People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
University of Oum El Bouaghi
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1st Year master of Urban Planning

Course: URBAN ECOLOGY

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Course content

Introduction

The term "ecology" was first introduced in 1866 by the German biologist Ernst Haeckel, derived from two Greek words: "oikos", meaning "house" or "habitat," and "logos", meaning "science" or "study." Haeckel used this term to describe the scientific discipline that studies organisms in relation to their environment. At its foundation, ecology is thus concerned with the study of the "household" of nature, including the interactions between living organisms (animals, plants, microorganisms) and the physical and chemical conditions in which they live.

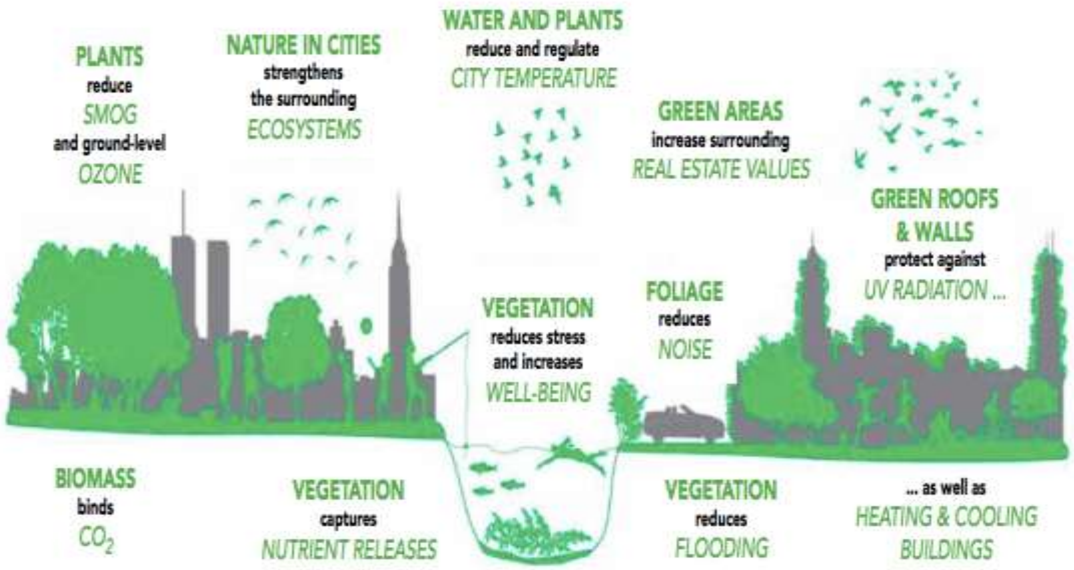
Ecology explores the conditions of existence and the interactions—both competitive and cooperative—that occur between organisms and their surroundings. These interactions determine how species survive, reproduce, distribute, and evolve over time.

The relationships may involve predation, mutualism, parasitism, competition, and niche differentiation, and all are essential in maintaining the balance and functionality of ecosystems. Furthermore, ecological study encompasses how organisms respond to variations in temperature, moisture, light, and nutrient availability, among other environmental factors.

The commonly accepted definition of ecology is: the scientific discipline that studies the relationships between living beings and their environment, including both biotic (living) and abiotic (non-living) components. However, ecology is far from a narrow field. Because the interactions in nature are complex and interconnected, ecology draws from a wide array of disciplines.

It incorporates principles and methods from climatology (study of climate and weather patterns), hydrology (study of water cycles), oceanography, geology, soil science, genetics, physiology, chemistry, and ethology (the study of animal behavior), among others.

This interdisciplinary foundation makes ecology a multidisciplinary science, essential not only for understanding natural systems but also for addressing pressing global challenges such as biodiversity loss, climate change, deforestation, pollution, and resource depletion. As our planet faces increasing environmental pressures, ecology plays a central role in guiding sustainable solutions and fostering a deeper understanding of the intricate web of life that sustains Earth's ecosystems.



Urban ecology : demonstration of some studied areas in the concept Source 01

On the other hand, urban ecology is a specialized branch of ecological science that focuses on the interactions between living organisms—including humans—and their urban environments. As cities grow in size and complexity, environmental challenges also increase, making urban ecology a crucial discipline for understanding and managing the ecological dynamics of urban spaces. It seeks not only to analyze environmental issues within cities, but also to integrate these concerns into urban planning and territorial policies, aiming to mitigate environmental impacts and enhance the quality of life for urban residents.

Urban ecology examines a wide range of interrelated themes, including:

- Energy consumption and sustainability,
- Water management and conservation,
- Urban mobility and travel patterns,
- Green spaces, landscape design, and urban biodiversity,
- Noise pollution,
- Waste production and recycling, and Air quality and atmospheric health.

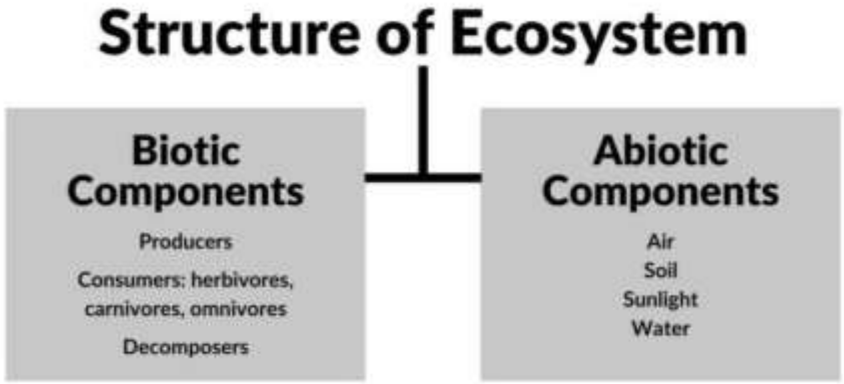
This field emphasizes a systems-thinking approach, recognizing that ecological, social, and infrastructural components are deeply intertwined in urban settings. Urban environments are no longer viewed as separate from nature, but rather as dynamic ecosystems that both influence and are influenced by natural processes. Urban ecology is generally accepted as an interdisciplinary field of study that draws upon ecology, urban planning, sociology, environmental engineering, and geography.

1st chapter: General ecology

1.1.Concepts of ecological factors

We call "ecological factor" any element of the environment that can act directly on living beings, ecological factors are of two types:

- Abiotic factors: set of physicochemical characteristics of the environment such as climatic factors (temperature, rainfall, light, wind, etc.), edaphic (soil texture and structure, chemical composition, etc.)…
- Biotic factors: set of interactions that exist between individuals of the same species or different species: predation, parasitism, competition, symbiosis, commensalism, etc.



Structure of an ecosystem Source: 02

1.1.1. Notion of ecosystems in the urban environment.

The notion of ecosystem is multiscalar (multi-scale), that is to say that it can be applied to portions of variable dimensions of the biosphere; a lake or a dead rat, depending on the scale of the ecosystem we have:

- a micro-ecosystem: example a tree
- a meso-ecosystem: example a forest
- a macro-ecosystem: example a region

1.1.2. Notion of materials in ecosystems.

The three main materials that cycle in every ecosystem are the water cycle, the carbon cycle, and the nitrogen cycle, the balance between these cycles is very important otherwise it would harm the ecosystem.

There is a continuous cycling of materials in the ecosystem. In the environment, waste and dead materials are continually recycled to support various life forms. This is not just limited to organic materials. Both organic and inorganic minerals are continuously exchanged and moved in the ecosystems to support the production of matter.

1.1.2. Energy transfer and productivity of ecosystems

Energy flows through an ecosystem in a unidirectional stream, beginning with the primary producers such as plants, algae, and certain bacteria—which convert solar energy into chemical energy through photosynthesis. This stored energy is then passed on to various levels of consumers, including herbivores (primary consumers), carnivores (secondary and tertiary consumers), and decomposers. One of the simplest models used to describe this flow is the **food chain**, a linear representation that illustrates how energy and nutrients move from one organism to another through the acts of eating and being eaten.

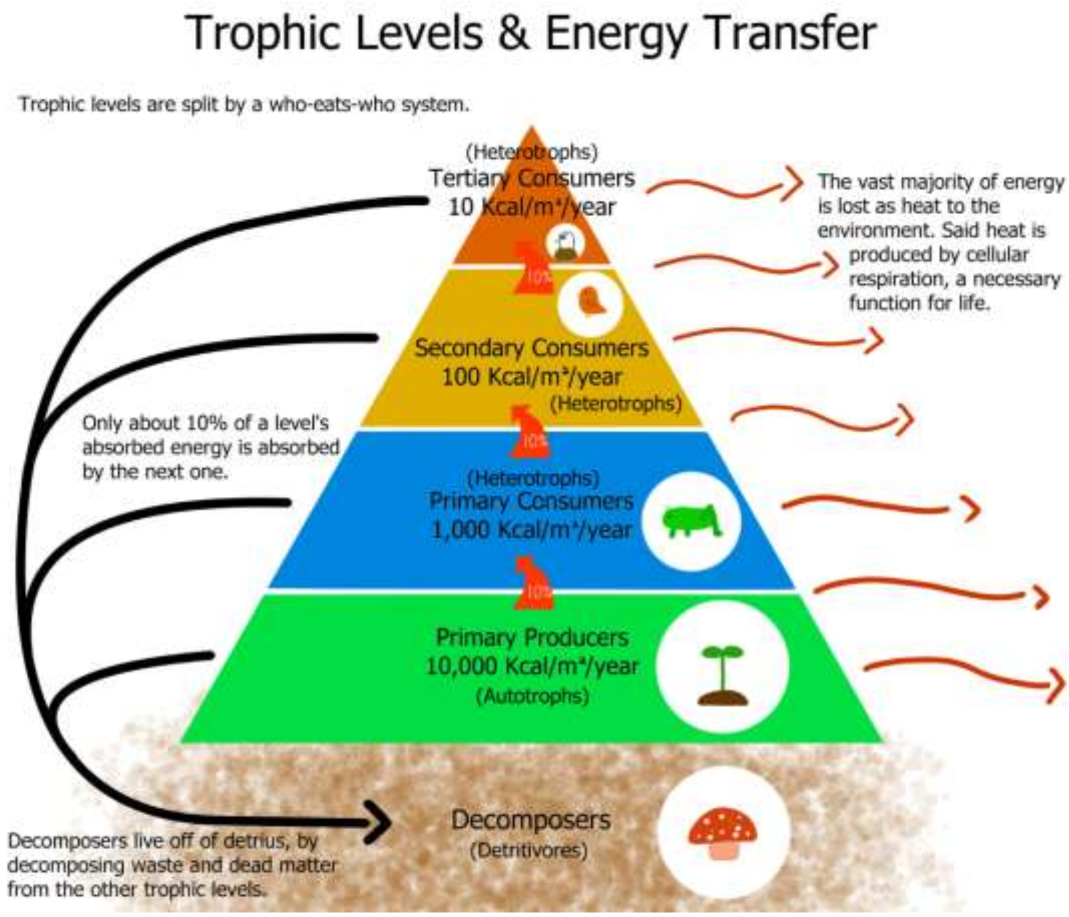
However, real ecosystems are far more complex, and energy transfer typically occurs through food webs, which are interconnected networks of food chains reflecting the diversity of feeding relationships among organisms.

It is important to note that food chains can vary in length, depending on the productivity and complexity of the ecosystem. In general, the number of trophic levels is limited because energy diminishes at each transfer. This is explained by the Ten Percent Law, introduced by Raymond Lindeman in 1942, which states that only 10% of the energy at one trophic level is passed on to the next level.

The remaining 90% is lost primarily as heat energy through metabolic activities such as respiration, movement, reproduction, and maintenance of body temperature. This law highlights the inefficiency of energy transfer in ecosystems and explains why top predators are fewer in number and why food chains rarely exceed four or five trophic levels.

Ecosystems differ greatly in their productivity, which refers to the rate at which energy is converted by autotrophs into organic substances. High-productivity ecosystems are those with optimal conditions of sunlight, water, nutrients, and temperature, enabling rapid growth and biomass accumulation.

In contrast, average productivity ecosystems such as temperate deciduous forests, grasslands, and typical croplands have moderate levels of energy input and biological activity. Factors like seasonal climate variation, nutrient availability, and human land-use practices can influence their overall productivity. Understanding these differences is essential for ecosystem management, conservation planning, and sustainable agriculture, as it allows scientists and policymakers to assess the carrying capacity of different ecosystems and their ability to support



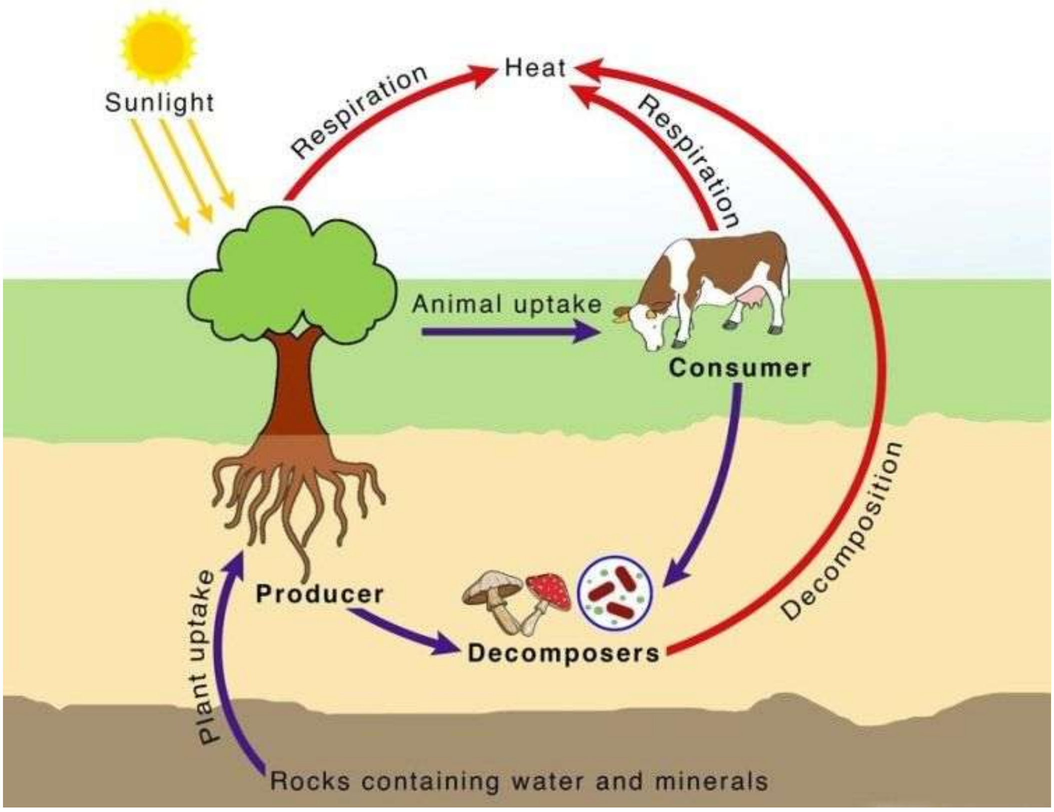
biodiversity and human needs over time.

Energy transfer in trophic levels Source 03

1.1.3. **Dynamics of living communities**

The interactions between these populations play a major role in regulating population growth and abundance. All populations occupying the same habitat form a community: populations inhabiting a specific area at the same time. The number of species occupying the same habitat and their relative abundance is known as species diversity. Areas with low diversity, such as the glaciers of Antarctica, still contain a wide variety of living things, whereas the diversity of tropical rainforests is so great that it cannot be counted. Ecology is studied at the community level to understand how species interact with each other and compete for the same resources.

The living organisms in an ecosystem can be divided into three categories: producers, consumers and decomposers, community dynamics are the changes in community structure and composition over time, often following environmental disturbances such as volcanoes, earthquakes, storms, fires, and climate change. Communities with a relatively constant number of species are said to be at equilibrium.



Categories of living organisms in an ecosystem Source04

1.2. **Urban nuisances**

A nuisance can be broadly defined as any factor, condition, or activity that causes harm, inconvenience, or discomfort to individuals or communities, whether in terms of health, well-being, quality of life, environmental integrity, or even psychological and socio-economic stability.

These nuisances may arise from direct actions or omissions, and they often interfere with a person's ability to fully enjoy and utilize their land, property, or public spaces. Nuisances can be both chronic and acute, localized or widespread, and their perception may vary depending on the sensitivity of the affected population and the intensity or frequency of the disturbance.

There are two general categories of nuisances:

1. Public nuisances, which affect the community at large, such as industrial pollution, traffic congestion, or waste mismanagement.

2. Private nuisances, which impact individuals or small groups such as noise from a neighbor, excessive light intrusion, or persistent odors.

Residents often express concern over exposure to particulate matter, nitrogen oxides, and volatile organic compounds all of which can compromise respiratory health, reduce urban air quality, and contribute to environmental injustice, where vulnerable populations are disproportionately affected.

In cities, nuisances not only undermine public health, but also create barriers to social cohesion, economic productivity, and environmental sustainability. When left unmanaged, they can erode trust in urban governance and generate social unrest. Therefore, identifying and addressing nuisances is a key concern for urban planners, public health officials, and environmental regulators, requiring a combination of policy enforcement, technological innovation, and community engagement to mitigate their impact and ensure a livable urban environment.

1.2.1. Sources of pollution in the urban environment

We can devide the sources of pollution (nuisances) in the urban environment into three main categories:

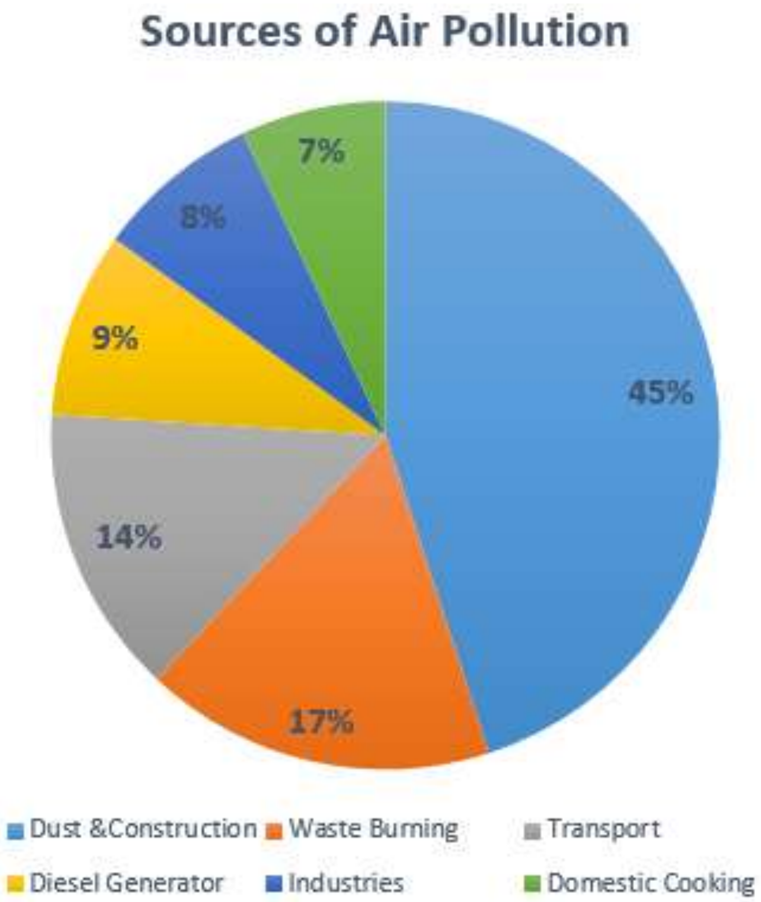
- pollution linked to traffic:

  Air pollution emitted from transportation contributes to smog, and to poor air quality, vehicle emissions are regarded as a primary contributor to air pollution and related adverse health impacts, heavy traffic congestion increases traffic flow and thus produces more O3 precursor emissions, leading to more adverse air quality issues, traffic also can create acoustic pollution in residential or recreational spaces.

- pollution linked to industrial zones:

  There are various causes of industrial pollution, industrial air pollution is when factories, mines, and transportation release harmful substances into the air. These pollutants can cause health problems such as respiratory diseases, cancers, decreased lung function, and asthma, they also can also harm the environment, leading to things like acid rain and climate change.

Also the untreated water from the industries is released into water bodies, causing water pollution, the different types of pollution linked to industrial zones include: air pollution, water pollution, soil pollution, radioactive pollution and acoustic pollution.

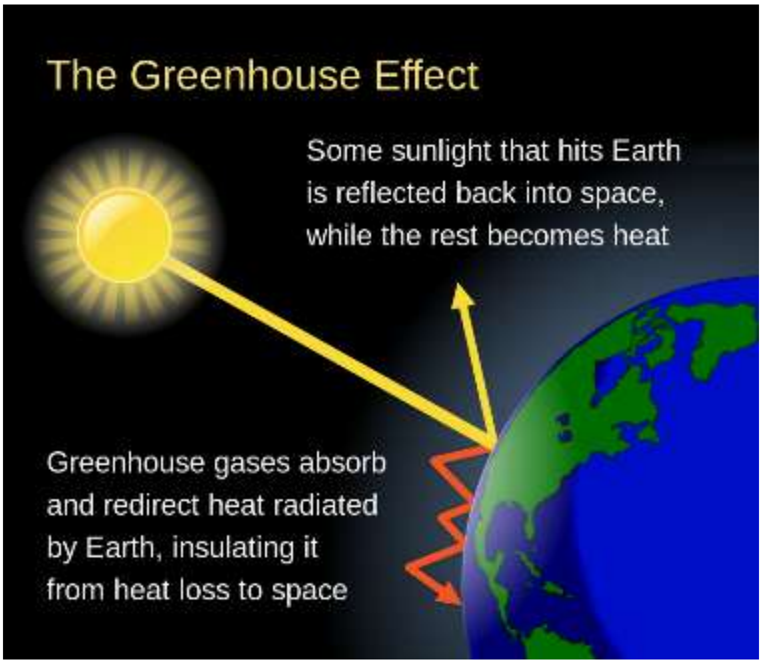


Sources of air pollution. Source : 05

- pollution linked into urban waste management

Poor waste management - ranging from non-existing collection systems to ineffective disposal -causes air pollution, water and soil contamination, open and unsanitary landfills contribute to contamination of drinking water and can cause infection and transmit diseases, the consequences of the mismanagement of solid waste are numerous, including water, air, and soil pollution, the generation of greenhouse gas emissions (AfDB, et al. 2019) and impacts on public health.

Therefore, the manner in which urban areas deal with waste really matters because; As waste decomposes it gives off Methane which is a powerful greenhouse gas (greenhouse gases absorb this radiation and trap its heat in the atmosphere, creating an effect that results in global warming and climate change)



The greenhouse effect Source 06

COURSE 02

Introduction

In 2025, more than a dozen urban agglomerations will have over 20 million inhabitants, and some will have over 30 million (kRaaS 2003), that was the estimated urban growth in 2003 where urbanised areas will be covering between approximately one and six per cent of Earth's surface with their extraordinarily large ecological 'footprints' and often indirect effects on ecosystems (land characteristics and ecosystem components artificial are determined by human action).

The aim of 'Urban Ecology' is to study these effects, according to Sukopp & Wittig (1998), the term 'Urban Ecology' **can be defined in two ways: within the natural sciences as a subdiscipline of biology and ecology** where urban ecology addresses **biological patterns and associated environmental processes in urban areas,.** In this sense, urban ecology push to analyse the relationships between plant and animal populations and their communities as well as their relationships to environmental factors including human influences.

However, the second, complementary, definition implies that **urban ecology is understood as a multidisciplinary approach to improving living conditions for the human population in cities, referring to the ecological functions of urban habitats or ecosystems for people –**

and thus including aspects of social, especially planning, sciences in artificial ecosystems, and this definition that we are carrying along this course.

The main types of artificial ecosystems are:

• **Urban ecosystems.**

• Agricultural ecosystems.

• Dam or reservoir ecosystems.

Urban ecology addresses processes in space and time, it can be understood as a spatial science in the same way as geography, Therefore the scale of the studies to be carried out is important, three different scales should be distinguished, especially in larger cities: the micro-scale of the local neighborhoods with its special built-up characteristics where the study or field experiment is carried out, the meso-scale of the district, which features a combination of different land use (built-up) types and finally the macro-scale of the total urban area, sometimes composed of different administrative entities or even cities.

Besides the spatial dimension, four main processes of change are the focus of recent research:

- **changes in urban biodiversity**: because species respond quite differently to urbanisation, climate Cities are important drivers of climate.
- **climate change** because for example, about 75% of greenhouse gas emissions are produced in urban territories.
- **Demographic change** because in highly industrialized countries people are growing older than ever before, while birth rate is simultaneously decreasing in countries like Germany.
- **Economic Change** because the existing economic activity that dominates the urban environment can transform its shape completely.

Chapter 2: the five pillars of urban ecological analysis

Introduction

It is well known that there are many differences between urban ecosystems and other ecosystems less dominated by humans, urban ecosystems are generally highly disturbed systems, subject to rapid changes in soil and plant cover, as well as temperature and water availability, buildings, roads, parking lots, shopping and residential constructions have covered the open land space with concrete to form a largely impenetrable covering of the soil that affects the flow of water and soil permeability for water getting into the land, so to conduct a full ecological analysis we will be dividing the analyze into the five main pillars of Eco-neighborhoods: Housing, transportation and walkability, vegetation and green areas, waste management, water.

2.1. 1st pillar: Housing

An ecological housing is a construction that limits the impact of the construction and use of the building on the environment, therefore, housing should be bioclimatic, made from ecological materials and uses little or no fossil fuels so the main characteristic of an ecological habitat is to be environmentally friendly.

Eco-housing involves three phases of the construction project to optimize the building as much as possible starting by the environmental control of site works phase to Conception and construction phase and finally the post construction phase

2.1.1 Environmental control of site works phase

2.1.1.1. choice of land

Choosing the proper site or the integration into the site should begin with the main question: what do we lack in the site? Starting by the orientation and climate to the size and shape of the site also the utilities existence in site or planned in the conception, it may be necessary to develop the land use plan that includes utilities, infrastructure and technical lines in advance.

We must estimate the level of urbanity of the site check the amenities available in the community and surrounding region (Shopping malls, schools, hospitals…) therefore we could estimate the needs of future inhabitants. Also a study of potential natural disasters should be conducted (fires, flooding, toxic waste dumping) in order to assess environmental risks.

Ecological site. Source: 01

2.1.1.2. implementation and management of site

Before starting the construction, we need to carry out an environmental site assessment to identify and mitigate potential ecological risks:

- Soils contaminated by past industrial activities
- Disturbance of habitats of protected species
- Risk of water pollution nearby
- Noise and vibrations generating noise pollution
- Air pollution from construction activities
- Protection of cultural heritage sites

Additionally, retain as many trees and vegetation as possible by incorporating them into the site design and protect them during construction.

2.1.1.3. Selective demolition

The majority of construction contractors favor demolition over deconstruction, deconstruction involves dismantling structures rather than easily demolishing them which requires more labor, but allows for much more material recovery that can be recycled or sold to generate a profit which offsets the cost of the additional labor required and invest in more ecological needs.

construction demolition. Source: 02

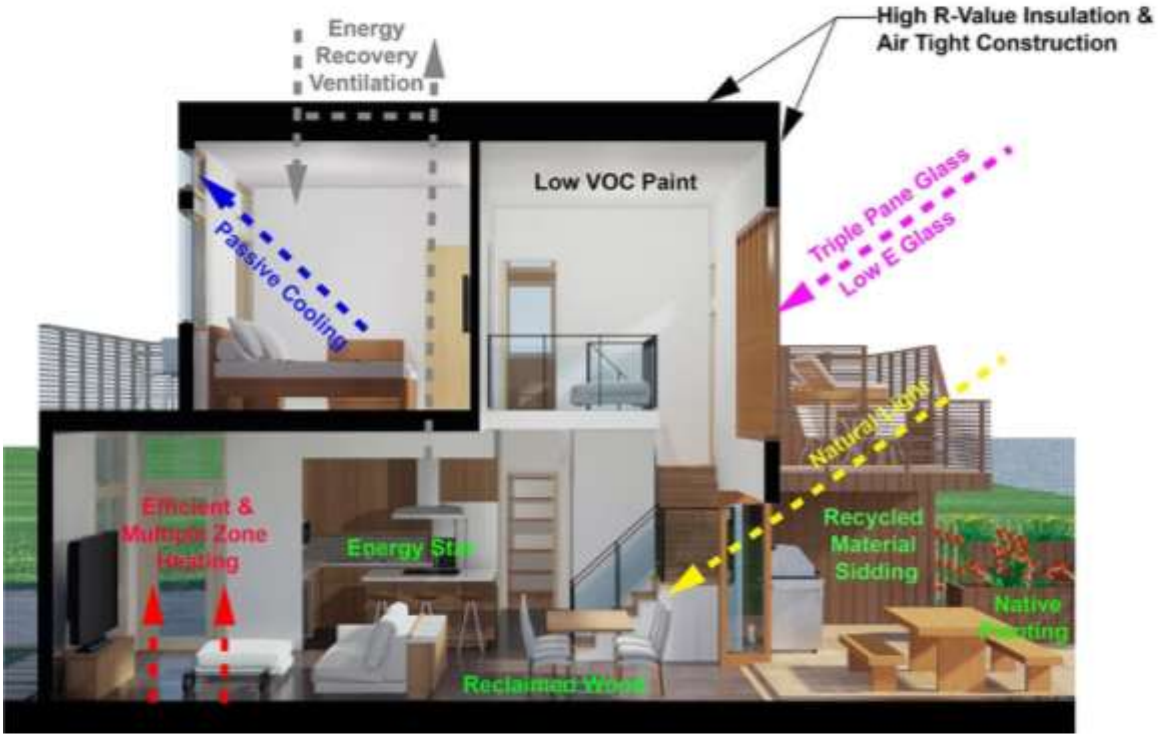
2.1.2. Conception and construction phase

In the conception phase and in order to design ecological housing we need to take into consideration the following notes:

- Promote the use of materials partially or entirely made from natural resources (green building materials), additionally, consider ordering local materials that require as little transportation as possible.
- Use highly recycled materials, such as recycled steel, glass and concrete, to minimize demand for virgin resources.
- To optimize the recycling of materials, it is important to know in advance which residues can be recycled and which waste must be sent to landfill, recycling construction materials is an essential aspect of a green construction site, if it is managed at the last minute, it can be confusing and poorly executed.
- Study the location of the structure must be taken into account for example: geographical location, climate, exposure to wind, sunshine or humidity, the insulation needs of the structure are not the same everywhere.
- Managing construction waste is a step that must be well planned from the start, depending on the type of work, residues must be collected at the beginning, at the end or throughout the operation of the site.

- Proximity to transport and places frequented by the occupants are to be studies, this helps mitigate transport-related emissions, but in the case of a renovation this criterion cannot be modified so it will be strictly in the site.
- Insulation is a key aspect in terms of energy saving at home level, ensuring good insulation of the building avoids heat loss and therefore excess energy consumption.
- Avoid devices using fossil fuels, by using sustainable energy devices: air-water heat pump, photovoltaic panel or wood stove.
- Insure a good ventilation: a home that is well ventilated is therefore less polluted, healthier and warmer which allows for less energy expenditure, good ventilation combines thermal comfort and eliminates toxic agents (which may be due to paints if they are not natural, to household products, etc.).
- Once the site has been deconstructed, it is time to manage its remains, this operation needs to be conducted in the eco-friendliest way possible.

Land, climate, orientation, transport and amenities are therefore elements to take into account to rethink the building in an eco-efficient manner.



Ecological design for homes. Source: 03

<u>2.1.3. Post construction phase</u>

The construction process does not stop when construction wraps, the phase following construction, post-construction, is a crucial component to the project as a whole, the post-construction stage helps to tie up any loose ends before the building is entirely ready for occupancy, this consists of final inspections.

2.2. 2nd pillar: Transportation

Travel/movement is at the heart of our daily lives and the development of our societies, nevertheless, the transport sector is one of the main causes of deterioration in air quality, this is why road traffic constitutes a burden on the health of citizens.

The movement of motorized vehicles running on fuel still represents a significant factor in air pollution, whether in cities or on industrial sites, CO2 levels are often very high in most of the world, causing numerous health, environmental and human problems, therefore, and due to its heavy dependence on fossil fuels, motorized transportation tools now represent a considerable weight in our ecological footprint.

Comparative size of fuel in 3 modes of transportation Source: 04

In order to reduce C02 emissions, many ecological solutions are now being tested, it is necessary to abandon polluting individual cars for more virtuous alternative means of transport, several are also at our disposal: the metro and tram; the bus ; the train ; walking; the bike ; the scooter, electronic cars …., the appropriate solution change from one urban model to another, therefore, finding the **ecological transportation tool or mode** is crucial to the ecological study.

Ecological transport belongs to a broader concept: eco-mobility (or sustainable mobility), this term refers to the fact of designing, implementing and using transport deemed less harmful to the environment, in particular with limited greenhouse gas emissions, the Organization for Economic Co-operation and Development (OECD) defines sustainable transport as transport which:

- does not endanger public health and ecosystems
- respects mobility needs
- is compatible with the use of renewable resources at a rate lower than that necessary for their regeneration
- is compatible with using non-renewable resources at a rate lower than that necessary for the development of alternative renewable resources

2.2.1. Choosing the proper ecological transportation mode/tool

In order to choose the most coherent mode or tool of transportation into our existing urban model (neighborhood, district, city) we need to ask a few question such as: what is the most used means of transport in the surrounding areas? what is the most ecological mean of transport based on gas emission? what is the most ecological mean of transport based on the price and the economic rang of its future inhabitants? What are the most needed amenities and the distance between them and the residential blocs? And finally, what are the means available in the areas/country?

In the urban areas, public transport is as fast as the car motor wise (public transport includes the bus, the bus, the train, the metro/RER or even the tramway), it’s very appreciated especially by workers, it pollutes less and it avoids the stress of traffic jams and searching for a parking space, for example a metro passenger consumes around 10 times less energy than using their car, nevertheless, public transportation can take longer to arrive or more expensive!

Mode of transport	Emission factor (km/passenger)	Assumption Number of Passengers
Airplane	**285 gCO2e**	**88**
“Greedy” car	**158 gCO2e**	**1.5**
“Efficient” or “small” car	**104 gCO2e**	**1.5**
Motorcycle / Scooter	**72 gCO2e**	**1.2**
Bus	**68 gCO2e**	**12.7**
Train	**14 gCO2e**	**156**

Therefore, the decisive criteria are the travel time and the price for the inhabitants and the fuel utilization and gas emission for the government or the designers, in the following lines we mention some of the ecological transportation means and its benefits and its difficulty of application:

Trains

For a similar journey, a plane consumes six times more energy than a train, for example areturn flight from Paris to Zurich emits 300 kg of C02 per person, compared to 48 kg for the train, likewise, 40% of air travel takes place over distances of less than 800 km, for which high-speed lines are often more practical despite the fact that the train serves city centers directly.

In fact, the train is considered to be the greenest mode of transport and the least polluting means of transport, the TGV is equivalent to around 14 g of CO_2 per kilometer, it has low energy consumption, avoiding the stress of traffic jams and fatigue during a long journey, nevertheless, most trains in the world are electric, but their carbon footprint depends on the country's energy mix, if the country produces its electricity other than with fossil energy, then the train is a mode of transport that emits little CO_2, if not, the use of electricity is as much fuel because it is generated of fossil energies.

The secondary problem is that the train is still very expensive for many people because usually it costs more to maintain its efficiency or to pay its electricity consummation.

Different type of trains Source: 05

Electric cars

As its name suggests, the electric car uses electricity instead of fossil fuels, it does not emit greenhouse gases because it does not have a heat engine, it is very practical in urban traffic with short distances. In addition, the electric vehicle reduces noise pollution but its sale at unaffordable prices to the majority of workers for example the cheapest electric automobile at can cost $27,495 = 3763076da for a maximum speed can go from approximately 125 km/h (small city car) at 412 km/h (Rimac Nevera) currently.

Electric car charging its battery Source: 06

Tram (tramway)

The tram is punctual, approximately every 5 minutes and can take up to 120 passengers at a time. Its speed rate is faster than buses but it is a heavy and mass medium mode of transportation, meaning that for the tram to be efficient we need large numbers of people on a daily basis to travel from a point to another, also it has the same difficulty in its electricity use as the trains.

A tram. Source: 07

Bicycles

The bicycle is economical, does not pollute, does not make noise, does not consume fossil energy, is not dangerous for others, is fast (its average speed is equivalent to that of the car in an urban environment) and is good for your health, nevertheless, this mode of transportation is considered the most efficient for distances of less than 6 km, so it depends on the urban model whether its compact or not, convenient to bicycles or more motorized …..

Bicycles' parking. Source: 08

Segways

Also known as a gyro pod, it represents an electric platform which operates on the basis of a gyroscopic stabilization system. The Segway was created by the American Firm Dean Kamen in 2001, and subsequently, the Segway was developed by other companies, but it requires certain quality of roads and it is expensive, not affordable to most people.

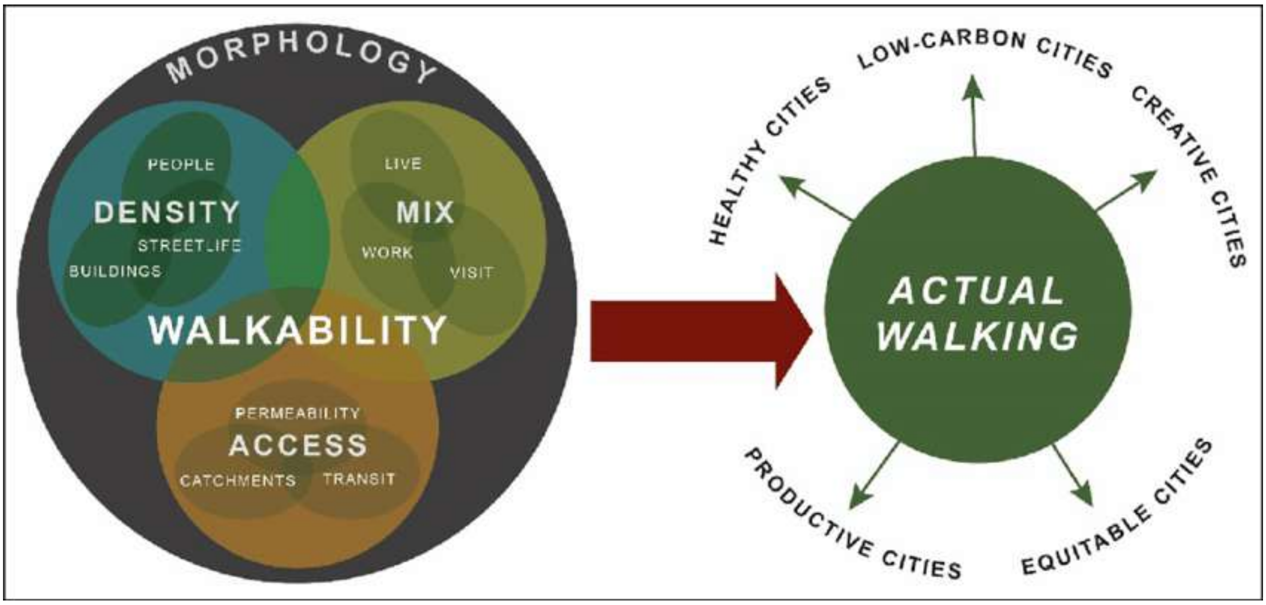
Example of segways Source: 09

In addition to those, there are other mode or means of transport that are not mentioned in this course due to its specificity, such as:

- River transport (hydrographic specificity)
- Transport of heavy goods (type of goods and its environmental effects)

2.2.2 walkability

The term "walkability" was primarily invented in the 1960s due to Jane Jacobs' revolution in urban studies. In recent years, walkability has become popular because of its health, economic, and environmental benefits, in urban planning, walkability is the accessibility of amenities by foot, it is based on the idea that urban spaces should be more than just transport corridors designed for maximum vehicle throughput, instead, it should be relatively complete livable spaces that serve a variety of uses, users, and transportation modes and reduce the need for cars for travel.



The functional mix of walkability Source: 10

Almost half of car trips are less than three km, these short journeys cause high fuel consumption and significant emissions, using cars for short distances is expensive and polluting, nevertheless, there are many Factors influencing walkability include the presence or absence and quality of footpaths, sidewalks or other pedestrian rights-of-way, traffic and road conditions, land use patterns, building accessibility, and safety, among many others.

Therefore, to promote walkability we need to create the functional mix, like density, shortens the distances between wherever we are and where we need to be, the live/work/visit triangle constructs a field of possible relations between three primary functions needs to be walkable and enjoyable.

COURSE 03

2.3. 3rd pillar: Vegetation and public space

Greening is one of the important issues at the heart of the thinking of several processes especially when we are talking about ecological cities, contrary to some beliefs, the countryside is not the only place where you can combine housing and vegetation, the notion of "vegetation" covers all actions which aim to integrate green spaces, especially in urban areas where it tends to be forgotten, by promoting the establishment of nature in cities, we directly strengthen biodiversity and develop a habitat favorable to life.

Many ecological projects invest in the multiplication of green spaces wish to (re)introduce plants into urban areas, this concerns both the choice of plantations and the techniques used for their maintenance, likewise, products harmful to the environment and humans as well as non-local plants are banned.

Vegetation in the city have many benefits for the environment and multiple positive effects on the population:

- Environmental regulator: many products produce chemical substances which spread quickly in the atmosphere and have consequences on the health of living beings the environment.
  Plants can limit toxic emissions, it functions as a natural barrier which absorbs polluting substances and in return, emits water vapor. Therefore, it humidifies the air and improve air quality.
- Reduce water waste: the revegetation of urban areas also fights against runoff and the infiltration of rainwater by de-waterproofing the soil, in urban areas, the benefits of plants are multiple. Among their advantages: they partially clean runoff water.
- Reduce stress and mental disturbances: access to green spaces truly contributes to improving the health of residents by reducing stress, promoting physical activity and calming the mind.
- Reduce noise pollution: one of the big advantages of integrating plants into the city is reducing noise pollution, vegetation absorbs 41% of noise and provides an environment conducive to rest and tranquility.

2.3.1. Types of green environment in ecological projects

There are many ways to increase plant biodiversity in cities, those are some different types of green environments to include when considering an ecological project:

- Collective gardens: a collective vegetable garden or shared garden in urban areas is always a pleasant way to grow and produce vegetables surrounded by your neighbors, as recently called 'urban agriculture", this community gardens can provide food for the inhabitants and invite relaxation and social exchanges along with economic benefits.
- Green roofs: a 10 cm thick green roof allows a reduction of 25%, we notice that the temperature rises up to 70% in summer on a so-called traditional roof, compared to 37% for a green roof but not all plants can be used for this type of development, it offers the inhabitants of each building the possibility of having a "private garden", nevertheless, its development conditions being difficult (little substrate and nutrients, intense sunshine in summer, drying winds, irregular water supply).
- Green spaces: here, the term "green spaces" is used in the sense of "large public outdoor areas". In order to integrate biodiversity into the city, the quality of landscaping depends on the balance between the types of species planted, their characteristics and their arrangements, the creation of green spaces can be based on vegetated areas already present on the sites and offering particular and interesting biodiversity, nevertheless, we may have to deal with different types of green spaces and diversified landscape styles
- Vertical revegetation: in addition to climbing plants and green balconies, Nathalie Mongé (2010) introduce a new technology for greening building facades, this system is made up of stackable and juxtaposable modules, made from a new material that can be seeded, associated with a substrate, the originality of the concept also lies in the aesthetic nature of the material, even in the absence of vegetation.
- An urban green network: the green network constitutes a system of green spaces establishing green continuities, in the form promenade avenues (greenways) and promenade banks, without obstacles or breaks, therefore, ecological corridors, interrupted routes, tree-lined areas without landscape continuity are to be avoided, to avoid that we need to follow some guidelines:
  - Connect all green spaces to each other in order to allow their colonization by wild animals and plants.
  - Organize flows (water, energy, waste, materials) in such a way as to reduce their ecological footprint.

- Promote air purification through planned use of vegetation.
- Choose plants according to the climate: plants with low water requirements in dry areas, water intensive plants in wet areas to limit erosion.
- When choosing plantations, favor local, diversified and easy-to-maintain species.
- Use natural materials (stone, wood) for fittings.

- The Eco-garden label: as a maintenance method not a type of greening in the city, it is a label valid for three years and subject to compliance with a certain number of commitments in ecological management practices, the label can only be obtained if the following criteria are respected:
  - absence of bare ground,
  - evaluation of the water needs of plants for watering and closed circuits of fountains,
  - implementation of measures to preserve biodiversity,
  - absence of use of products resulting from synthetic chemistry and/or dangerous for auxiliary fauna and/or the environment,
  - reduction in the production of green waste,
  - existence of a training plan including ecological themes.

2.3.2. types of foliage:

There are two different types of trees based on its foliage:

- evergreen foliage: Those trees seems to remain always green throughout the months, a generation of leaves remains in place for at least 2 years, or even 3, it has leaves from the current year as well as leaves aged 2 to 3 years, when a new generation of leaves appears, the first ones are still there, the good thing about evergreens is that they always seem to stay green, this is why we use them as a permanent backdrop or as a hedge, nevertheless, the flowering of evergreen shrubs is sometimes much less ornamental but that is the price to pay

- deciduous foliage: in those trees, the leaves generally appear in spring and then fall all together in the fall, the leaves are therefore all the same age, and when they fall, the tree is stripped until new buds appear the following year, it breaks the monotony of the view and offers more ornamental and efficient coverage from the sun but harder to maintain.

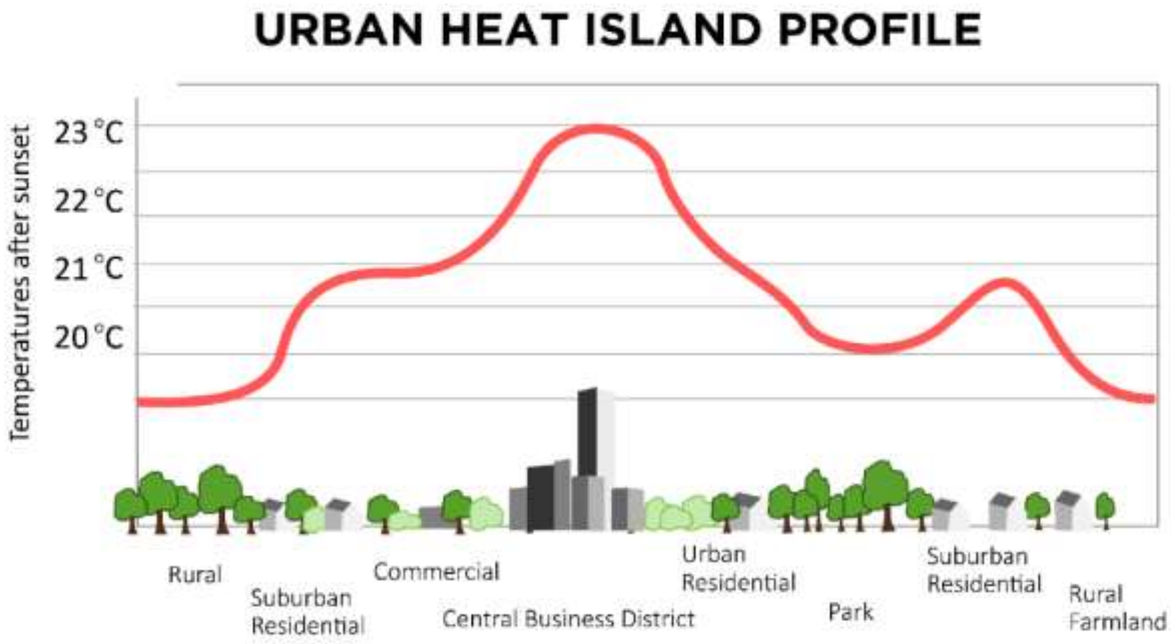
Evergreen and deciduous foliage. Source: (01)

2.3.3. Urban heat island (Ilot de chaleur)

The urban heat island is a thermal dome effect, creating a sort of urban microclimate where temperatures are significantly higher: the closer you get to the center of the city, the denser and higher it is, and the higher the thermometer rises, according to a study published in March 2018 in Physical Review Letters (UHI) this phenomenon affects more than 80% of the population living in urban areas.

Various studies on urban heat islands have shown that these temperature differences are a fairly complex phenomenon where causes and effects intertwine. Because it depends on many factors such as the "type of weather" but also on the geographical and climatic location, the vegetation cover and the topography of the city.

The urban heat island also depends on winds, a strong wind will promote air circulation and therefore reduce the heating of the urban areas, on the contrary, a weak wind leads to stagnation of the air masses which then have time to heat the building: thus, the calmer and clearer the weather, the more intense the urban heat island. In addition, the urban form affects the wind regime: a narrow and steep street, forming a canyon, prevents the winds from circulating and then causes the air masses to stagnate.



Schematic section showing temperatures in heatwave night, Geneva, 2008 Source: (02)

Effect of vegetation on the temperatures in urban areas. Source: (3)

Green spaces play a **critical role in mitigating the Urban Heat Island (UHI) effect**, a phenomenon in which urban areas experience significantly higher temperatures than surrounding rural regions due to dense infrastructure, reduced vegetation, and excessive heat absorption by buildings and paved surfaces. The disparity in temperature not only affects **thermal comfort** but also contributes to **increased energy consumption**, **air pollution**, and **public health risks**, especially during heatwaves.

Plants and vegetated areas help combat this imbalance through multiple synergistic mechanisms. First, vegetation reflects a greater portion of incoming solar radiation compared to built surfaces, reducing overall heat absorption. Second, the process of evapotranspiration the combination of water evaporation from soil and transpiration from plant leaves absorbs latent heat from the atmosphere, leading to a cooling effect in the surrounding air. Third, the shade cast by trees and shrubs significantly lowers surface and ambient temperatures, especially in pedestrian zones, parks, and along streets.

Moreover, the strategic integration of green infrastructure such as urban forests, green roofs, vertical gardens, and community parks not only contributes to thermal regulation but also enhances air quality, biodiversity, stormwater management, and aesthetic and psychological well-being. Studies have shown that urban neighborhoods with higher green coverage can be several degrees cooler than nearby built-up zones with minimal vegetation.

Addressing the heat imbalance between rural and urban areas through the expansion and preservation of green spaces is a vital component of climate adaptation strategies in modern cities. Urban planners and policymakers are increasingly recognizing the need to incorporate nature-based solutions into city design to foster resilient, healthy, and livable urban environments for present and future generations.

2.4. 4th pillar: Water management

2.4.1. Water distribution

The preservation of drinking water resources is a major issue at the ecological, economic and social level, better consideration of the water cycle in the city aims to manage rainwater close to its natural cycle. The principle is to allow it to infiltrate quickly and as close as possible to the place where it falls, this type of development is specific to humid environments, as for the dry environment the easiest solution is the development of open-air, shallow retention basins or swales.

Planning ecological water distribution involves designing a system that prioritizes sustainability, efficiency, and minimal environmental impact. Here are some key factors to consider when planning ecological water distribution:

- Assess Water Availability and Demand:

- Understand the local water sources, including rivers, lakes, groundwater, and rainwater.

- Evaluate the current and future water demand based on population growth, industrial needs, and agricultural requirements.

- Conduct a Water Quality Analysis:
  - Assess the quality of available water sources to ensure they meet health and environmental standards.
  - Identify potential pollutants and contaminants that may affect water quality.
- Integrate Rainwater Harvesting:
  - Incorporate rainwater harvesting systems to capture and store rainwater for later use.
  - Implement green infrastructure, such as permeable pavements and green roofs, to enhance rainwater infiltration.
- Implement Sustainable Technologies:
  - Utilize sustainable water treatment technologies to minimize the environmental impact of water treatment processes.
  - Explore eco-friendly water distribution technologies, such as leak detection systems.
- Adapt to Climate Change:
  - Consider the potential impacts of climate change on water availability and plan for adaptive strategies.
  - Implement measures to increase resilience to extreme weather events, such as floods and droughts.
- Monitor and Evaluate:
  - Establish a monitoring system to track water quality, usage, and distribution efficiency.
  - Regularly evaluate the ecological and social impacts of the water distribution system and make adjustments as needed.

- Obtain necessary permits and approvals for water extraction and distribution activities.

2.4.2. Sanitation network and techniques

Planning an ecological sanitation network involves careful consideration of various factors to ensure sustainable and environmentally friendly solutions, in order to create an ecological sanitation network the following guidelines are to be considered:

- Understand Local Context:
  - Assess the local environmental conditions, climate, soil type, and water availability.
  - Consider the population density, demographics, and cultural practices.
- Conduct a Needs Assessment
  - Identify the sanitation needs of the community, including current sanitation practices, challenges, and potential health risks.
  - Consider future population growth and changing needs.
- Select Appropriate Technologies:
  - Choose ecological sanitation technologies that are suitable for the local context specially from an economic and availability point of view.
- Integrate Water Management:
  - Incorporate water conservation and reuse strategies into the network design.
  - Consider rainwater harvesting and greywater reuse for non-potable purposes.
- Consider Resource Recovery:
  - Explore opportunities for resource recovery from waste, such as producing compost or biogas.
  - Implement systems that allow for safe and beneficial use of by-products.
- Budget and Funding:
  - Develop a detailed budget for the construction, operation, and maintenance of the ecological sanitation network.
  - Explore funding options, including government grants, NGOs, and community contributions.
- Implement in Phases:

- If the project is large, consider implementing it in phases to manage resources effectively and allow for adjustments based on early experiences.

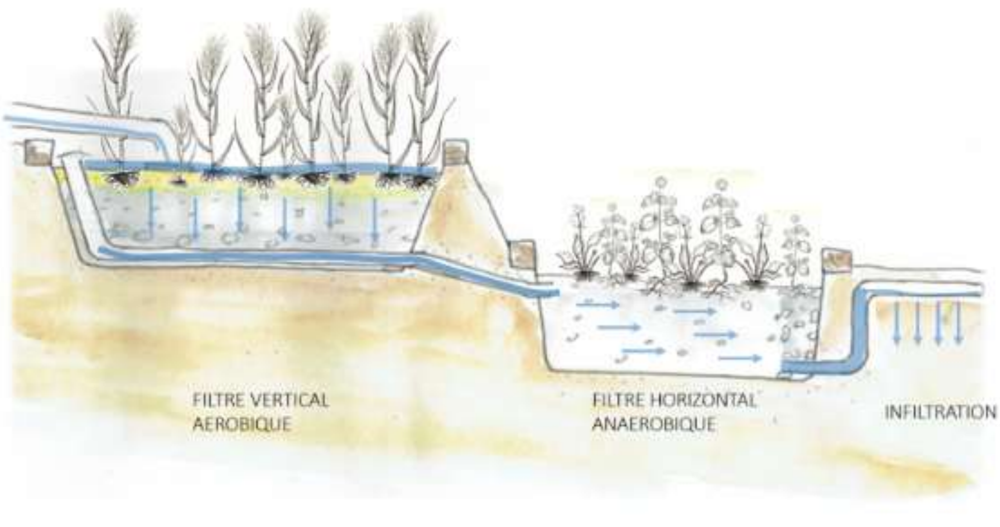
2.4.2.1. Ecological sanitation

This is a global ecosystem approach that protects aquatic environments at the basis of ecological sanitation, there is the separate management of gray water and dark water,

In ecological sanitation, it is essential to promote methods based on the following principles:

- separate our waste at the source: Urine, faeces and gray water do not mix, which simplifies their recycling.
- simplify the sanitation system: limited to gray water, treatment requires few resources, it uses renewable materials and it is technically and financially accessible to the majority of inhabitants.

The technique of Phyto-purification: is a natural process of filtration or depollution of wastewater, using plants, it involves purifying wastewater using bacteria hidden in the root system of plants which are called purifiers. The process is completely ecological, odorless and can be very aesthetic.



Phyto-purification technique. Source: (04)

A phyto-purification model. Source: (05)

The technique of lagunage:

The lagunage is a technique where used water is sent to successive bassins in the lagoon and treated by bacteria and aquatic plants, these lagoons have a profound (1 x 1.2 m) and placed on a compact armrest.

The lagunage technique Source: (06)

COURSE 04

2.5. 5th pillar: Waste management

The solving of the waste management problem is relatively easy in rural areas where the organic matter from household, organic waste can be buried to amend the soil and the rest destroyed by combustion without too much nuisance, it is much more complex in urban areas.

In these areas, the high concentration of populations and economic activities is the cause of a significant and diversified production of waste, the management of which requires the implementation of significant resources and suitable infrastructure.

Furthermore, given this difficult to control situation, the spiral of rapid urbanization is developing without control of infrastructure (road network, water and electricity distribution) or management of municipal revenues, which are nevertheless necessary for financing these additional services such as solid waste collection.

At the same time, this movement of population towards the cities generates a series of difficulties which are: poverty, unemployment, unsanitary conditions and deficits of all kinds, these difficulties are all challenges that the authorities must meet while taking into consideration public health and environmental problems.

Wastes collect area in Paris. Source:01

Defining an ecological waste management policy is therefore not so simple, it must take into account numerous parameters such as the administrative structures of the city, demographic data, access conditions for waste removal, urban facilities and the financial resources of households and local authorities, etc. Faced with this complexity, it is easy to understand that certain problems can appear.

2.5.1. Definition and typology of wastes

Waste can be defined as follows: *"any residue from a production, transformation or use process, any substance, material, product or, more generally, any object, movable property of which the holder discards, plans to get rid of, or which he has the obligation to get rid of or eliminate."*

The simplest typology characterizes waste according to their dangerousness and their potential impact on health and the environment, the generic term "dangerous" brings together a community list, waste presenting characteristics recognized as dangerous: explosive, toxic, flammable, capable of emitting harmful substances, etc.,

Waste can be classified into 2 main categories either according to the origin of the waste or according to the nature of the danger.

according to the origin of the waste	according to the nature of the danger
Household and similar waste (DMA)	Radioactive waste.
Ordinary industrial waste (DIB)	Hazardous waste.
special industrial waste (DIS).	Inert waste.
Agricultural waste	Final waste.
Construction and demolition waste (inert waste)	Non-hazardous waste.
Healthcare waste (DAS)	
or infectious waste (DASRI).	
Waste electrical and electronic equipment	
Automotive waste	

An ultimate waste resulting or not from the treatment of waste, which is no longer likely to be treated under the technical and economic conditions of the moment, in particular by extraction of the recoverable part or by reduction of its polluting or dangerous nature.

Technical Landfill Center (CET) Facilities where waste is buried, since the obligation to bury only final waste, these centers are now called Final Waste Storage Centers.

2.5.1.1. Household and similar waste:

This category of solid waste covers household waste, municipal waste or urban waste, urban residue (cleaning waste), the term "assimilated" refers to waste from industrial companies, artisans, traders, schools, public services, and hospitals which have physicochemical or toxicity characteristics equivalent to those of household waste.

According to Algerian legislation relating to the management, control and elimination of waste, article 03 of law 01/19 of December 12, 2001 (JORADP), household waste is defined as follows: *"Household and similar waste: all waste from households as well as similar waste from industrial, commercial, craft and other activities which, by their nature and composition, are comparable to household waste."*

The quantities of household waste produced can be expressed in weight or volume. However, due to the compressibility of household and similar waste, only the weight constitutes reliable and measurable data on a weighbridge, we then measure the quantities of household waste in kg/inhabitant/day or per year. On the other hand, to define the size of the containers, the estimation of volumes is necessary.

According to the Ministry of the Environment and Regional Planning (2011), each Algerian produces on average 0.65 kg of waste per day. But in large cities like Algiers, a citizen generates around 1.7 kg of waste per day.

Calculation of the daily ratio (R) Simply divide the total weight of household waste collected in one day by the number of inhabitants using the following method:

$$R=p/h$$

2.52. waste's sorting

Waste sorting is mandatory from an ecological perspective because:

➢ it Guarantees personal safety

➢ Respect public health and the environment by ensuring that each waste follows an appropriate channel

Implementation of an ecological sorting procedure needs to meet with the following criteria:

- simplicity: simple typology, acceptable and known to all

- security: absence of DASRI in DAOM (DAOM is Waste Assimilated to Household Waste, DASRI is Household Waste 'Infectious Risk Care Activities)
- consistency: with regulatory texts
- stability over time
- monitoring (training and information): evaluation of effectiveness on the environment

Sorting facilities. Source: 02

The simplest way to identify the different categories of waste and encourage sorting is to separate waste into containers or plastic bags of different colors and/or marked with a symbol, the international recommendations are as follows:

- Waste must be collected regularly, at least once a day.
- it must not accumulate where they are produced.
- A daily program and a collection circuit must be planned.
- Each category of waste will be collected and stored separately.
- Waste of an infectious nature (categories 1 and 2) must under no circumstances be stored in places open to the public.

The reality in Algeria is that garbage of all kinds is put in the same bag and thrown into the same garbage bin, or next to it when it fills up, very quickly in fact, the waste is then buried underground, awaiting the future incinerators that the State intends to acquire.

2.5.3. The recycling

Recycling has a significant impact on the environment. Indeed, the economic and environmental benefits of recycling are considerable: it helps protect resources, reduce waste, create jobs, protect nature and save raw materials.... For example: each ton of recycled plastic saves 700 kg of crude oil; recycling 1 kg of aluminum can save around 8 kg of bauxite, 4 kg of chemicals and 14 kWh of electricity; each ton of recycled cardboard saves 2.5 tons of wood; each sheet of recycled paper saves 1l of water and 2.5 W of electricity in addition to 15 g of wood.

Selective trash can for recycling purposes. Source: 03

2.5.3.1. Recyclable waste: Recyclable waste is that which can be sorted and given a new life under different packaging. Recyclable waste is classified into 4 main categories: plastic, glass, paper and metal.

Recyclable plastic waste: all plastic containers are recyclable: Plastic bottles and flasks. Transparent or opaque plastic bottles and vials.

Recyclable glass waste: All glass containers are recyclable: Bottles. The jars. Small glass jars.
Recyclable paper waste: Almost all paper and cardboard are recyclable provided they are clean and unsoiled (from food waste for example).

Recyclable metal waste: steel cans, Steel bombs, aluminum cans, aluminum trays, milk or fruit juice beverage cartons, Glass containers are recyclable: bottles, jars, small glass jars., Vials without recessed cap. Non-recyclable waste is sent to the Energy Recovery Treatment Unit (UTVE) where it is incinerated with the production of electricity as an ecological solution.

The socio-economic and socio-cultural issues of waste management: By asking the relevant questions who pays what and who does what? Some issues must be studied:

- the redefinition of costs in relation to the life cycle of products
- integration of social and environmental costs
- resource centers (community reduction, reuse and recycling-composting centers)
- make waste producers responsible
- regionalization of waste-resource management

Recycling collection locations: it must be clear, installed as close as possible to users, adapted to the quantity of waste produced, and easily accessible for service providers; it must not generate nuisance and be cleaned frequently, it must be the subject of particular attention to prevent them from becoming "a sort of landfill" which could cause inconvenience and nuisance.

2.5.4. The major problems linked to waste management in urban areas

- Health legislation and regulations are poor and disparate.
- Legislation exists but is not adapted to the situation in the country (transposition of legislation from industrialized countries).
- Well-considered strategies are enacted at the national level but the follow-up and actions are slow to be put in place.
- National regulations exist but the municipality does not receive, or cannot grant itself (cannot levy the tax), the financial means to organize and control the collection.
- In the field, it is difficult to distinguish the hierarchical structure between the authority responsible for waste management, collection operator, controller, citizen. Each blames the other for the poor functioning of the system.
- Waste is collected but dumped further away without precaution or authorization: the collector does not fulfill the mission for which he is paid or his mission is not well defined due to a lack of land dedicated to the final disposal of garbage.
- The collection rate does not always exceed 50%, or even less than 30%. Low-income neighborhoods, where the consequences of non-waste collection are the most serious, are the least served due to lack of access (unstructured urbanization) or safety for the operator and their equipment.
- Adequate or overly sophisticated equipment has been donated by foreign cooperation organizations but the operators do not or no longer have the means to maintain it or purchase spare parts.
- The trucks used to collect waste are not always equipped with a compaction system or nets and, during transport, some of the waste escapes from the skip.

- Neighborhood containers are unsuitable for children and women who are frequently responsible for bringing waste there.
- The tax collection rate for waste management is insufficient, or does not even exceed 40% in middle and high income neighborhoods.
- In neglected neighborhoods, we frequently observe that uncollected garbage piles up, or is even dumped by local collectors, in the city's vacant lots, in gutters, gullies or is sometimes incinerated in the evening, creating problems health and environmental.

The fundamental causes behind these situations are multiple and not always perceived as such, mainly due to lack of information, but this is not the only reason:

- The financial factor also has a certain importance: with few means, it is difficult to work miracles.
- The need for large-scale organization and planning is not always well perceived by the authorities involved or indirectly concerned (police, public health, town planning, etc.).
- Citizens are not always called to the table to participate in the first phases of waste management, which are often the most significant and costly.
- Finally, the accountability of the different actors could often be increased by clearly defining the mission to be fulfilled and introducing clear taxes to the actors.

COURSE 05

3. different methods of an urban ecological evaluation

The choice of evaluation method depends on the objective of the evaluation and the resources available, in the case of urban ecology assessment, it is important to choose a method that allows measuring the contribution of a project to the preservation and improvement of biodiversity and ecosystem services, there are several methods for evaluating urban ecology, these methods can be classified into two main categories:

- Quantitative methods, which use measurable indicators to evaluate the ecological performance of a project.
- Qualitative methods, which rely on more subjective criteria, such as the perception of residents.

Among the most common quantitative methods, we can cite:

- The biodiversity index, which measures the diversity of species present in an area.
- The air quality index, which measures the concentration of pollutants in the air.
- The water quality index, which measures the quality of water in a stream or lake.

Some of the most common qualitative methods include:

- The survey of residents, which allows us to collect their perception of the urban environment.
- Analysis of aerial or satellite imagery, which makes it possible to visualize land use and the presence of natural elements.
- The analysis of urban plans, which allows us to understand the design and management of urban space.

3.1. High environmental quality

High environmental quality (HQE) is a concept which aims to improve the quality of life of city residents by taking into account environmental issues, it is based on a set of principles and criteria which are applied to the design, construction and management of buildings and urban spaces.

High environmental quality HQE is a process which makes it possible to measure the contribution of an urban project to the preservation and improvement of the environment, it can be used to evaluate construction, renovation or urban development projects.

3.1.1. HQE 2R: High Environmental Quality for Rehabilitations

HQE 2R is a French certification process which aims to evaluate and promote the environmental quality of rehabilitation projects, it is based on taking into account 14 targets divided into 4 areas:

- Eco-construction
  - Ecological choices of materials and products
  - Management of construction site waste and deconstruction
  - Low nuisance construction site
  - Water and energy conservation
- Comfort and health

  - Indoor air quality
  - Acoustic and thermal comfort
  - Sanitary quality of water
  - Security and accessibility
- Operation management
  - Environmental management of the operation
  - Management of the quality of execution
  - Communication and awareness of occupants
- Territory and biodiversity
  - Integration into the site and respect for the environment
  - Management of green spaces and contribution to biodiversity
  - Management of rainwater and wastewater
  - Control of energy consumption

HQE 2R certification is available in 3 levels:

- Basic level which guarantees compliance with environmental regulations and the implementation of good practices.
- Intermediate level which allows you to go beyond regulations and improve the environmental quality of the project.
- The highest level which rewards exemplary projects which integrate an ambitious environmental quality approach.

HQE 2R presents several advantages for rehabilitation projects:

- Improvement of the environmental quality of the building:The HQE 2R approach makes it possible to reduce the environmental impacts of the construction site and the operation of the building, to guarantee the health and comfort of the occupants, and to enhance the architectural heritage.
- Operating savings:** Taking into account water and energy efficiency as part of the HQE 2R approach makes it possible to reduce the building's operating costs.
- Better valuation of real estate:An HQE 2R certified building is more attractive for occupants and investors, and can result in an increase in its real estate value.
- Contribution to sustainable development:The HQE 2R approach contributes to the creation of more sustainable and environmentally friendly cities and neighborhoods.

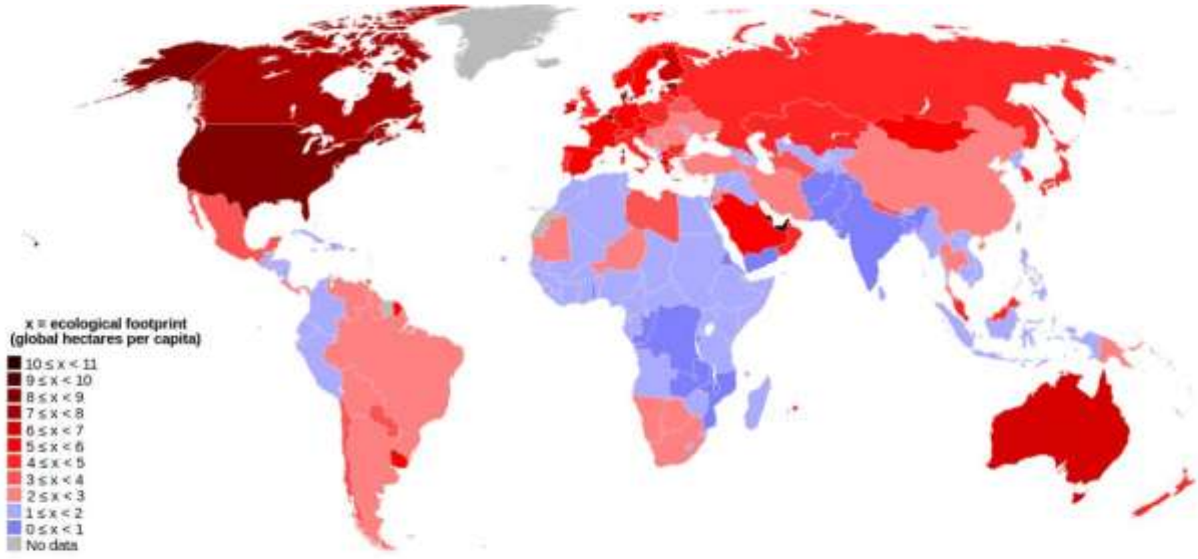
In Algeria, the HQE 2R approach is still little known and little used, However, it presents significant potential for rehabilitation projects, particularly in the context of the energy transition and the fight against climate change.

3.2. The ecological footprint

The ecological footprint is a measure of the pressure that humanity exerts on the planet, it is calculated by the amount of productive land and water needed to support the consumption and waste absorption of a given population.

The ecological footprint is calculated by dividing a population's resource consumption by global biological productivity, resources considered include agricultural lands, forests, grazing lands, wetlands, fresh waters and oceans.

The ecological footprint of a population is expressed in global hectares per person (gha/person), global hectare is a unit of area equal to 10,000 square meters m².



A world map for ecological footprint 2017. Source: 01

The global ecological footprint has grown exponentially in recent decades. In 2016, the global ecological footprint was 2.8 planets, this means it would take 2.8 planets to support humanity's consumption and absorption of waste, the growth of the ecological footprint is due to several factors, including population growth, economic growth and lifestyle changes.

Population growth means more people are consuming resources, economic growth means people consume more goods and services, which leads to increased resource consumption, lifestyle changes, such as urbanization and motorization, also lead to increased resource consumption

3.3. Sustainable urban analysis indicators

Sustainable urban analysis indicators are a valuable tool for cities and neighborhoods that wish to engage in sustainable development, it makes it possible to assess the environmental and social performance of cities and neighborhoods, to define sustainable development objectives and to monitor changes in performance over time, sustainable urban analysis indicators can be used to:

- Evaluate the environmental and social performance of a city or neighborhood
- Define sustainable development objectives for the city or neighborhood
- Monitor the evolution of the environmental and social performance of the city or neighborhood over time

The 14 sustainable urban analysis indicators (17 or more including the new added area of governance) are criteria used to assess the environmental and social quality of a city or neighborhood, it can be divided into 4 areas:

A/ Environment

1. Air quality
2. Water quality
3. Waste
4. Energy
5. Biodiversity.

B/ Social

6. Quality of life
7. Social inclusion
8. Mobility
9. Security
10. Education

C/ Economy

11. Green growth
12. Job
13. Innovation
14. Competitiveness

D/ Governance

15. Local governance
16. Citizen participation
17. International cooperation

Each indicator is rated on a scale of 1 to 5, with 5 corresponding to the best performance, here are some examples of sustainable urban analysis indicators:

A/ Environment

- Rate of Waste production per Hab
- Rate of Energy consumption per hab

B/ Social

- Unemployment rate
- Scolarisation rate

C/ Economy

- Employment rate
- Market share of local companies

D/ Governance

- Citizen participation in local decisions
- Number of partnerships between the city and businesses

CONCLUSION

The study of urban ecology, as developed throughout this course, offers a multidimensional and interdisciplinary perspective on the interaction between human settlements and the natural environment. With cities becoming the predominant human habitat in the 21st century, understanding and applying the principles of ecological balance in urban contexts is no longer optional—it is essential for achieving long-term environmental sustainability, social well-being, and economic resilience.

In Chapter 1, we laid the foundational understanding of general ecology, with a focus on its application within urban environments. We explored the basic ecological factors that regulate life in ecosystems, including biotic and abiotic components. The notion of ecosystems in the urban context revealed how cities, despite being artificial constructs, function as dynamic ecosystems where materials, energy, and living communities interact in complex ways. The section on energy flow and productivity emphasized that ecosystems depend on efficient energy transfer and material cycling, concepts that are critical when planning energy-efficient urban systems. Additionally, the discussion on the dynamics of living communities—including population structure, species interactions, and succession—highlighted how urban development can disrupt or support biodiversity.

We also examined urban nuisances—a key concern in densely populated areas—such as air and noise pollution, light pollution, and the heat island effect. These nuisances degrade quality of life and are closely tied to issues like poor planning, uncontrolled emissions, and lack of green infrastructure. Recognizing the sources of urban pollution enables more targeted interventions and policies aimed at protecting public health and ecological integrity.

In Chapter 2, the course introduced the five pillars of urban ecological analysis, each representing a critical domain for intervention and innovation in sustainable urbanism.

The first pillar, housing, addressed the life cycle of buildings—from land selection and site management to construction and post-construction operations. This holistic view revealed how architecture and urban planning must integrate ecological thinking from the earliest stages of design. Environmental controls during site works, selective demolition, and energy-efficient construction can significantly reduce a building's ecological footprint. Post-construction practices, such as water and energy monitoring, ensure that ecological goals remain operational over time.

The second pillar, transportation, focused on mobility as a central feature of urban life and a major contributor to pollution. We discussed the importance of selecting ecologically sound modes of transport, such as public transit, cycling, and electric vehicles. Furthermore, promoting walkability was identified as a low-cost yet highly effective strategy to reduce greenhouse gas emissions, improve public health, and foster social interaction.

The third pillar, vegetation and public space, underscored the importance of integrating nature into urban design. Urban greenery—including parks, green roofs, and street trees—not only enhances aesthetic value but also combats the Urban Heat Island effect, improves air quality, and supports biodiversity. Different types of green spaces and foliage offer varying ecological services, which must be thoughtfully selected and maintained. Public spaces, when designed with ecological principles in mind, become zones of environmental learning, recreation, and community cohesion.

The fourth pillar, water management, addressed the vital issue of urban hydrology. From water distribution systems to ecological sanitation techniques, cities must find ways to ensure safe and sustainable water use while minimizing pollution. We explored how decentralized, low-impact sanitation systems can be integrated into urban infrastructure to conserve water, recycle nutrients, and reduce environmental degradation.

The fifth pillar, waste management, dealt with one of the most visible challenges in urban ecology. We discussed the classification and typology of waste, with particular attention to household waste, sorting practices, and recycling mechanisms. The ability to transform recyclable waste into new materials was presented as a key strategy for reducing landfill use and closing resource loops. However, significant barriers still exist, such as inadequate infrastructure, lack of public awareness, and insufficient regulatory enforcement—making this a priority area for reform in many urban settings.

Finally, Chapter 3 introduced various methods for evaluating urban ecological performance, emphasizing the importance of measurement and accountability in ecological planning. The High Environmental Quality (HQE) approach, particularly HQE 2R for rehabilitations, allows cities to ensure that both new developments and renovations meet high ecological standards. Additionally, tools like the ecological footprint provide a quantifiable measure of human impact on the planet, while sustainable urban analysis indicators help policymakers and urban planners monitor progress across domains such as energy, water, mobility, and social equity.

This course has demonstrated that urban ecology is far more than a theoretical discipline—it is a practical framework for rethinking how cities are designed, built, and managed. By bridging environmental science with urban planning, architecture, engineering, and public policy, urban ecology provides actionable strategies for creating healthier, more resilient, and more inclusive urban environments.

As future professionals, policymakers, or citizens, understanding the interconnectedness of ecological systems and human infrastructure will empower us to make decisions that reduce environmental harm while promoting sustainability and equity. Whether it's by choosing sustainable transportation, supporting urban agriculture, participating in waste sorting, or advocating for green spaces, everyone has a role to play in shaping the ecological cities of tomorrow.

The ecological challenges facing urban areas—from climate change to resource scarcity—are significant. But as this course has shown, they are not insurmountable. Through thoughtful analysis, innovative design, and collective action, it is possible to build cities that are not only functional but also regenerative, harmonious, and ecologically sound.

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COURSE 05

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