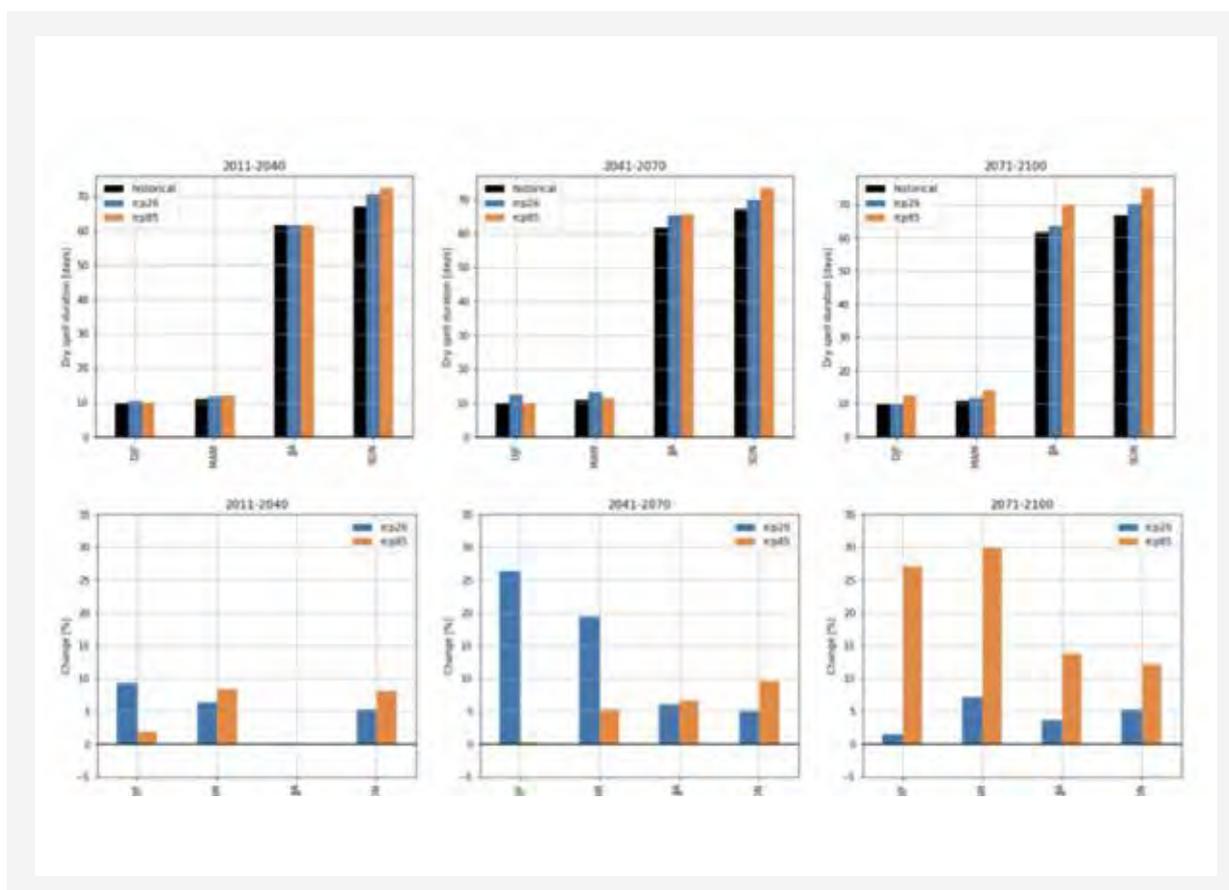


Figure 7: Average duration of dry spells [days] in Teresina (top) and relative change [%] with respect to the historical period [bottom] for the two scenarios (RCP2.6 and RCP8.5) and different periods. Source: Lobelia.

Projected extreme precipitation events show a marked contrast with the general dryer climate expected for Teresina during next decades. In general, Teresina will face less frequent abundant rainfalls (of over 10 mm or 20 mm/day) during the dry season but the contrary during the wet season. It is important to highlight in terms of climate risks the impact of this intensity increase in heavy precipitation during the wet season in comparison with the also significant but less sensible reduction of extremes during the dry season.

The decrease will affect especially those months of both hot-dry season (June to November) when heavy rainfall events will become visibly rarer both in the near- (with decreases in the range of 13 to 65%) and mid-future (32 to 44%) under RCP2.6, as well as in the mid- (35 to 71%) and far-future (24 to 64%) under RCP8.5. However, over the December to February interval (the beginning of the wet season), it is projected that Teresina will be affected by an increase in the frequency of heavy precipitation events. The trend towards an increasing torrentiality of rainfalls in this interval was projected in the mid- and far-future of both scenarios, but it is stronger under RCP8.5 (14 to 18% increase in the frequency of heavy rainfall events of at least 20 mm per day) (not shown).

The future trend of increasing rainfall torrentiality over December-February is also suggested by the projections of the maximum 1-day and 5-days precipitation in both scenarios (figure 8). The future trends of these extreme precipitation indices are more pronounced in the mid- and far-future projections with the RCP8.5, ranging between 20-45% for the maximum 1-day precipitation amounts and between 16-34% for the maximum 5-day precipitation. For RCP2.6, the projected upwards are generally below 14%. Outside this time interval of the year, slighter increase (below 10%) in such extreme precipitation amounts are also expected at the end of the wet season (from March to May).

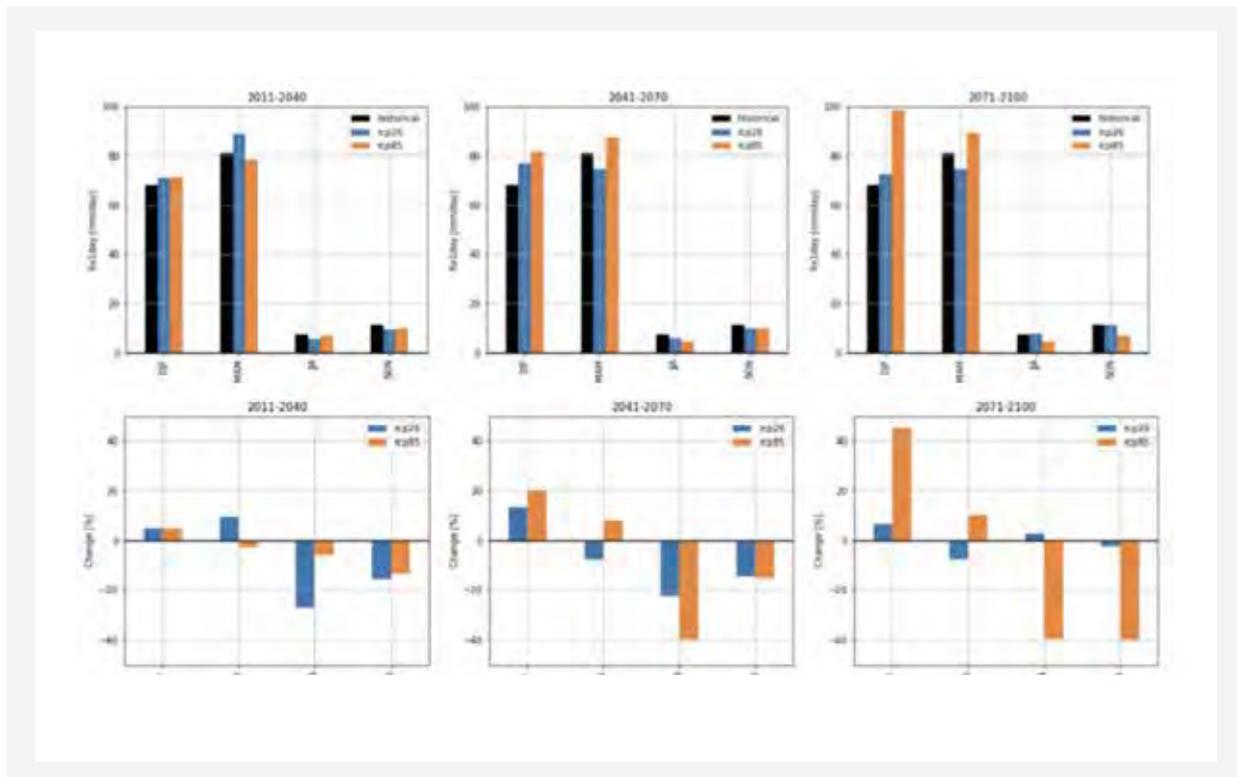


Figure 8: Average maximum daily precipitation for each season [mm/day] (top) and relative change [%] with respect to the historical period [bottom] for the two scenarios (RCP2.6 and RCP8.5) and different periods. Source: Lobelia.

Key Messages

In summary, the key future climate changes in Teresina City indicate that:

- The local climate will grow warmer and drier throughout most of the year;
- Local warming will be significant both during nighttime and daytime;
- Heat waves will become more frequent and much more persistent;
- Warm (tropical) nights will become very frequent in most months of the year, especially at beginning of the hot season (June to August interval);
- The dry season will become drier and hotter;
- The hot season will become hotter, longer and drier (especially in June, September and October); - Precipitation will decrease throughout most of the year under both emission scenarios; - Dry spells will become more persistent favouring the gradual transition towards a drier local climate;
- The frequency of heavy rainfall events and the extreme rainfall amounts in time sequences of 1 and 5 days will significantly increase (20%-40%) over the December to February interval (the beginning of the wet season), especially in the mid- and far-future under RCP8.5; a slight increase in the extreme precipitation amounts is also expected at the end of the wet season (from March to May).

Expected Future Impacts and Vulnerabilities in Teresina Due to Climate Change

Future climate change is expected to aggravate the existing environmental, health and urban problems and to increase risk, especially for communities already living in vulnerable conditions.

- Increasing heat-health risks, due to the augmented heat stress and urban heat island effects, in response to the significant temperature increase both daytime and nighttime; additional risks for residents and tourists is expected to be posed by the increasing frequency of warm (tropical) nights and heat wave duration;
- Climate is one important driver of the current distribution and incidence of dengue fever (Menezes et al., 2014), as well as a significant co-factor for malaria (Githeko et al., 2000). Important epidemics in Teresina were observed in the periods 1983-1985 and 1992-1994, that coincided with major droughts caused by El Niño. As the climate of Teresina will grow generally drier by 2100 and the frequency of heavy precipitation days and extreme precipitation amounts are expected to increase, a likely to increase in the exposure to dengue and malaria disease is possible in the future. However, other factors (e.g. individual behavior, immunity and socioeconomic factors), showing non-linear relationships with the disease incidence, together with the effectiveness of implemented preventive measures such as vaccination campaigns, disease surveillance and vector control might be more relevant in understanding the seasonal timing of outbreaks under the future climate.
- Through its location, at the confluence of the Parnaíba and Poti rivers), Teresina is expected to face an increase of urban (fluvial) flooding in response to the projected increases of torrential rainfalls (e.g. heavy precipitation days with at least 20 mm and extreme rainfall amounts in 1 and 5 consecutive days) projected at the beginning of the wet season (from December to February). The future flooding risk is expected to be high in the areas with high social vulnerability under the present climate conditions. Along with, the contamination level of local water rivers and of soils in their adjacent areas (floodplains) is expected to maintain high in the light of the projected increase of rainfall torrentiality, if the waste management in Teresina will continue to be deficient.
- On the other hand, the increasing duration of dry spells is likely to hydrological and agricultural implications, through more occurrences of hydrological drought events, deficiencies in water supply and decreased soil moisture.

References

- Dai A.** (2011), Drought under global warming: a review. *Wiley Interdisciplinary Reviews: Climate Change*, 2(1), p. 45-65.
- Donat M.G., L.V. Alexander, H. Yang, I. Durre, R. Vose, R.J.H. Dunn, K.M. Willett, E. Aguilar, M. Brunet, J. Caesar, B. Hewitson, C. Jack, A.M.G. Klein Tank, A.C. Kruger, J.A. Marengo, T.C. Peterson, M. Renom, C. Oria Rojas, M. Rusticucci, J. Salinger, A. Sanhouri Elrayah, S.S. Sekele, A.K. Srivastava, B. Trewin, C. Villarreal, L.A. Vincent, P. Zhai, X. Zhang, and S. Kitching** (2013), Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: the HadEX2 dataset. *Journal of Geophysical Research: Atmospheres*, 118(5), 2098-2118.
- Githeko A.K., Lindsay S.W., Confalonieri U.E., Patz J.A** (2000), Climate change and vector-borne diseases: a regional analysis. *Bulletin of the World Health Organization*, 78(9).
- Menezes T., Pereda P., Alves D.** (2014), Impacts of climate change on dengue risk in Brazil, 54th Congress of the European Regional Science Association: "Regional development & globalisation: Best practices", 26-29 August 2014, St. Petersburg, Russia, European Regional Science Association (ERSA), Louvain-la-Neuve.

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Urban Resilience Diagnosis

TERESINA

This report presents the results of data and information gathering on the urban resilience context of the City of **Teresina**, with the purpose of picturing the city's panorama and most relevant sectoral information.