SUSTAINABLE LIVING

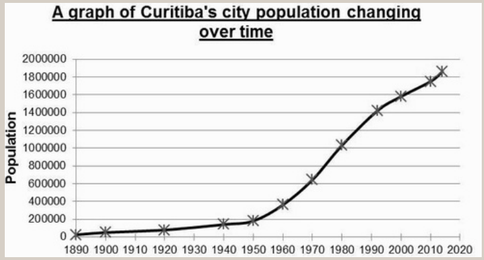
TABLE OF CONTENTS

CURITIBA, BRAZIL

CURITIBA,BRAZIL

POPULATION / LAND AREA

1,750 million / 435 km2 (2010)

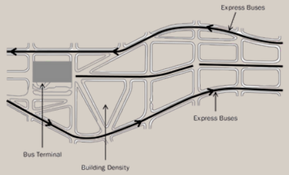


Curitiba is the capital and largest city in the state of Paraná, located in southern Brazil

INNOVATIVE PUBLIC TRANSPORTATION

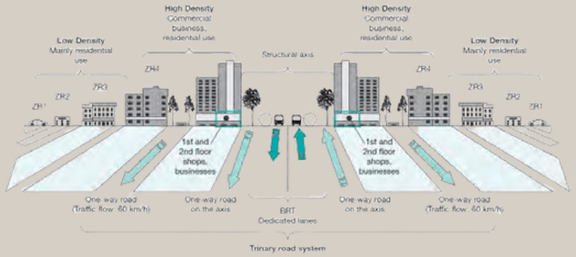
Bus Rapid Transit (BRT)

Known as Rede Integrada de Transporte (RIT), featuring dedicated bus lanes to provide efficient and affordable public transit



Trinary Road System

Central Bus-Only Lanes for Efficient Public Transit

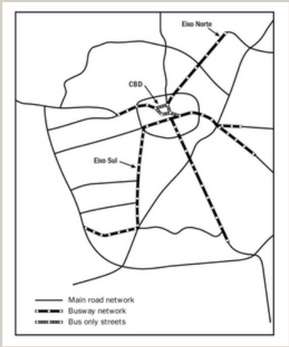


A cross-section of the BRT trunk corridors in Curitiba, Brazil

Flanking One-Way Streets to Enhance Traffic Flow

- **One-way side streets**: Located on both sides of the central bus lanes.
- **Purpose:** Designated for local traffic, including cars and bicycles.
- **Benefit:** Separates traffic types to reduce congestion and improve mobility.

ECONOMIC DEVELOPMENT



System of Bus Services

Industrial City of Curitiba (CIC)

- **Job creation:** Around 50,000 direct jobs and 150,000 indirect jobs.
- **Economic impact:** Significant contribution to Curitiba's local economy.

PIONEERING URBAN PLANNING

Curitiba's Axes: high density zones marked in red

Curitiba Master Plan

- Adoption Year: 1968
- Lead Planner: Architect and urban planner Jaime Lerner

Objectives:

- Manage rapid urban growth
- Integrate transportation, land use, and environmental consideration

Zoning for Density

- Established to guide urban development.

Pedestrian-Friendly Initiatives

Creation of pedestrian-only streets, such as Rua XV de Novembro, to enhance walkability and reduce vehicular traffic in the city center.

Institute for Research and Urban Planning of Curitiba (IPPUC)

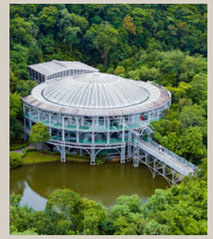
Purpose: To manage, implement, and ensure the continuity of the Curitiba Master Plan.

CULTURAL INSTITUTIONS:

Ópera de Arame (Wire Opera House)

- Known for its unique and innovative architecture
- Located in a lush park setting

- Made primarily of steel tubes and glass
- Hosts concerts, theater, and festivals



Museu Oscar Niemeyer

- Nicknamed the **"Eye Museum"** for its distinctive shape
- Focuses on modern and contemporary art, architecture, and design

- Features works by Oscar Niemeyer
- Hosts rotating exhibitions showcasing creativity and innovation

INTERNATIONAL RECOGNITION

Global recognition

Curitiba is internationally recognized for its sustainable urban development.

Award

Received the Globe Sustainable City Award in 2010.

GREEN INFRASTRUCTURE

Green Infrastructure is a type of infrastructure that integrates vegetation and ecosystems. Their main function is to reduce flooding, manage rainwater, promote biodiversity, make cities cooler and more livable.

Curitiba, Brazil, is widely regarded as a global leader in sustainable urban planning and green infrastructure. The city has pioneered the efficient Bus Rapid Transit (BRT) system, extensive green spaces and nature-based flood control through parks.

Total Green Area: **19.25 km²**

Major Green Spaces: **48**

Green Area / Resident: **52m²**

Major Green Initiatives: **7**

GREEN INITIATIVES

Green Spaces Initiative
In the 1970s, Curitiba faced frequent flooding. As a response, the city converted flood-prone zones into public parks.

Urban Agriculture Program
Established over 150 urban gardens on underutilized public and private lands, particularly beneath power lines.

Green Line (*Linha Verde*) **Project**
A major urban corridor that integrates sustainable transportation with green spaces.

NOTABLE PARKS

Parque Barigui was established in 1972 and park serves as a significant floodplain, mitigating flooding risks from the Barigui River.

Jardim Botânico is a symbol of the city, with a greenhouse inspired by London's Crystal Palace and diverse native flora.

Parque Iguaçu, covering over 8.000.000 m², it plays a crucial role in preserving the Iguaçu River's ecosystem.

HOW CAN GREEN INFRASTRUCTURE MITIGATE NATURAL DISASTERS?

- Curitiba has dozens of parks (e.g., Barigui Park, Tingui Park) built along its flood prone riverbanks. They act as **natural floodplains**, absorbing and holding excess rainwater, preventing it from flooding streets and buildings.

- Parks also include **retention ponds or lakes** designed to fill during heavy rains. They can temporarily **store water**, reducing runoff diverting water to them, easing pressure on storm drains.

- Some green areas and walkways use **permeable paving materials** that allow water to **soak into the ground** rather than running off into streets.
- Tree planting and preserving vegetation on hillsides helps **stabilize soil** and **prevent erosion**. Tree roots anchor the soil, reducing the chance of slope failure during heavy rain.

CHALLENGES

Urban Heat Island effect caused by the lack of green spaces in some areas

Uneven Distribution of Green Spaces, some neighborhood have less access to parks and urban gardens.

Flooding caused by unpredictable rain events are testing the Curitiba's drainage systems and green infrastructure

FUTURE DEVELOPMENT OF GREEN INFRASTRUCTURE

Curitiba, Brazil, is charting an ambitious course for the future of its green infrastructure, building upon its legacy of sustainable urban planning.
PlanClima, the city's comprehensive climate action plan aiming for carbon neutrality by 2050. This plan emphasizes expanding green spaces, enhancing urban biodiversity, and integrating nature-based solutions to address challenges like flooding, heat stress, and air quality.

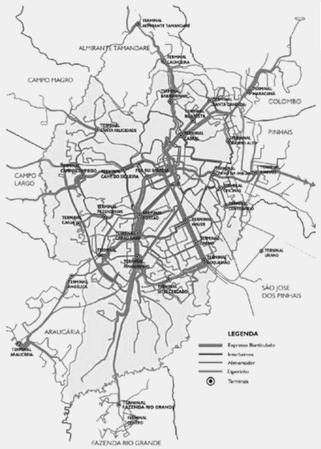
The Solar Pyramid, Latin America's first solar plant on a former landfill, exemplifies the city's commitment to renewable energy and repurposing degraded lands. On top of using it as a solar plant, the previous landfill was also **converted into a green area**, only then was the solar plant established

Additionally, the city is investing in urban agriculture, promoting community gardens and urban farms to enhance food security and reinforce green infrastructure

GREY INFRASTRUCTURE

Curitiba stands out as a global model where grey infrastructure—covering transport, waste, water, and energy—drives sustainable urban growth.

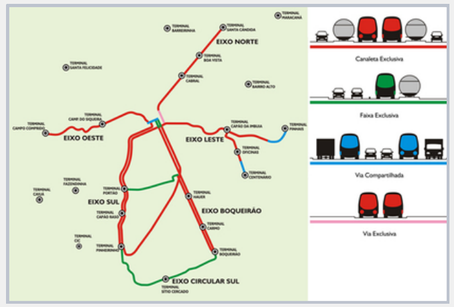
URBAN MOBILITY INFRASTRUCTURE



Urban road network planning

Optimize traffic flow

Reduce congestion



30% less fuel per capita

27 million fewer car trips annually

14% reduction in CO_2 emissions

Bus Rapid -Transit (BRT) system

Transfer terminals
integration with bicycles/pedestrians

- Different bus lines and integrate with pedestrian and bicycle pathways, promoting multimodal transportation.

Operates seven corridors **spanning 74 km**

Serving approximately **721,500 passengers** daily

WASTE MANAGEMENT INFRASTRUCTURE

Waste-for-food/barter programs

- Citizens exchange recyclables for transit tokens, food, or school supplies.
- Enhances social inclusion and environmental awareness.

Decentralized eco-stations and drop-off points

- Makes recycling accessible in low-income areas.
- Reduces informal dumping.

"Lixo que não é lixo" (Trash that is not trash) program

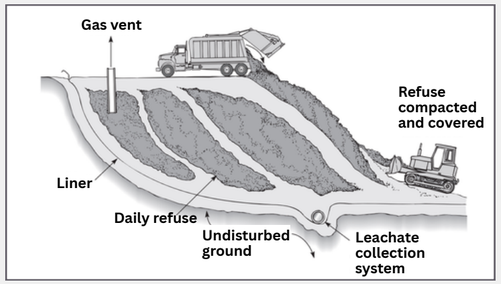
- Citywide recycling education and separation program.
- Residents sort waste into organic and recyclable.

70%

Achieved a **recycling rate of approximately 70%**, significantly higher than the national average.

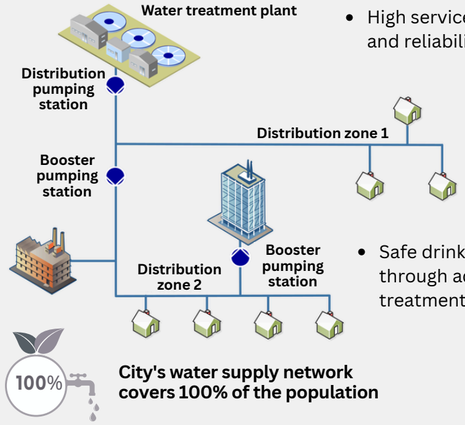
Sanitary landfills with environmental controls

- Employs sanitary landfills equipped with systems to manage leachate and capture methane gas, mitigating environmental impacts.



WATER SUPPLY AND SANITATION INFRASTRUCTURE

Municipal water supply networks



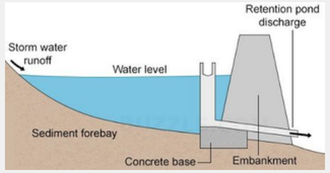
- High service coverage and reliability.
- Safe drinking water through advanced treatment.

100%

City's water supply network covers 100% of the population

Stormwater drainage and retention systems

Retention ponds double as recreational green spaces.

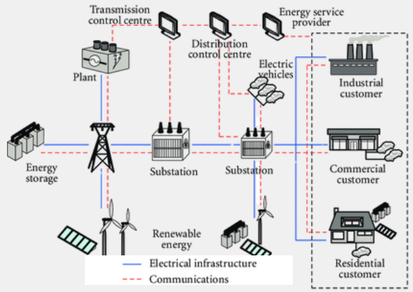


Drainage canals reduce flood risk in heavy rain.

UTILITY AND ENERGY INFRASTRUCTURE

City-wide electrical grid and energy access

- Ensures consistent supply to all sectors including underserved areas.



LED lighting & smart systems

- Efficient public lighting in parks, roads, and public spaces.
- Sensors optimize energy usage.

reduce energy consumption by at least 33%

modernize approximately 157,000 public lighting points with LED luminaires

Solar Infrastructure

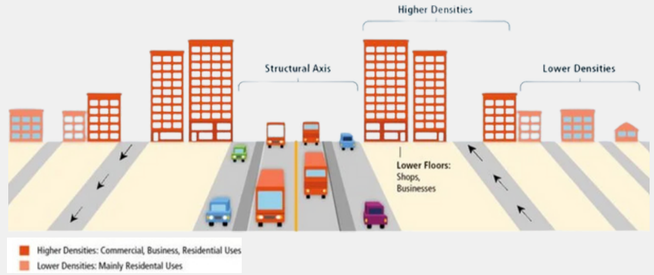
- Curitiba built the first solar plant on a landfill in Latin America and the largest urban solar farm in Brazil.

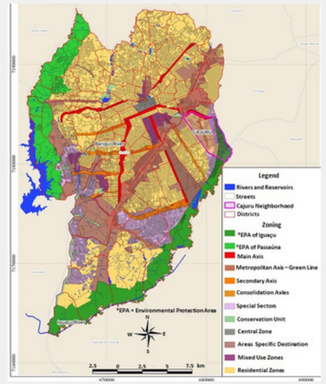
- Includes the Solar Pyramid and rooftop solar panels on public buildings, supporting clean, local energy generation.

LAND USE & URBAN ZONING INFRASTRUCTURE

Transit-Oriented Development (TOD)

- Promotes high-density development along BRT lines.
- Encouraging the use of public transportation
- Encourages car-free lifestyles and mixed-use growth.





Mixed-use zoning

- Combination of residential, commercial, and institutional functions within the same area.

Reduces travel distances

Boosts local economies

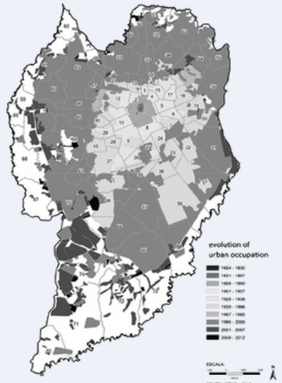
Encourages walkability

Affordable housing with infrastructure access

- Low-income residents have access to public services and mobility.

BLUE INFRASTRUCTURE

WATER SOURCES

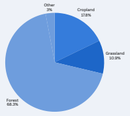


PRIMARY WATER SOURCE

- Iguazu River - greatest volume of raw water for treatment and distribution

WATER SOURCES

- GROUNDWATER
- SURFACE
- DESALINATION/OTHER



- CROPLAND
- GRASSLAND
- FOREST
- BARREN
- DEVELOPED
- OTHER

STORAGE AND PRESSURE ZONES

STORAGE VOLUME : 377,650 CUBIC METERS
NUMBER OF PRESSURE ZONE : 160 ZONES

CAPACITY AND FLOW

- IRAÍ TREATMENT PLANT: 3,200 LITERS PER SECOND (L/S)
- IGUAÇU TREATMENT PLANT: 3,500 L/S
- MIRINGUAVA TREATMENT PLANT: 1,000 L/S

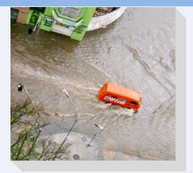
FLOOD RISK

TYPES OF FLOOD

Tributary floods: Caused by urbanization in smaller basins, mainly affecting downtown Curitiba and metropolitan cities

Main river floods: Due to low capacity of the Iguaçu River, worsened by floodplain occupation and flow obstructions

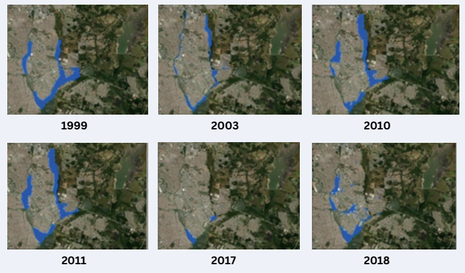
WHEN DOES CURITIBA FACE FLOODING PROBLEMS ?

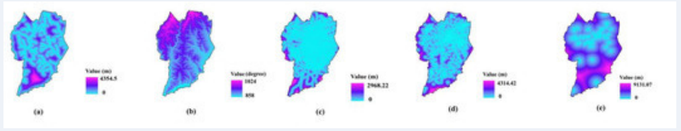


1. intense rain seasons
2. river overflow, notably from the Iguaçu River basin
3. densely populated, consolidated urban settlements
4. heavy rainfall overwhelming drainage systems

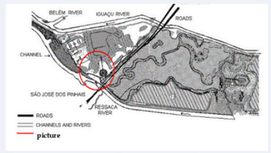
FLOODING AREAS

HISTORICAL EVOLUTION OF FLOODS IN URBAN AREAS





CAUSES OF FLOOD



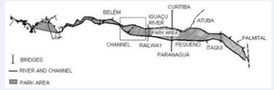
Low River Capacity

The Iguaçu River and its tributaries in the Curitiba metropolitan area have limited flow capacity (about 55 m³/s with a 2-year return period), which is insufficient to handle heavy rainfall events, leading to river overflow and flooding

Floodplain Occupation

unplanned occupation of natural floodplains by the population, including invasion of public green areas and unapproved developments. This reduces natural water storage areas and increases flood risk

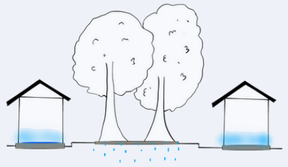
Urban Infrastructure Obstruction



Bridges, landfills, and poorly designed or inefficient drainage systems obstruct river and stream flows, exacerbating flooding by blocking natural water pathways

Increase in Impermeable Surfaces

Urban growth has led to a significant increase in impermeable surfaces (up to 40% in some tributary basins), which reduces soil infiltration, increases surface runoff, and amplifies flood volumes by up to six times compared to pre-urban conditions



Heavy and Prolonged Rainfall

Extreme rainfall events, such as the seven-day rainfalls in July 1983 and January 1995 (the latter being the largest in 110 years of records), cause critical flood volumes that the rivers and drainage cannot handle

WATER TREATMENT PLANTS

WATER TREATMENT PLANTS FOR DRINKING WATER

These units collectively produce approximately 6,950 liters per second of drinking water


IGUAZU


IRAÍ


PASSAÚNA


PEQUENO

ETE BELÉM (BELÉM SEWAGE TREATMENT PLANT)

largest sewage treatment plant in Paraná state

underwent a major expansion
1,500 liters per second to 2,520 liters per second

advanced technologies such as stainless steel primary decanters for faster installation and improved energy efficiency

produces sludge that is anaerobically treated to generate biogas converted into electricity and heat

ATUBA SUL SEWAGE TREATMENT PLANTS

This plant features a thermal sludge drying system powered by biogas and biomass, reflecting Curitiba's commitment to sustainability and low-carbon economy initiatives

TYPES OF WATER SYSTEMS


Surface Water Systems


Groundwater Systems


Integrated Urban Water Systems

- a river basin committee responsible for managing the upper Iguaçu river basi
- This basin includes sub-basins such as the Pequeno River, which also contribute significantly to the water supply
- affluents of the Ribeira river, including Açungui and Capivari rivers

- Curitiba also utilizes groundwater sources, including artesian wells
- for example, the Eurobusiness building in Curitiba is self-sufficient in water by using an artesian well as its main source of drinking water, combined with onsite treatment and reuse of wastewater

- The city code mandates treatment and reuse of greywater and rainwater harvesting to reduce runoff and drinking water consumption
- Innovative systems like green roofs are used to treat 100% of wastewater onsite, combining rainwater capture, condensation water from air conditioning, and reuse of grey and black water.

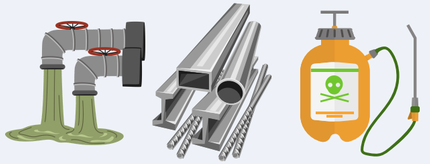
WATER POLLUTION

largely due to rapid urbanization — **inadequate sewage infrastructure** — **the degradation of local water bodies**

Extensive deforestation and urban development led to soil erosion — **poor land management during 20th century**

CURRENT POLLUTION SOURCES

the improper disposal of domestic and industrial sewage Inspections have revealed that a substantial number of properties (over 90,000 connections) were discharging waste directly into rivers or rainwater tunnels instead of the sewage system.



The Iguaçu River, which flows through the region, has been documented as contaminated with a variety of pollutants, including sewage, heavy metals, pesticides, and hydrocarbons. These contaminants have been shown to negatively affect aquatic life and pose risks to public health

IMPACTS

Water pollution has led to increased risks of mosquito-borne diseases and has historically degraded the quality of life for residents living near polluted rivers

RED INFRASTRUCTURE

Curitiba's red infrastructure supports its sustainable growth through efficient energy distribution, digital connectivity, and integrated public services. Curitiba also benefits from Brazil's renewable energy grid, enhancing local energy efficiency.

Area:
430.9 km²

Population:
1.8 million

Population Density:
4100 people per km²

Passenger Traffic:
5.18 million

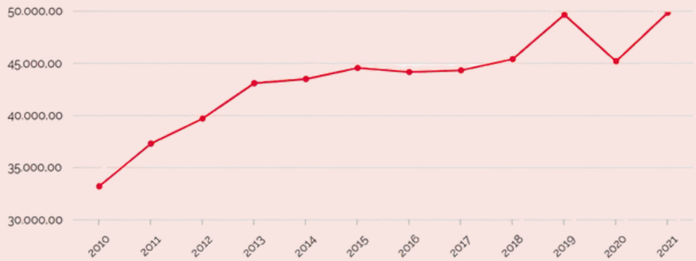
GDP:
44.5 billion USD

GDP per Capita:
13,000 USD

GDP Growth:
3% annual change

Aircraft Movement:
55,820

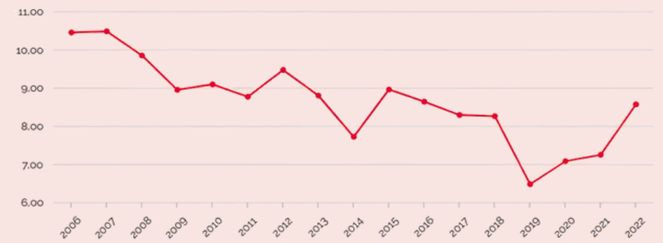
GDP PER CAPITA



The graph shows Curitiba's GDP per capita from 2010 to 2021, highlighting a general upward trend. After steady growth from 2010 to 2013, the rate leveled off slightly until 2018. A peak occurred in 2019, followed by a dip in 2020 likely due to the pandemic, with a strong recovery in 2021, returning to the previous high.

POPULATION

The graph shows a general decline in Curitiba's infant mortality rate from 2006 to 2022, indicating improved healthcare. After fluctuating between 8 and 10 for several years, the rate dropped significantly in 2019, then slightly rose during the pandemic, reaching around 8.5 in 2022. Despite a growing population and urban density, the long-term trend reflects progress in child health and public services.



ENVIRONMENTAL ISSUES: URBAN HEAT ISLAND EFFECT

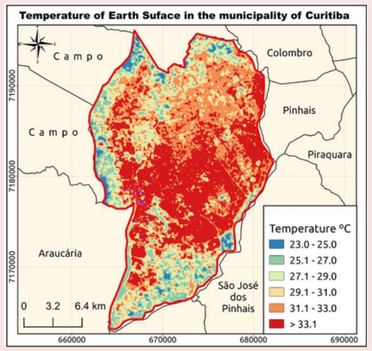
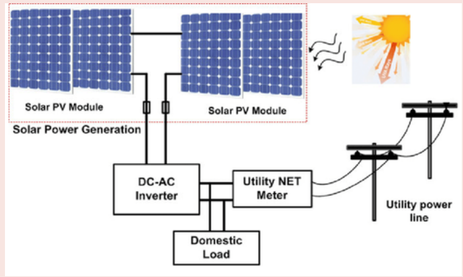


Diagram shows a phenomenon where **urban areas become significantly warmer than their surrounding rural areas** in **Curitiba**

Diagram show **departures from outdoor temperatures during night time** in the 6 monitored houses

ENERGY DISTRIBUTION AND EFFICENCY

Curitiba experiences significant **Urban Heat Island (UHI)** effects, especially in summer, leading to heat stress indoors in some areas. Key factors include **dense urban layout, land use, and building materials** with limited vegetation.

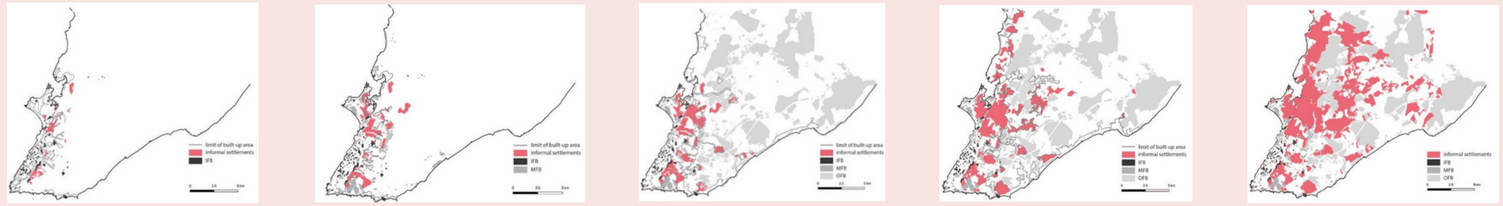


UTFPR (Federal University of Technology of Paraná) has installed grid-connected solar energy systems on its campuses, **contributing to both renewable energy generation** and research on solar technology performance in local conditions.

SOLAR ENERGY INITIATIVES IN CURITIBA

Curitiba's Solar Pyramid at the Caximba landfill is the first of its kind in Latin America. It involves **installing photovoltaic panels** on a deactivated landfill to generate clean energy, which is to **reduce electricity costs** for public buildings and support the city's **renewable energy objectives.**

INFORMAL SETTLEMENT AND BUILDING TYPOLOGY



Limits of the built-up area, the Inner Fringe Belt and informal settlements in the **early 20th century**
The **current city (2020)**. Most of the **territory is occupied**, and **informal settlements become pervasive**.

Fringe-Belts Concept:
Areas that emerge during slow urban growth, occupied by specific land uses, including institutional, industrial, and open spaces.

ROSARIO, ARGENTINA

ROSARIO, ARGENTINA

- **Strategic Location:** Positioned as a major river port on the Paraná River.
- **Industrial Significance:** Functions as a key industrial hub in Argentina.

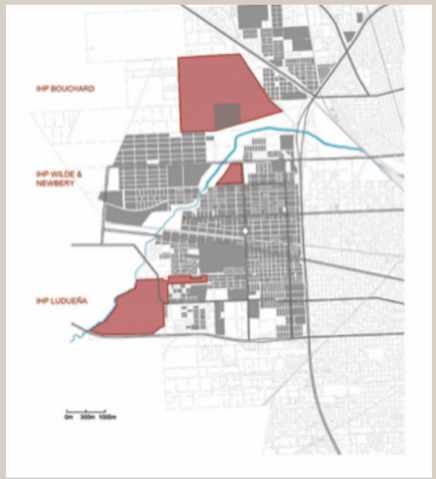
Urban vector city map of Rosario, Argentina

POPULATION / LAND AREA

1.8 million / 178.69 km²
third-largest city in Argentina.

EXPANSION PATTERN

- Rapid suburban sprawl
- low-density developments
- gated communities in the metropolitan area



Rosario West Side.
Three Integrated Housing Parks

CULTURAL SIGNIFICANCE

Modern Architecture and Urban Art

Rosario Argentina In The 19th Century Image.

The city blends

- Neoclassical
- Art deco
- Modern architecture

Art deco style house on the coast at Curl Curl.

3 Houses in Rosario

Street art and murals

MIXED-USE AND ARCHITECTURAL DIVERSITY

Maipú Building by Nicolás Campodonico

- **Design Approach:**

Introduces architectural diversity through a distinctive elevation.

- **Urban Integration:**

Respects the existing street order while standing out visually.

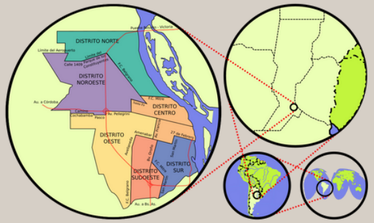
- **Contribution**:

Enhances Rosario's urban façade with a modern yet contextual presence.

ELEMENTS OF ROSARIO'S URBAN DESIGN PATTERN

Polycentric and District-Based Structure

The city is organized into several districts (Centre, North, Northwest, West, Southwest, South), each with distinct densities and functions. The Centre District is the historic and commercial core, surrounded by residential and industrial districts.

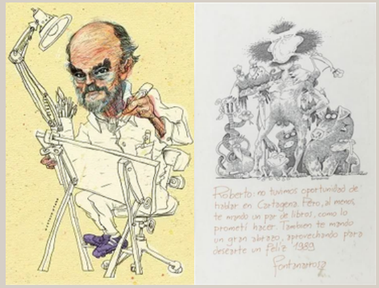


Map of the City of Rosario, in Argentina.

ECONOMIC HUB

- **Economic Role:** Plays a central role in Argentina's export economy, especially in:
  - Grain
  - Agricultural products
  - Manufactured goods

LITERARY HERITAGE



Birthplace of **Roberto Fontanarrosa,** a famous Argentine humorist and cartoonist.

Cultural Impact:
an essential part of Argentine popular culture

CULTURAL INSTITUTIONS

Museo Castagnino

- Located in a neoclassical building near Parque Independencia
- Housing an extensive collection of Argentine and European art.

One of Argentina's most important art museums.

Centro Cultural Parque de España

It hosts concerts, plays, and art shows, and is known for fostering cultural exchange between Argentina and Spain.

A major venue for concerts, theater, and exhibitions.

GREEN INFRASTRUCTURE

Green Infrastructure is a type of infrastructure that integrates vegetation and ecosystems. Their main function is to reduce flooding, manage rainwater, promote biodiversity, make cities cooler and more livable.

Total Green Area: **9.3 km²**

Major Green Spaces: **8**

Green Area / Resident: **12.5m²**

Major Green Initiatives: **6**

Rosario, Argentina, is internationally recognized for its innovative approach to green infrastructure, particularly through its **Urban Agriculture Program i**nitiated in response to the economic crisis of the early 2000s.

GREEN INITIATIVES

Programa de Agricultura Urbana started in 2002 in response to an economic crisis to enhance food security by transforming unused land into urban gardens.

The Green Belt Program (Programa Cinturón Verde) was launched in 2016, extending urban agriculture to Rosario's peri-urban areas.

The "**Calle Recreativa**" program, started in 2010 promotes active lifestyles by closing certain streets to motor vehicles on Sundays.

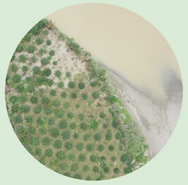
NOTABLE PARKS

Parque de la Independencia is Rosario's largest park, spanning about 64 hectares, and features an artificial lake, rose garden and museums.

Parque Nacional a la Bandera, located along the Paraná River, is home to the National Flag Memorial and offers riverfront views.

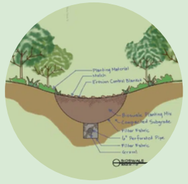
Parque Alem, located in the north, provides wooded areas, playgrounds, a swimming pool, and community spaces, making it a popular with families

HOW CAN GREEN INFRASTRUCTURE MITIGATE NATURAL DISASTERS?



- **Urban wetlands** and **green buffers** along rivers can Absorb overflow from the Paraná River and reduce the intensity of any floods.

- **Green roofs, rooftop gardens** and **green walls** can capture rainfall and reduce runoff from buildings. They can also help reduce the urban heat island effect through evaporative cooling and transpiration.



- **Bioswales**, and **permeable pavements** can help absorb and slow stormwater runoff, reducing pressure on drainage systems and reducing the chances of flash floods. They can also work with rainwater harvesting systems to stockpile water and retention of moisture for droughts.

CHALLENGES

Droughts caused by intense heat waves reduce local availability of water.

Rapid Urbanization can conflict with preserving green and urban agricultural zones.

Urban farming areas near industrial zones suffer from **soil and water pollution**. This can affect the quality and safety of food grown in these spaces.

FUTURE DEVELOPMENT OF GREEN INFRASTRUCTURE

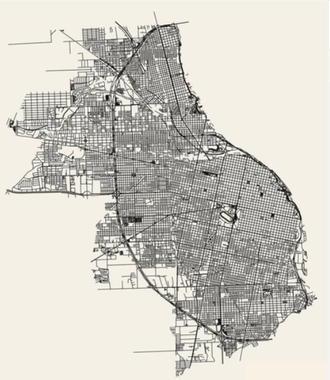
With the expansion of **Urban Agriculture** and the **Green Belt Project**, Rosario has designated an additional 400 hectares in and around the city for the expansion of urban agriculture. This includes the **Green Belt Project**, which permanently allocates peri-urban land for agricultural fruit and vegetable production, aiming to protect these areas from urban development.

The city's urban agriculture initiatives are now fully integrated into multiple strategic plans, such as the **Urban Plan of Rosario**, the 1**0-year Strategic Plans**, and the **Environmental Plan.**

Rosario has established several **Vegetable Garden Parks** (*Parques Huerta*) in traditionally low-income neighborhoods. These parks serve as community spaces that promote urban agriculture, enhance food security, and contribute to climate resilience by reducing dependency on imported food and associated greenhouse gas emissions.

GREY INFRASTRUCTURE

Rosario's grey infrastructure supports urban life through its transport, water, energy, and waste systems. While essential, aging networks and limited resilience highlight the need for sustainable upgrades.



ROADS AND TRANSPORT INFRASTRUCTURE

Public Transit

- Public transport is predominantly bus-based
- Some using compressed natural gas

60 bus lines

700 buses

100 km of cycle lanes

- **Mi bici tu bici**, the city's bike-share program has helped integrate over

- **Trolleybus lines** provide limited electric-based public transport, though expansion has stalled.

Port Infrastructure

- Located on the Paraná River, vital export hub for **soybeans**, **grains**, **vegetable oils**, handling millions of tons annually.
- Part of Argentina's agro-export corridor, with **heavy truck** and **rail traffic** converging into the city.

CHALLENGES

Limited Mass Transit
- Absence of subways or rapid rail systems reduces mobility efficiency.

Infrastructure Maintenance
- Potholes, poor signage, and uneven surfaces persist in many urban and suburban roads.

Traffic Congestion
- Increasing car usage, freight vehicles, and underdeveloped rail contribute to urban congestion.

ENERGY AND ELECTRICITY INFRASTRUCTURE

Electricity Supply

- Electricity is provided by Empresa Provincial de la Energía (EPE), which oversees a vast network of high, medium, and low-voltage lines across the province.
- The city consumes a significant share of Santa Fe Province's **11,900 GWh annual output**.
- While electricity reaches nearly 100% of the urban population

Outer zones:

Energy losses

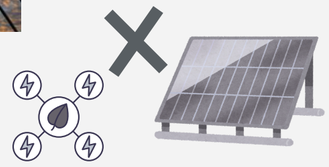
Voltage drops

Urban Lighting and Utilities

Traditional incandescent

Sodium vapor lamp

- Most street lighting still uses traditional incandescent or sodium vapor lamps, although LED retrofits are being slowly introduced in select areas.
- Renewable energy, such as solar or biomass, remains largely unintegrated into the main urban grid



CHALLENGES

Summer Blackouts
- High heat and air conditioning use strain the grid, causing outages in densely populated districts.

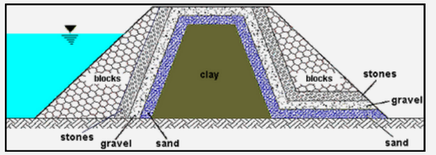
Grid Lag
- Urban sprawl has outpaced upgrades to transformers and lines, especially in new housing developments

Low Renewable Penetration
- Grey energy systems dominate, lacking policy and infrastructure for cleaner alternatives.

STORMWATER MANAGEMENT

Drainage Infrastructure

- Stormwater is managed via a network of underground culverts and open channels. The system is especially reliant on the capacity of the Ludueña Stream, a natural river that has been partly channeled underground to manage flows through the city.



Earth-fill dam

- A 1.5 km underground conduit system and a flood control dam (1995) were built to mitigate flooding risks.

Flooding Issues

- Low-lying areas, especially near the floodplain of the Paraná River, frequently experience seasonal flooding, particularly in summer.

Paraná River

- Urbanization has paved over many natural wetlands, reducing the land's natural capacity to absorb runoff.

CHALLENGES

Insufficient Drainage Capacity
- Current systems are unable to handle the increasing intensity of rainfall due to climate change.

Maintenance Problems
- Blocked drains and clogged channels lead to overflow and surface water flooding.

Sprawl
- Expansion into natural buffer zones disrupts hydrological flows and increases runoff volume.

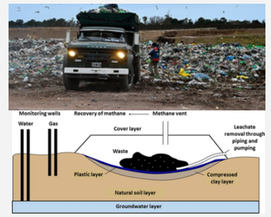
SOLID WASTE AND WASTE MANAGEMENT

Waste Collection and Processing

- Managed through public-private partnerships, waste is collected and transported to landfill sites outside the city.
- The city has built a waste transfer station to centralize collection and improve routing.
- A municipal composting facility is under construction to process organic waste from homes and markets.

Landfill Sites

- Still the primary disposal method for household and commercial waste.
- Open dumps have largely been eliminated, but landfill dependence remains high.



CHALLENGES

Lack of Circular Systems
- Minimal infrastructure for recycling, waste-to-energy, or reuse.

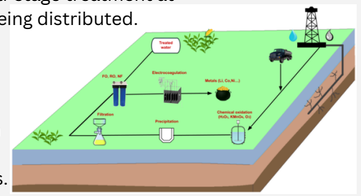
Environmental Impact
- Existing landfills risk groundwater contamination and methane emissions.

Behavioral Gaps
- Public awareness and participation in waste separation remain limited.

WATER SUPPLY AND SANITATION

Water Supply

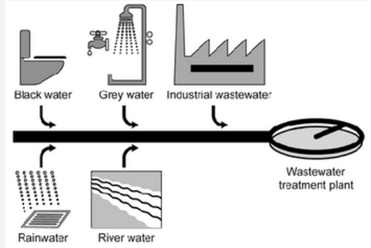
- Managed by Aguas Santafesinas S.A. (ASSA), Rosario's potable water is sourced directly from the Paraná River
- Water undergoes multi-stage treatment at major plants before being distributed.
- The supply network spans over **2,200 km, serving around 1 million residents** with more than 240,000 domestic connections.



- Water metering still has low coverage, making consumption patterns harder to track and regulate.

Sanitation

- Older neighborhoods—especially those built in the early 20th century—still suffer from combined sewer overflows (CSOs) during heavy rainfall, leading to pollution and health hazards.
- The sewer system includes over 2,100 km of pipeline, but infrastructure aging is a critical issue.
- Informal settlements or peripheral barrios often lack proper sanitation access, depending on septic tanks, open drainage, or community-built systems.



CHALLENGES

Aging Infrastructure
- Frequent leaks, inefficiencies, and loss of water.

Equity Gaps
- Peripheral and low-income communities have limited or no access to adequate sanitation.

Storm Overflows
- The combination of aging CSO infrastructure hand more frequent extreme rainfall due to climate change increases the risk of flooding and contamination.

BLUE INFRASTRUCTURE

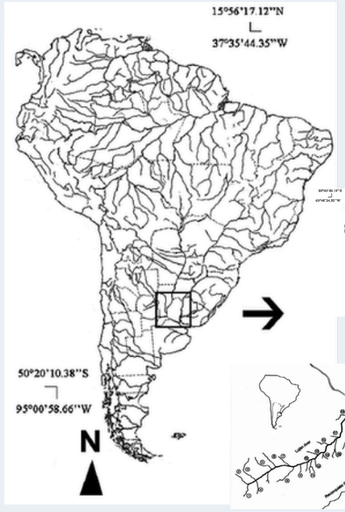
WATER SOURCES

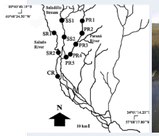
Paraná River
Primary source of drinking water, industrial and agricultural use, navigation, and trade

Saladillo Stream
Urban drainage, local environmental management

The Gran Rosario Water Supply System
Key infrastructure project supplying potable water to Rosario This system includes water intake, treatment plants, storage reservoirs, and distribution pipelines.

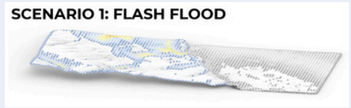
WATER AND FLOOD MANAGEMENT CHALLENGES

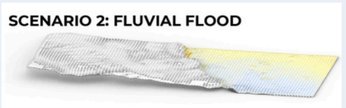




Local streams like the Saladillo and Ludueña can rapidly flood during intense rain events, turning into dangerous torrents.

Different types of flood under different scenario





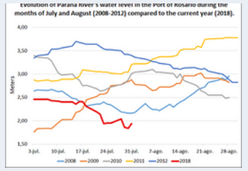
River flood hazard is classified as high based on modeled flood. informatipn currently available to this tool. This means that potentially damaging and life-threatening river floods are expected to occur at least once in the next 10 years

Apocalyptic storms turn low-lying areas and river.Cities like Buenos Aires and Rosario into flood zones. Feeble defenses crumble as torrents inundate streets within minutes. With river bursting their banks, entire neighbourhoods vanish beneath the deluce. Despite efforts to fortify and warn , the danger of flooding looms large over these vulnerable cities

WATER SCARCITY

THE PARANÁ RIVER, WHICH BORDERS ROSARIO, HAS EXPERIENCED HISTORICALLY LOW WATER LEVELS, NOTABLY IN 2021, IMPACTING WATER SUPPLY AND QUALITY.

Rosario's main source of drinking water. often caused by drought, can threaten the reliability and quality of the city's water supply



DUE TO A PROLONGED SHORTAGE OF RAINFALL IN BRAZIL, THE PARANA'S WATER LEVELS HAVE DROPPED DRAMATICALLY

WATER POLLUTION

LACK OF COMPREHENSIVE WASTEWATER TREATMENT INFRASTRUCTURE

UNTREATED WASTEWATER, INDUSTRIAL DISCHARGES, AND SOLID WASTE.

WATER POLLUTION AFFECTS PUBLIC HEALTH, BIODIVERSITY, AND ECONOMIC ACTIVITIES

WATER POLLUTION IN GENERAL (LIKELY INCLUDING RIVERS, LAKES, AND URBAN RUNOFF) IS MODERATE, INDICATING SOME ENVIRONMENTAL STRESS

WATER SUPPLY

21% **OF THE POPULATION LACKS HOUSE WATER CONNECTIONS**

52% **OF URBAN RESIDENTS DO NOT HAVE SEWER ACCESS**

THE CITY FACES CHALLENGES WITH WATER SUPPLY RELIABILITY DUE TO INFRASTRUCTURE LIMITATIONS AND INCREASING DEMAND.

WATER CONSUMPTION

EXHIBITS RELATIVELY HIGH PER CAPITA WATER CONSUMPTION AROUND

230 LITRES PER DAY

, COMBINED WITH LOW HOUSEHOLD METERING, WHICH CAN CONTRIBUTE TO INEFFICIENT WATER USE AND STRESS ON WATER RESOURCES

CAUSES OF FLOOD

River Overflow and Hydrology

poses a high river flood hazard due to periodic overflow during heavy rainfall and upstream hydrological events

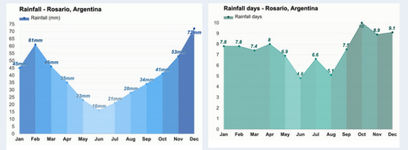
Obstruction of Waterways

Infrastructure such as poorly located bridges and urban development can obstruct natural water flow that increases flood risk

Urban Drainage Limitations

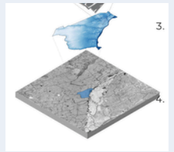
intense rainfall events can overwhelm drainage systems, causing pluvial (surface) flooding

1ntense and Prolonged Rainfall



Heavy and sustained rainstorms are a primary cause of flooding in Rosario. For example, in March 2007, nearly a week of continuous rain led to rivers and streams overflowing, resulting in widespread urban flooding and mass evacuations.

Low-Lying Topography



Rosario is situated on relatively flat and low-lying terrain, which makes it more susceptible to flooding. Water tends to accumulate and drain slowly in such areas, especially when combined with saturated soils from previous rainfall.

Extreme Weather Events (e.g., El Niño)

Climatic phenomena like El Niño can bring unusually high rainfall and severe storms, exacerbating flood risks. These events often lead to river levels rising beyond their banks and can trigger widespread displacement and infrastructure damage

RED INFRASTRUCTURE

Rosario's red infrastructure supports its role as a major economic hub in Argentina, contributing over 50% of Santa Fe's GDP. Key challenges include managing informal settlements, enhancing energy efficiency, and addressing environmental issues like urban sprawl and flooding.

Area:
178 km²

Population:
1.75 million

Population Density:
4713 people per km²²

Passenger Traffic:
493,000

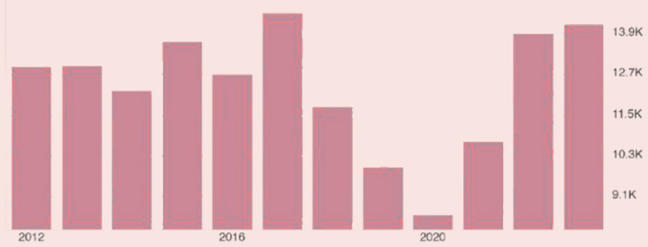
GDP:
37.9 billion USD

GDP per Capita:
12,600 USD

GDP Growth:
6.6% annual change

Aircraft Movement:
99,324

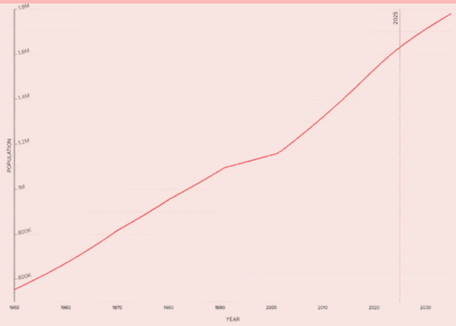
GDP PER CAPITA



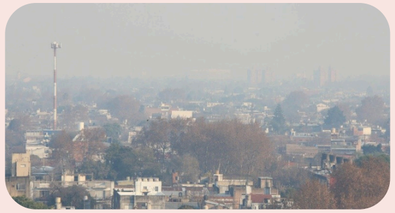
Rosario stands as a vital economic engine in Argentina, contributing significantly to both the provincial and national GDP. Its strong industrial base, strategic location, and diversified economy suggest that Rosario maintains a GDP per capita close to or above the national average.

POPULATION

The population of Rosario, Argentina, has steadily increased from around 500,000 in 1950 to over 1.8 million projected after 2025. Growth was strong from 1950 to 1990, slowed slightly around 2000, and then accelerated again in recent years. A marked increase is expected to continue beyond 2025.



ENVIRONMENTAL ISSUES



Wildfires & Climate Change
Fires linked to land-use changes and climate variability, causing air pollution.

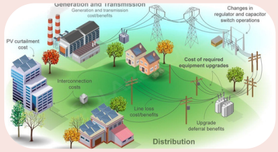
Water Pollution
Contamination of water bodies (Ludueña and Saladillo streams) and pollution from industrial discharges and agricultural runoff

Urban Agriculture
Implementation of local food production programs to enhance ecological sustainability.

Waste Management
Challenges with municipal solid waste management.

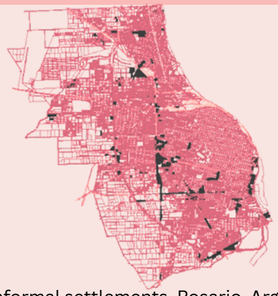
ENERGY DISTRIBUTION AND EFFICENCY

Energy Efficiency Brief by the Copenhagen Centre:
The Copenhagen Centre on Energy Efficiency published an **energy efficiency brief** for Rosario, highlighting factors such as **industrial activity, residential demand, and seasonal variations.**



Distributed Photovoltaic Generation in Argentina:
This study examines the **expansion of energy provision** in rural Argentina through public-private partnerships and **renewable energy**, focusing on the PERMER program.

INFORMAL SETTLEMENTS & BUILDING TYPOLOGY



Informal settlements. Rosario, Argentina
Informal settlements are shaded

Urban Planning:
No formal urban planning, leading to overcrowded, irregularly laid-out housing. Lack of public spaces and recreational areas, hindering community development.

Villa la Cava in the municipality of San Isidro, in the north of Greater Buenos Aires

Building Typology
Low-rise, densely packed structures with self-built homes.Lack of standardized architecture due to absence of formal urban planning.

PHASE 3
(PROPOSAL)

COMPARISON

	GREEN	GREY	BLUE	RED
CURITIBA	52 m²	Bus Rapid Transit (BRT) with Trinary Road System	Iguazu River, supplemented by groundwater	Urban design prioritizes green space integration into city life improves air quality, enhances quality of life.
	Parque Barigui, Jardim Botânico, Parque Iguaçu (flood control + biodiversity)	70% recycling rate, Green Exchange (Cambio Verde), sanitary landfills	100% sewage treated, integrated water reuse, advanced treatment plants (e.g., ETE Belém)	Policies emphasize public participation in environmental planning and sustainability efforts.
	Floodplain parks, Green Line Project, Urban Agriculture Program	Advanced stormwater systems, 100% treated sewage	Retention ponds, floodplain parks, canal networks	Well-integrated renewable energy system, utilizing both solar and grid-connected systems
	Uneven distribution, urban expansion pressure, unpredictable rain events	LED lighting, solar on landfills, sustainable public buildings	Low river capacity, floodplain encroachment, impermeable surfaces	Approach to integrating informal settlements into the formal city grid.
ROSARIO	12.5 m²	Basic bus system, heavy private vehicle use, traffic congestion	Paraná River	Lack of green space and urban planning leads to overcrowded, polluted.
	Parque de la Independencia, Parque Nacional a la Bandera, Parque Alem	Limited recycling, illegal dumping, weak waste separation systems	Incomplete sewage coverage, low metering, high water consumption, untreated discharges	Struggles with social inequality, where access to services and resources is limited.
	Urban Agriculture (PAU), Green Belt Program, Calle Recreativa (car-free Sundays)	Inadequate drainage, aging systems, limited sewage treatment in peripheral areas	Frequent flooding from streams (e.g., Saladillo), flat topography, inadequate drainage	Energy efficiency efforts are more localized and less integrated across the urban landscape.
	Limited integration in flood prevention, urban sprawl threatens green spaces	Mostly conventional grid, minimal renewable integration, no major sustainable building codes	Water scarcity during drought, pollution from industrial/agricultural runoff, insufficient treatment	Lack of formal urban planning means informal settlements contribute to poor living conditions .

GREEN INFRASTRUCTURE

Observations

Curitiba green spaces :
52m^2 /resident

Rosario green spaces :
12.5m^2 /resident

Issues

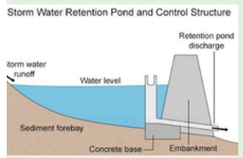
The parks on the riverside have little trees and are mostly flat with many paved areas.

Despite being located next to a river, Rosario experiences droughts during the La Nina weather phenomenon

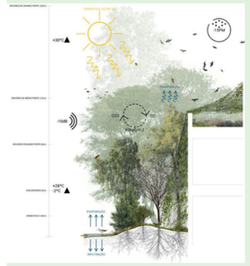
Rosario experiences flooding during seasons with heavy rainfall, particularly affecting neighborhoods near the river or its tributaries.

Proposal 1

Integrate as floodplain



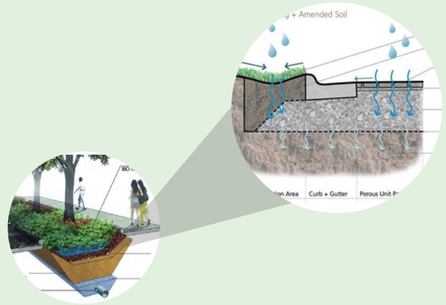
Depressions and Retention Ponds that can hold water



Dense vegetation that slows down water flow and enhance soil structure. This increases the land's ability to absorb and retain water

Proposal 2

Integrating permeable surfaces

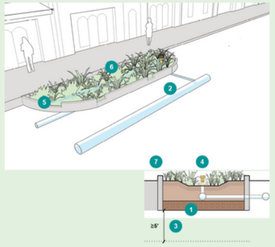


This, allows plants to stay hydrated, by maintaining soil moisture, helping plants survive dry periods

Proposal 3

Linear Parks and Flood-Control Greenways

Taking Curitiba as an example, Rosario could build more parks that could act as flood plans on the riverside.



Features such as bioswales that divert water from flooding the city to places that can store it. Possibly using it to alleviate issues regarding lack of water.

Proposal 4

Green Roofs and Vertical Gardens

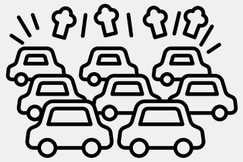
Encourage vertical gardens on public buildings and schools

Pilot green wall projects on public transit terminals

GREY INFRASTRUCTURE

Observations

Curitiba has a robust public transport system and an effective recycling program



Rosario experiences heavy traffic congestion and an inefficient public transport system, as well as widespread illegal dumping

Issues

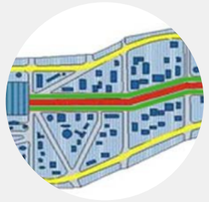
Rosario's lack of comprehensive waste management infrastructure is a reason why illegal dumping becomes an issue there

Rosario experiences heavy traffic congestion due to its reliance on public transport as the main mode of transport in the city

Proposal 1

Implement public transport system

BRT system in Curitiba connects high density mixed use neighbourhoods through public transport corridors, allowing the BRT system to efficiently serve people.



Rosario's could create zoning for mixed-use, high-density corridors such as Curitiba's Trinary Road system

Proposal 2

Education and Community Engagement

Curitiba's Green Exchange Program (Cambio Verde) is a great example of a recycling program

High usage due to its incentive of obtaining coupons that can be exchanged for food or transportation coupons which are desirable to the local community

Proposal 3

Road and Utility Resilience Retrofit

Reinforce existing roadways, utility trenches, and bridges with climate-resilient materials

Embed sensors in roads to monitor wear and storm impact

Proposal 4

Community-based Solid Waste and Recycling

Install Eco-Points (public drop-off stations) in underserved districts

Deploy segmented waste collection zones (organic, recyclable, landfill)

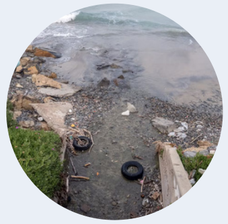
BLUE INFRASTRUCTURE

Observations

Curitiba has more blue infrastructure despite both cities facing flooding problems

Rosario faces water scarcity problem despite being next to a river.

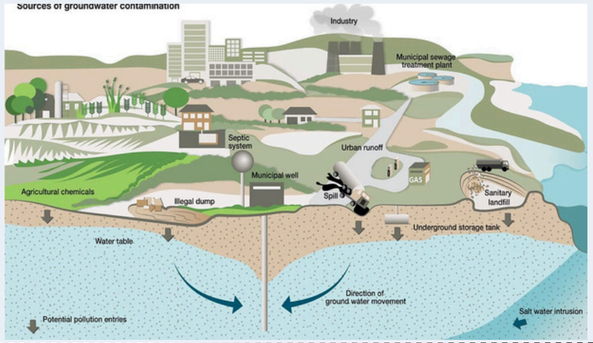
Issues



Rosario faces water quality problem due to insufficient wastewater treatment

Rosario doesn't have advanced sewage treatment infrastructure that increases direct discharged of untreated sewage into river

Sources of groundwater contamination :



Proposal 1

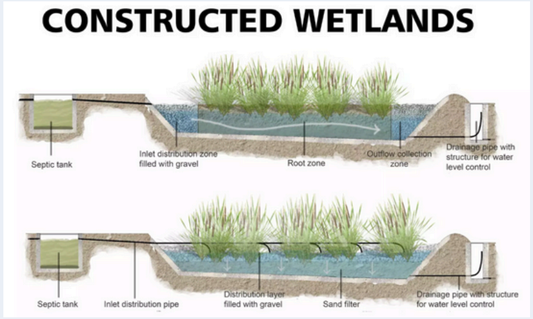
Implement Integrated Water Management Programs

able to implement sustainable development as a policy and maintain its economic prosperity.

main goal is to reduce water shortage risks, especially with the preservation of water springs that supply the city

Proposal 2

Lakes and Wetland Systems



- Establish retention wetlands in flood-prone areas like the northwest district of Rosario.
- Use seasonal wetlands in public parks for flood mitigation and stormwater filtration.
- Design wetlands as attractive public spaces (inspired by Curitiba's artificial lakes).

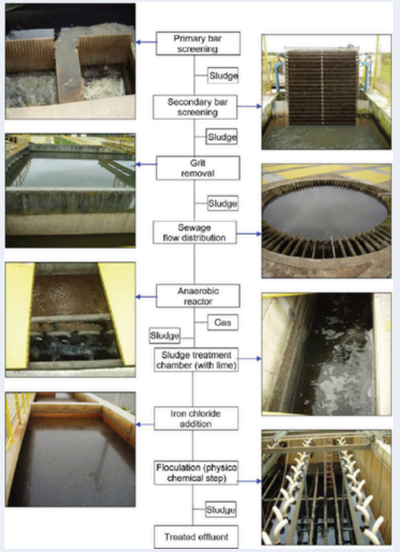
Proposal 3

Expand and Upgrade Wastewater Treatment Infrastructure

anaerobic process combined with post-treatment efficiently removes contaminants

contributing to better effluent quality

reduced pollution loads in receiving water bodies



Proposal 4

Integrating Stormwater into Public Space Design

- Public spaces can be shaped to capture, filter, store, and reuse stormwater through attractive and ecologically beneficial features that can solve water scarcity issues

RED INFRASTRUCTURE

Observations

Curitiba has a well-integrated renewable energy system, utilizing both solar and grid-connected systems

Rosario’s energy efficiency efforts are more localized and less integrated across the urban landscape.

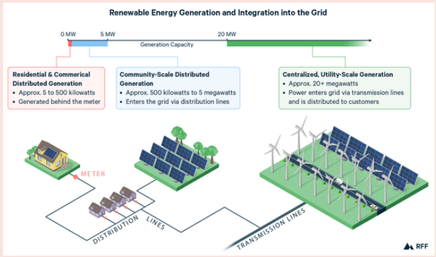
Issues

Rosario struggles with social inequality, where access to services and resources is limited.

Rosario’s lack of formal urban planning means informal settlements contribute to poor living conditions

Proposal 1

Grid-Connected Solar Systems

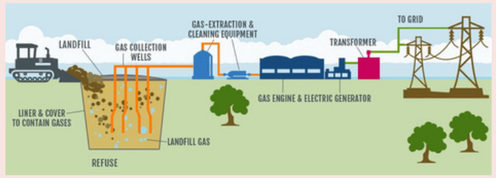


Develop grid-connected solar networks that allow for excess solar energy generated during the day to be fed back into the grid.

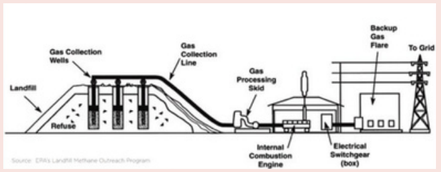
Outcome: Enhance energy distribution, ensuring that solar energy is accessible to all areas of the city

Proposal 2

Renewable Energy Infrastructure at Landfills



Transform decommissioned landfills into solar energy farms, to utilize unused land for renewable energy production.



Outcome: Turning waste areas into productive spaces, reducing landfill methane emissions and providing clean energy to the local grid.

Proposal 3

Affordable Housing Initiatives

Develop affordable housing projects in underdeveloped areas to provide safe, quality homes for low-income families.

Proposal 4

Comprehensive Zoning and Land Use Planning

Implement zoning reforms that clearly define residential, commercial, and public spaces, with a focus on affordable housing

Outcome: Reduce overcrowding, facilitate efficient land use, and ensure that all neighborhoods well integrated into the urban fabric.

CONCLUSION

GREEN INFRASTRUCTURE

Curitiba leads in green infrastructure with abundant parks, floodplain integration, and urban agriculture. Rosario progresses through community gardens but lacks green coverage and climate resilience. Both need fair access to green spaces, especially in low-income areas.

Curitiba uses parks as floodplains, promotes urban farming, and has 52 m² green area per resident.

Rosario has only 12.5 m² green area per resident, with drought, urban heat, and pollution issues.

Proposal: Expand green belts, use permeable surfaces, and create linear flood-control parks.

Prioritize green access in underserved neighborhoods to improve equity and climate adaptation.

GREY INFRASTRUCTURE

Curitiba stands as a global model with integrated transport, energy, water, and waste systems. Rosario, while functional, struggles with aging infrastructure, limited resilience, and inequality in access.

Rosario struggles with congestion, outdated roads, and poor waste handling.

Expand green belts, use permeable surfaces, and create linear flood-control parks

Build BRT with mixed-use zones to cut traffic.

Start recycle-for-reward programs in low-income areas.

RED INFRASTRUCTURE

Curitiba has a more integrated and sustainable red infrastructure than Rosario, with strong renewable energy, planning, and public services. In contrast, Rosario struggles with informality, weak planning, and fragmented energy systems, needing better strategies for long-term resilience.

Curitiba uses grid-connected solar systems and landfill solar projects.

Strong integration with Brazil's renewable energy grid.

Rosario lacks formal urban planning and faces energy distribution issues.

Environmental challenges in Rosario include wildfires and water pollution

BLUE INFRASTRUCTURE

Curitiba leads in blue infrastructure with strong flood control, water treatment, and sustainable systems. Rosario lags behind due to pollution, drought, and poor sewage access. Both cities need equitable upgrades, especially in informal areas.

Curitiba excels in flood control, stormwater reuse, and wetland integration.

Rosario suffers from drought, river pollution, and limited sewage systems.

Proposal: Implement decentralized blue infrastructure (like rain gardens, constructed wetlands) to enhance local water management and resilience.

Both cities need improved systems in informal settlements.

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