

# DP IB Geography: SL



Your notes

## Urban Environmental & Social Stresses

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## Urban Microclimates

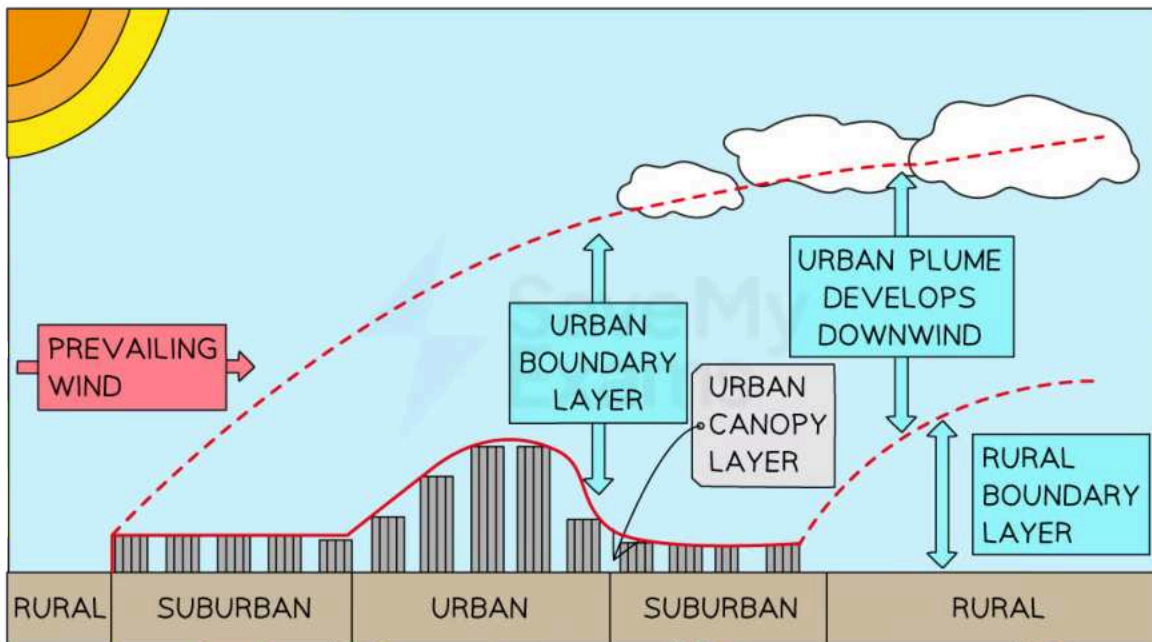
# Urban Microclimate Modification

- Cities create their own **microclimate domes**
- This means that they have unique:
  - Temperature ranges
  - Wind patterns
  - Clouds and precipitation rates
  - Pollution
- Urban microclimates vary according to urban areas' size, shape and location
- There are several causes, some of which include:
  - Changes to **land surfaces**: concrete, brick and tarmac
  - Cities have **fewer trees** than surrounding rural areas
    - Trees shade the ground, preventing heat from the sun from being absorbed
  - **Dark** rooftops and dark pavement absorb more solar radiation
  - **Tall** buildings reflect and absorb sunlight
  - **Cars** engines and factory exhaust produce heat
  - **Fewer plants** in urban settings mean that less evapo-transpiration occurs (a process that cools the air)
  - **Poor building insulation** means the release of heat at night
- Within these microclimate domes, there are two levels:
  - **Urban canopy** - processes act in the spaces between buildings below roof level
  - **Urban boundary** - processes acting above roof level and extends downwind as a plume into the surrounding rural areas
- Patterns of precipitation and air quality are extended to immediate areas via the prevailing winds

## A diagram of the microclimate dome



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**A microclimate dome**

- Urban climates have the following **characteristics**:
  - Lower relative humidity
  - 2–3 weeks fewer frosts
    - Greater diurnal temperature range: higher max and min temperatures as compared to rural areas
  - Pollution levels are higher
    - Fog and photochemical smog are likely
  - 5–10% more cloud
    - 5–15% more precipitation
    - Increased thunderstorms
  - Lower wind speeds, with the exception of the tunnelling effect
    - Varying pressure gradients

## Urban Heat Island Effect

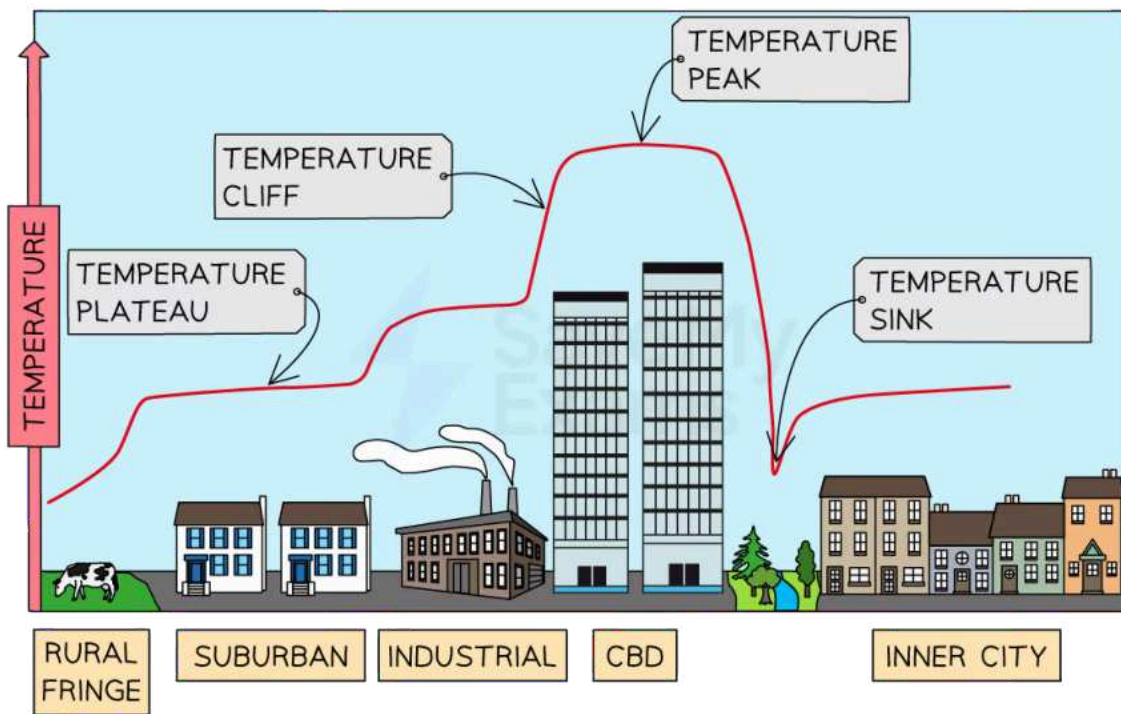
- The air in urban areas can be 2 – 5°C warmer than nearby rural areas



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- This is known as the **urban heat island (UHI)** effect
- The UHI is most noticeable when there is little wind
- The highest temperatures are found in densely built-up areas and industrial areas, where activities generate more heat
- **Temperature sinks** (where temperatures fall) are found above green spaces and water - e.g. parks and lakes
- **Temperature plateaus** (where temperatures remain the same) occur in areas with the same land use - e.g. industrial areas
- **Temperature cliffs** (where temperatures increase) occur when temperatures change rapidly from one land use to another - e.g. suburban housing to high-rise inner city buildings

### Illustration of the urban heat island effect

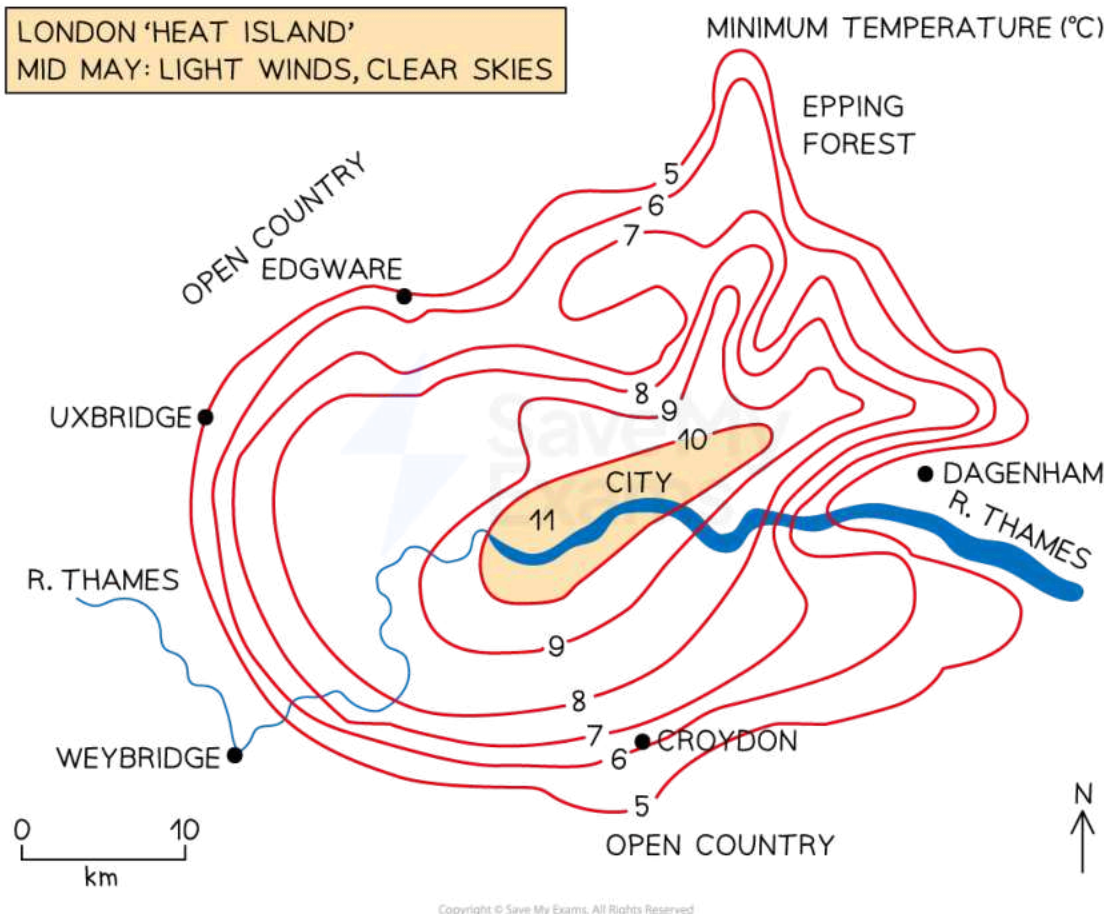


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*Urban heat island effect*



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London's urban heat island - note how the isotherms curve around open areas such as Epping Forest, indicating large areas of reduced temperature. Central London shows a greater concentration of heat due to high density land use

## Causes of the urban heat island effect

- The main causes of the UHI effect are:
  - **Air pollution:** pollution from cars, industry, etc. increases cloud cover and produces a pollution dome. Both of these trap outgoing heat and reflect it to the surface
  - **Heat from human activities:** air conditioning units, heating homes and offices, etc.—all release heat into the surrounding area
  - **Absorption of heat by urban surfaces:** urban surfaces have a low **albedo**. Tall buildings reflect and absorb sunlight

- **Less evapotranspiration:** removal of green spaces and trees reduces the cooling effect of evapotranspiration

## Diurnal and seasonal temperatures

- There is a larger range between daytime and night-time temperatures (**diurnal range**), compared to rural differences
- In urban areas, daytime temperatures are approximately  $0.6^{\circ}\text{C}$  warmer and night-time temperatures can be up to  $4^{\circ}\text{C}$  warmer
- Rural areas do not store as much energy and release heat quicker than urban areas
- Average urban summertime temperatures can be as much as  $5^{\circ}\text{C}$  warmer in mid-latitude cities, with average winter temperatures of  $2^{\circ}\text{C}$  warmer
- Temperatures can increase during periods of anticyclonic weather (high pressures)
  - These produce clear skies and low winds
  - Which allow greater **insolation** to reach urban surfaces
  - The low winds prevent warm air from being dispersed

## Urban Microclimate Management

### Strategies to reduce the urban heat island (UHI) effect

- Strategies are aimed at reducing the causes of the UHI effect, which are:
  - Air pollution
  - Heat from human activities
  - Absorption of heat
  - Removal of green spaces

### Reduction of air pollution

- Reducing emissions by introducing clean air zones and congestion charges

### Modifications to buildings and planning

- Changes to building design, such as using reflective materials, can reduce the absorption of heat
- Adding gardens to rooftops increases the amount of vegetation as well as decreasing heat absorption
- Making buildings more energy efficient to reduce the loss of heat



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## Increasing green spaces

- Parks, gardens and vegetation increase evapotranspiration, which has a cooling effect
- The increased vegetation cover also improves air quality

# Air Pollution Patterns & Management

## Air pollution patterns

- The amount of **particulates** in urban areas is greater than in rural regions
- Sources include:
  - Vehicle exhausts
  - Burning wood, coal, cigarettes, rubbish, etc. releases fine and coarse particulates
  - Construction, mining and quarrying
  - Plants and moulds generate coarse particulates such as pollen and mould spores
- Poor urban air quality has several effects, including:
  - Respiratory problems such as asthma
  - Increasing haze through increased emissions of sulphur dioxides and nitrous oxides
  - An increase in carbon dioxide, adding to the enhanced greenhouse effect and global warming
  - Increased particulates in the atmosphere attack building **facades**
  - **Photochemical oxidants** cause eye irritations and headaches

## Smog

- Smog happens when smoke particulates, **sulphur oxides**, **hydrocarbons**, etc. mix with fog
  - The London smogs of the 1940s were caused by the sinking of cold air trapping air, pollutants in a pollution dome
  - Today smog is more likely due to **photochemical** reasons:
    - Sunlight reacts with the chemical pollutants in the atmosphere
    - UV light causes them to break down into secondary, harmful chemicals to form photochemical fog
  - Photochemical fog is a major problem in large cities like Los Angeles, Mexico City, Beijing, etc.

- Smog is more common in warm, sunnier cities, as these places tend to suffer from **temperature inversion** fog (a layer of warm air is trapped below dense, cooler air)
  - This keeps the pollutants at the surface level

## Air pollution management

- Rapidly developing countries have some of the highest rates of air pollution and reducing urban air pollution globally, is a challenge
- Strategies include:
  - **Technical innovations**
  - **Vehicle restrictions**
  - **Government legislation**

## Technical innovations

- **Filters**
  - Fitted to industrial gas and particulate exhausts, filters carbon out of the gases released during industrial processes
  - **Catalytic converters** fitted to vehicle exhausts remove harmful pollutants before being released
- **Photo-catalytic materials (smog-eating material)**
  - Façades are retrofitted to the front of old buildings or new buildings are constructed with **photocatalytic concrete**
  - Special tiles are coated with **titanium dioxide**, which is a pigment that acts as a **catalyst** and is also used in sunscreen
    - When UV rays hit the tiles, a reaction occurs, converting mono-nitrogen oxides (smog-producing substances) into less harmful calcium nitrate and water
- **Self-cleaning concrete (Tiocem)**
  - This is **photocatalytic concrete** that has titanium dioxide mixed in
  - When sunlight strikes a building, nitric and nitrogen oxides will be able to break down
- **Greening the urban area**
  - Improve air quality by planting trees and vegetation
  - Vertical gardens: around concrete columns and on the sides of buildings
  - Roof gardens



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- Urban agriculture using open and derelict spaces
- **Air purification towers**
  - Dutch designed “Smog Free Tower”, which is an air purifying tower that sucks in pollution and expels clean air
  - The first tower was installed in Rotterdam and cleans 3.5 million cubic metres of air per day
- **Self-driving cars**
  - Studies have estimated that self-driving vehicles could improve fuel efficiency by 15–40%, which would reduce local emissions of pollutants as well as global greenhouse gases
- **Hydrogen fuel additives**
  - Additives improve fuel combustion and reduce emissions in existing vehicles
  - UK-developed '**ezero1**' **technology**, feeds small amounts of hydrogen into the vehicle's air intake, creating a more efficient burn
- **Alternative fuels**
  - **Electric vehicles**
  - **LPG**
    - Dual fuel or bi-fuel vehicles that can switch between LPG and petrol
  - **Synthetic “gas to liquid” (GTL)**
    - Reduced nitrogen oxide (NOx) emissions of 5–37% and particulate matter (PM) emissions of 10–38%.
  - Natural gas can also be converted into **dimethyl ether (DME)** as another alternative to diesel
    - Reduces NOx emissions by around 25%, and PM emissions are virtually eliminated

## Vehicle restrictions

- **Congestion charge**
  - Charges for using vehicles in certain places at certain times (e.g. London's congestion charge)
  - This reduces pollution through a reduction in road traffic (London's emissions dropped 15% in its first year)
  - However, it can increase fringe/outer zone traffic and emissions as people try and avoid the charge by using alternative routes
- **Selective bans**
  - Certain days and times are designated as no travel times for vehicles

### ▪ Pedestrianisation

- Vehicles are restricted from entering certain places at certain times
- This reduces emissions by reducing road traffic

### ▪ Park and ride

- Local authorities provide buses at the urban periphery, and they charge a flat rate for all-day parking and transportation from the parking area to the urban centre

### ▪ Improvements to public transport

- Improved bus services make accessing areas cheaper, faster and more efficient
- Trams and light railway services run on lines that avoid congestion

### ▪ Car sharing/pooling

- Many urban centres have designated lanes for cars with two or more people in them
- This keeps the flow of traffic moving and reduces journey times and emissions

## Government legislation

- Legislation can be local or global
- However, according to the UN,



One in three countries in the world lack any legally mandated standards for outdoor air quality -  
[UNEP 2021](#)

- Laws aim to reduce pollution by limiting emissions from industry, private and public facilities and vehicles
- **Industries** are regulated under **Integrated Pollution Prevention and Control (IPPC)**, set up under the Pollution Prevention and Control Act of 1999
  - Factories are not allowed to emit 'dark' smoke under the Clean Air Act of 1993, except in unavoidable circumstances (e.g. starting up)
  - The amount of dirt and dust emitted is also strictly monitored/controlled
  - Chimneys must have up-to-date modern filters/scrubbers fitted
- The Air Quality Standards Regulations of 2010 in the UK regulate significant air pollutants



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- Laws set air quality standards such as:
  - **UK Clean Air Acts** of 1956 and 1968 reduced domestic pollution through the introduction of smoke free zones
  - Industrial pollution was reduced by introducing tall chimneys, thereby dispersing pollutants higher into the atmosphere
  - The introduction of the MOT emissions test by the Road Vehicles Regulations means all vehicles have to pass an emissions test to be allowed on UK roads
  - In Scotland, roadside emissions tests are carried out and fines issued if the vehicle fails
  - Local authorities in the UK can issue fines to people leaving their engines running unnecessarily

## Case Study: New Delhi

- In 2023, New Delhi was identified as the most polluted capital city in the world
- During 2022, schools and colleges were closed for several days at a time due to the levels of pollution
- In November 2023, the air pollution level was 100 times the World Health Organisation's healthy limit

## Causes of pollution in New Delhi

- Over 19% of the pollution is the result of the over 3,000 industries in the area
- New Delhi is inland so there is often little wind to move the pollution away
- The areas around New Delhi are agricultural and crop burning in winter adds to the pollution levels
  - The use of diesel-powered irrigation pumps also contributes to emissions from agriculture
- There are 11 coal-fired power stations in the area surrounding New Delhi
  - In 2023, all but one of the power stations exceeded the allowed emission levels
- Many residents still use wood and biofuel for heating and cooking
- Between 1988 and 2020, the number of cars in New Delhi increased by 3.1 million
- Burning of waste and landfill fires
  - In April 2022, the Bhalswa landfill site caught fire and burned for twenty days
- Methane emissions from the landfill sites
  - Since 2020, there have been 37 major methane leaks from the Ghazipur landfill site

## Impacts of pollution in New Delhi

- A study by Greenpeace and IQAir estimated that 54,000 **premature deaths** in New Delhi were caused by air pollution
- Doctors during times of high pollution report increased numbers of patients with:
  - Breathing problems
  - Irritated eyes and throats
  - Asthma
  - Lung cancer
- The University of Chicago energy policy institute estimates that life expectancy in New Delhi is reduced by 11.9 years due to air pollution
- Schools and colleges are frequently closed during winter due to air pollution levels
- It is estimated that 50% of children in New Delhi have irreversible lung damage



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## Traffic Congestion



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# Traffic Congestion Patterns & Trends

- Many urban areas grow faster than the local government can improve and extend the area's infrastructure
- This leads to challenges such as **traffic congestion**

## What is traffic congestion?

- Traffic congestion is when:
  - **Traffic flow** is significantly reduced
  - There is a **reduction** in vehicle **speed**
  - The number of vehicles is increased
- The view of what constitutes traffic congestion varies from place to place
- Traffic congestion affects both **people** and the **environment**
- The extent of traffic congestion depends on several factors, including:
  - **Size of the urban area**
  - **Urban planning**
  - **Population density**
  - **Transport infrastructure**
  - **Population density**
- These factors affect the amount of traffic and its flow through the urban area

## Patterns of traffic congestion

### Peak hour congestion

- Cities all experience peak-hour congestion
- This is increased traffic during morning and evening **rush hours**
- It occurs when most people are travelling to and from work

### Events

- Urban areas often experience traffic surges when there are events such as concerts or sporting competitions
- The amount of traffic is unpredictable and can cause significant congestion

## Seasonal variation

- The patterns of traffic change during public holidays, school holidays or seasonal events
- This can lead to both increases and decreases in traffic

## Bottlenecks

- These are locations in urban areas where congestion regularly occurs, such as at particular junctions in the traffic infrastructure

## Trends of traffic congestion

### Urban expansion

- As cities expand, they will experience all of the following, which will increase the amount of traffic on the roads:
  - Growth of industries and businesses
  - Population increase
  - Increased size of the urban area

### Increased wealth

- Increased wealth means that more people can afford cars
- Fewer people are using public transport

## Traffic Congestion Impacts

- There are several impacts of traffic congestion including:
  - Increased pollution
  - Longer journey times
  - Unpredictable journey times
  - Slower speeds
  - Increased stopping and starting

### Increased pollution



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- More traffic and starting and stopping leads to **higher emissions** in urban areas
- Congestion in London is estimated to increase emissions by 15%, in Berlin it is estimated to be an 11% increase in emissions
  - Imperial College London's research estimates that pollution caused the **premature deaths** of 4000 London residents in 2019
- In Delhi, India, 67% of pollution is from traffic and it is estimated to lead to 5000 premature deaths a year



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## Longer and more unpredictable journey times

- The slower traffic impacts the economy
  - In London it is estimated that traffic congestion costs the economy £5.1bn a year
- Research shows that in 2021, the average driver in London spent 148 hours sitting in traffic

## Case Study: Rio de Janeiro

- Rio de Janeiro has a population of 6.7 million (2020)
- The population of the greater metropolitan area is estimated at 13.5 million
- The **mountainous landscape** surrounding the city increases the issues with traffic because:
  - A large volume of traffic is forced into only a few roads
- Air pollution causes approximately 5000 premature deaths a year

## Causes of traffic congestion in Rio de Janeiro

- **Car ownership** in Brazil has increased by over 25% between 2012 and 2022
- The average journey during rush hour takes 50% longer than at other times
- Buses are the main form of transport but there are a number of issues with the bus system, including:
  - There are too few buses for the number of passengers
  - Safety fears, particularly at night
  - Lack of air conditioning
- **Bottlenecks**, such as the ones at either end of the Rio Niteroi Bridge, are common
  - The bridge is 14km long and saves an 80km journey
  - Cars often breakdown on the bridge, leading to longer journey times



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## Traffic management in Rio de Janeiro

- There have been several attempts to manage traffic congestion in Rio de Janeiro including:
  - Yellow Line Expressway
  - Rio Niteroi Bridge
  - Metro Rio
  - Trams
  - Bike Rio
- All the management schemes aim to reduce the amount of traffic on the roads
- The schemes include both public and private strategies

### Yellow Line Expressway

- The expressway connects Barra da Tijuca to the North Zone and the international airport
- The cost of the road building was so high that it is now a **toll road**
- Every day, 70 000 vehicles use it
  - This is 13 000 more than it was built for, which has led to congestion
- It has reduced traffic on local roads by 40%

### Rio Niteroi Bridge

- The bridge was built to replace a one-hour ferry crossing or an 80 km road journey
- Although effective in reducing journey time, it experiences bottlenecks and congestion due to its popularity

### Metro Rio

- Three subway lines cross Rio de Janeiro
- There are 41 subway stations
- The metro carries over 1 million passengers a day

### Trams

- A tram system connecting the port to the city centre and the airport
- There are no emissions
- There are 300 000 users per day



- The trams decrease journey times

## Bike Rio

- Bike Rio began in 2011
- It is a bicycle-sharing scheme
  - There are 600 bicycles available at 60 rental stations across Rio de Janeiro
  - The cycle lanes cross 450 km
  - Solar panels power the bike stations



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## Land Use Changes

# Contested Land Use Changes – Slum Clearance

- **Contested land use** refers to areas of land where many **stakeholders** have views about how the land should be used
- This may lead to conflict between different groups, as they want the land for different purposes
- The main issues around contested land use are:
  - The clearance of 'slums'
  - Urban redevelopment
  - Depletion of green space

## 'Slum' clearance

- The term 'slum' is used to describe:
  - Illegal settlements or inadequate housing in LICs
  - Older 19th-century housing in industrial areas in HICs
- The UN's definition of 'slum' is



Where the inhabitants suffer one or more of the following:

1. Lack of access to improved water source
2. Lack of access to improved sanitation facilities
3. Lack of sufficient living area
4. Lack of housing durability (poor building materials)
5. Lack of security of tenure (there is no protection against forced eviction)

- Clearance of these areas can be controversial

## Illegal settlements in LICs

- The settlements are built **illegally** often on **wasteland** at the edge of cities in LICs



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- Local authorities or local government may order them to be cleared:
  - For **new infrastructure developments**, such as roads or train lines
  - To improve the area
- This issue is contested because local governments or businesses typically decide whether to clear these areas
- These organisations have more power than the people living in the settlements
- 'Slum' clearance often involves forced evictions
- Any new housing is often too expensive for the original residents to afford

## Dharavi, Mumbai

- Over 1.2 million people live in the illegal settlement of Dharavi, which covers an area of 1 square mile
- It has developed on low-lying land which used to be a waste tip and mangrove swamp
- Conditions in the informal settlement are often poor:
  - Many houses are made from scrap materials
  - Only 24% of people have access to clean water
  - The level of toxic waste is three times the recommendation
  - Over 4000 cases of disease a day are reported
- There is a strong community spirit
- Many people are employed in the informal sector and the annual business turnover is over \$650 million a year
  - The settlement has over 5000 businesses and 15 000 single-room factories
- The settlement is located next to Mumbai's financial district, which means the land is valuable

## Contested land use in Dharavi

- Vision Mumbai** in 2004 aimed to:
  - Replace inadequate housing with high-rise tower blocks
  - Improve water, sanitation and healthcare
  - Improve transport
  - Increase businesses
- By 2007, 45 000 homes were demolished and 200 000 people were moved



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- The new apartment buildings were not popular
  - They split communities apart
  - People had to pay rent
  - The apartments were very small
  - Many people were made homeless because they could not prove they were Dharavi residents

## Contested Land Use Changes – Urban Redevelopment

- As well as slum clearance, urban land use change may also include:
  - Gentrification
  - Urban redevelopment
- Both gentrification and redevelopment are controversial because they may not provide affordable homes for local people

## Gentrification

- Development of a city neighbourhood from low to high-value
- A poor area experiences an influx of educated or wealthy individuals who gradually renovate and push up property values
- This often forces out poorer families as the area becomes too expensive to live in
  - Portland Road in Notting Hill, was one of London's most run-down and deprived areas; now houses sell for £2 million
- Ultimately, the character and demographic make-up of the neighbourhood are changed completely through new services and functions of the area

## Urban redevelopment

- Urban **redevelopment** attempts to reverse inner city decline by improving an urban area through:
  - Demolition of buildings
  - Reconstruction
  - Renovating existing buildings and infrastructure


## Redevelopment in Hackney Wick, East London

- The renovation of buildings such as the Bagel Factory in gentrified Hackney Wick, east London

- The building is full of residential apartments now but in the early twentieth century, it was the site of a bagel factory.



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NAMING THE DEVELOPMENT 'BAGEL FACTORY' MAINTAINS A CONNECTION WITH THE BUILDING'S INDUSTRIAL PAST

RETAIL AND COMMERCIAL SPACE AT THE BOTTOM OF THE BUILDING CONTRIBUTES TO THE IDENTITY TO THE AREA

FLATS IN THE BUILDING ARE FOR SALE BETWEEN £450 000 AND £750 000 SHOWING HOW GENTRIFICATION HAS SIGNIFICANTLY INCREASED HOUSE PRICES IN THE AREA

FLATS ARE DEVELOPED TO BE 'WAREHOUSE STYLE', MEANING OPEN PLAN WITH MATERIALS SUCH AS BRICK AND IRON TO KEEP A LINK WITH THE BUILDING'S PAST THIS IS ALSO THE TYPICAL DESIGN AESTHETIC OF GENTRIFICATION

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## Contested Land Use Change – Depletion of Green Spaces

- As urban areas grow, the green spaces within them are at increased risk of development

- The value of the land for economic use outweighs the value for social use, such as parks
- Green spaces are at risk of development into illegal settlements in areas where there are high levels of rural-urban migration
- The loss of green spaces leads to a reduction in:
  - Air quality
  - Biodiversity and habitats
  - Areas for physical activity and community events
  - The urban heat island effect
- In the UK, 9.6 million people live in areas which lack green spaces

## Auckland, New Zealand

- In 2011, green space made up 47% of the urban area
  - Approximately, 50% of this was residential gardens and 33% were public parks
- Green space per person in Auckland decreased by 30% between 1980 and 2016
- The causes of the decrease include:
  - Infill development, where open spaces between buildings are built on
    - This includes building on gardens
  - Higher-density buildings in new developments
    - In new developments, the average amount of green space has decreased from 55% (pre-2016) to 28% (post 2016)
- It is estimated that the loss of green space will:
  - Increase average temperatures; every 10% decrease in green space could increase temperatures by 0.3°C
  - Increase surface runoff; a 10% increase in impermeable surfaces could increase runoff by 18%



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## Urban Social Deprivation



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# Social Deprivation

- There is significant **inequality** in urban areas both in HICs and LICs
- In many areas groups and areas are experiencing **social deprivation**
- **Social deprivation** can be defined as people or communities lacking access to the resources they need to have a reasonable quality of life
- In the UK social deprivation is measured on the **index of multiple deprivation** which measures deprivation using measures of:
  - Income
  - Employment
  - Education
  - Health
  - Crime
  - Housing and services
  - Environment

# Cycle of deprivation

- The cycle of deprivation occurs when poverty is passed from one generation to the next
- The limited resources of one generation mean that the next generation's opportunities are limited
  - Parents can't afford or access educational resources, which disadvantages their children
- The educational disadvantages mean that educational attainment is lower and this affects job prospects
- Lower standards of living and low incomes affect health and well-being

# Barcelona

- Barcelona has a population of over 5.7 million people
- The highest levels of deprivation in Barcelona are located in:
  - **El Raval** which is an inner city area with old, substandard housing



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- **Can Peguera** is situated at the city edge
  - It is one of a number of estates of social housing built in the 1960s
- Deindustrialisation in the 1970s and 1980s led to unemployment in Barcelona reaching 20%
  - Leading many areas to become rundown and derelict
- The areas of deprivation have a number of features in common, including:
  - Low and very low incomes
  - Higher than average unemployment
  - Higher than average numbers of single-parent families
  - Lower levels of educational attainment
  - Higher incidence of crime and anti-social behaviour

## Geographic Patterns of Crime

- Crime rates are higher in urban and industrial areas
- Much crime is concentrated in areas of **high population densities**
  - The exceptions to this are crimes such as fraud and sexual offences, which are more common in areas of low population density
  - The wealthier areas see car theft, kidnapping, and property damage
- Within urban areas, crime rates tend to be higher in areas of **social deprivation**
  - Crime is partly due to a lack of job opportunities and large-scale unemployment
  - Gangs and intimidation are more likely to rule in areas of social deprivation
  - Rates of vandalism, burglary and vehicle crimes are higher in more deprived areas
- **Crime hotspots** are areas where crime rates are particularly high
- These areas often have similar characteristics, including:
  - Easy access and lack of security
  - Higher numbers of offenders
  - High levels of residential buildings
  - A lack of services
  - A lack of a police station



## Managing urban crime

- There are several ways to reduce urban crime, including:
  - Increased police presence
  - Use of CCTV
  - Improved street lights
  - Women only taxis
  - Greater number of taxi services around closing time of clubs and bars
  - Zero tolerance of crime



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