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Urban Ecology

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1. Introduction

The growing population of urban centers necessitates the study of interaction between living organisms and urban environment, which is defined as the environment surrounded by man-made structures, such as residential and commercial buildings, paved surfaces etc [1]. Within this scope, urban ecology developed as a branch of ecology in the last few decades. According to United Nations [2], in forty years' time, two-third of the world's population will be living in growing urban centers, thus it is apparent that urban ecology is fairly important.

As the ecological processes in urban environment are comparable to those outside the urban context, the methods and studies at urban ecology are similar to ecology, in general. Urban ecology dictates that local-scale dynamic interactions between socioeconomic and biophysical forces leading to development of a concept called city. Alberti et al. [3] states that distinctive ecology and ecological forcing functions for urban areas were also shaped by means of these complex interactions.

Inherently, urban ecology is an interdisciplinary field of study. The examination of complex interactions between humans and their surrounding, such as construction, production, housing, transport etc., necessitates the involvement of natural and social sciences as well as humanities and engineering. The direct consequence of this interdisciplinary nature is that urban ecology can be used not only for understanding the urban systems but also for improving the conditions of urban environments. For example, it is required to comprehend how the urban system functions and in which extent it is affected from the global and local processes so that we can analyze how to maintain the water cycle working in a region and which factors, such as the use of landscape, the effect of green spaces, climate conditions, the coexistence of species etc., affect this. Similarly, the study of urban ecology is vital if we would like to understand where and how human activity harms the urban environment or in which way we could improve the living conditions of humans without giving any damage to the urban environment. While traditional lines of urban ecology still have a close

connection to the scientific and social context of their time as well as to the respective urban structures [4], today's urban ecology differs widely from its beginnings.

This chapter aims to examine the differences between the ecological relationships in urban areas and rural areas. The chapter analyzed landscape degradation and anthropogenic impacts, and city patterns in terms of urban ecosystems; urbanization; the necessity of the ecological areas in urban landscapes; urban climate; urban hydrology; urban soil; urban biodiversity; and, urban wildlife.

2. Urban ecology

Urban ecology studies the relations of mankind with each other and their surroundings including cities and urbanizing landscapes. This recent and interdisciplinary field tries to understand the coexistence of human and ecological processes in urban environment and help humans to build more sustainable living. It is a subfield of ecology and it has strong connections with many disciplines like sociology, geography, urban planning, landscape architecture, engineering, economics, anthropology, climatology and public health. Therefore, urban ecology is used to define the study of humans in urban environment, of nature in cities, and of the relationships between humans and nature [5].

As seen in Fig. 1, urban ecology can be viewed as composing of ecology 'in' cities and ecology 'of' cities to functionalize the interdisciplinary nature of it. [5-7]. The former term deals with the questions asking the effect of urbanization on the ecology of living organisms as well as the differences between the ecological processes in cities and those in other environments. The latter one is associated with the interactions between ecological and social systems in an urban environment. According to Wu [7], in order to investigate the relation between ecology and humans in urban habitats, the terms 'science' (ecology) and 'art' (the humanistic and holistic perspectives) should be taken into consideration for maintaining urban sustainability. Urban ecology basically concerns the relationship between the spatio-temporal patterns of urbanization and ecological processes [8].

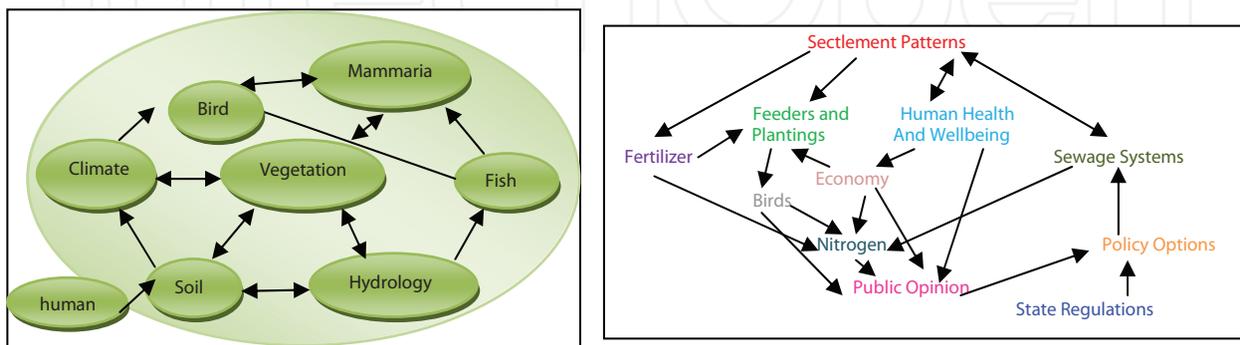


Figure 1. Charts showing the relationships for the ecology *in* the city (left) and ecology *of* the city (right) [5].

There is a mutual interaction between cities and ecological processes such that both are affecting to each other. This is true not only within the boundaries of the cities but also beyond them. As a result of this strong interaction, it is not possible and even useful to insulate human and natural components of urban ecological studies. Based on the definition of cities, i.e. complex phenomena emerged by human activity, new approaches are necessary to comprehend their properties [5], which can be outlined as:

1. The complex structure of the cities, a social and biophysical phenomenon, could be defined by simpler and definable structures, functions and processes.
2. The effects of the cities on the ecological and environmental processes should be well studied. While the tremendous amounts of requirements of the cities, such as energy and food, use the natural resources, the emissions and wastes produced by them are disposed to the country regions. As a result of this strong interaction, it is highly probable that the ecological processes in the Earth are strongly affected by the cities, which has not been studied yet. In fact, there is a possibility to conserve the natural resources and reduce the negative impacts of human activity on the environment with the help of the concepts emerged by the cities.

Marzluff et al. [5] pointed out that urban ecology can be viewed from three points: (1) ecology and evolution of living organisms residing in city boundaries; (2) biological, political, economic, and cultural ecology of humans in urban landscape; (3) cities resultant of the coupled relations of humans and natural processes. According to them, the third view in which human and nature are observed as interacting forces shaping the measurable patterns and processes should be followed by the field. Human factors and nature systems with biotic and abiotic factors are coupled together since they both drive and are affected by the patterns and processes they create, see Fig. 2.

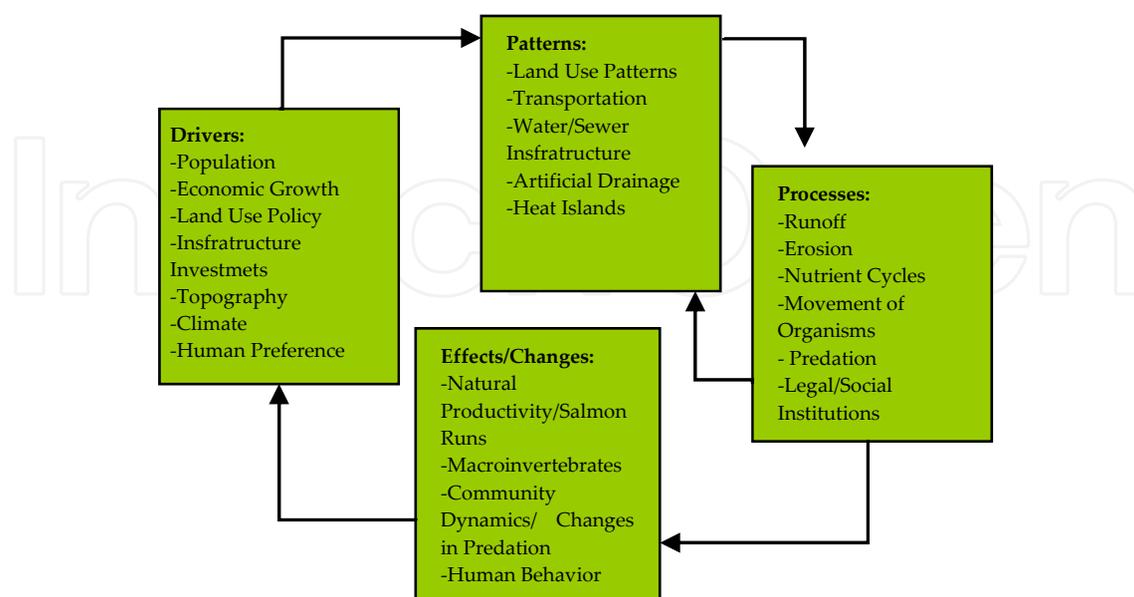


Figure 2. A scheme of urban ecology showing the relationships between humans and natural drivers which are influenced by the patterns and processes of abiotic and biotic drivers [5].

3. Urban ecosystems

According to Moll and Petit [9], “a set of interacting species and their local environment working cooperatively to stay alive” is called as ecosystem. In urban environments, it could be difficult to distinguish different forms of ecosystems. In fact, one can define the whole city as a single ecosystem, while it is also possible to consider a city is a collection of many individual ecosystems, such as parks, lakes [10], urban forests, cultivated lands, wetlands, sea and streams [10]. Here, the second approach is preferred which covers all natural green and blue areas in the city. Based on this definition, street and ponds should be considered as individual ecosystems, while actually, Bolund and Hunhammar [11] states that they are very small and could only be defined as the elements of a larger ecosystem.

According to Marzluff et al. [5], regardless of the approaches mentioned above, the whole ecosystem in a city is called urban ecosystem which includes abiotic spheres (the *atmosphere*, *hydrosphere*, *lithosphere*, and soil or *pedosphere*) and biotic spheres (often viewed as an interacting *biosphere* of urban plants and animals plus the socio-economic world of people, the *anthroposphere*).

4. Urbanization

Big cities, highly dense population and maximum-imperviousness are local- and regional-scale environmental effects of urbanization, which are caused by million-plus, core-oriented, high-rise concentrations [12]. Urban regions are continuing- will most probably continue in future- to be attraction centers for a number of people [8]. Accordingly, in Europe 75 % of the population live in big cities, 80% will be so by the year 2020 [13]. Repercussions of the issue have yet to be grasped within society as a whole. On the other hand, how natural resources are understood, connected and used is profoundly affected by the phenomenon of urbanization. For the great majority of population, various types of urban landscape are ‘familiar’ environments, and it is expected to be so in future [8]. Landscape is turned into a complex structure by urbanization in terms of forms, materials and activities, which are different characteristics compared to rural landscape [14].

Human populations living in urban areas cause dramatic effects on the Earth, even though those urbanized parts cover small areas on Earth’s surface. The most critical point is that urbanization affects global biodiversity and ecosystems, yet this is not understood adequately. Although there is an increasing interest in urban ecological research, and the understanding of biotic effects of urbanization is better grasped, still, the efforts to bring these issues on the agenda of policy, governance, and planning is lacking [8].

At the end of the day, urbanization has numerous effects on environment, but this does not mean that all of them are negative. Urban environment is diversified by human effects in various means; this variety of human impact changes ecosystems through urban ecosystems [15]. As a bottleneck, urban areas make environmental changes multiple level issues. Material repercussions of production and consumption modify the usage of land; and affect biodiversity, and hydro systems both locally and regionally; discharge of urban waste

impacts on biogeochemical cycles as well as climate at the local and global scales. On the other hand, according to urbanites, the drastic changes in local environment also destroyed global environment [16]. Urban ecology concentrates on this diversity, which is characterized by the interaction between organisms and connections to human doings [8].

Ecologists did not study urban areas for the first half of the twentieth century, which is worth noting especially considering the concerns of urbanites regarding the future of urban plants and animals [16]. Sukkop [17] claimed that a systematic approach to urban ecological research started after the World War II. Central Europe and the UK can be considered as the pioneers of the oldest urban ecological research tradition. In Berlin, for example, the topic has long been studied (since 1950s) [8]. Now that, as Alberti [18] mentions, the focus on urban ecology studies has augmented, different arguments on dynamics of urban ecosystems are accrued. It is of vital importance to offer a common action that includes comprehensible definition of ecological conditions inside and outside of cities all around the world [8].

Berkes et al. [19] claimed that, in 19th and early 20th century periods environmentalists and ecologists neglected the urban landscape, as a result, the 'wilderness' or 'pristine' has been esteemed very highly over the 'human' environments. This perspective approached people as the problem itself; in this sense, removal of people from naturally resourceful areas was the only solution so as to protect the landscape. As a result, cities became the scape goat; they were reasons to destroy nature. Today, this approach is changing; many people are comfortable with the idea that cultural and biological diversity support resilience and sustainability [8].

One should take into account several urban dynamics in order to understand the relationship between urban sites and biodiversity, and develop a concept satisfying their needs [13]:

- Urbanity stands for city's life quality and character; it refers to the particular pattern of functional, structural, socio-economic and cultural interplay in urban sites. Although many enjoy urbanity, still they prefer to live near nature when they need to make a decision. In this sense, urban revitalization is an attempt to combine nature and city, especially in popular public sites.
- Urbanization is a general term for urban population increase, urban densification and/or expansion and fragmentation of urban sites. It usually leads to increase in a city's ecological footprint, and affects biodiversity and environment as a whole. On the other hand, the nature of footprint depends on the shape and structure of urbanization.
- Urban design is about describing cities' location, physical shape and the construction; therefore, it makes a number of functionalities and life styles possible. In this sense, through a successful urban design additional urban land-take and fragmentation can be reduced. What is more, urban design can provide green areas, and support biodiversity in cities. Additional green areas, recreating brown fields, promoting 'green' roofs and walls, and keeping the density and compactness in urban areas will maximize

ecosystem activities and ecological footprint in big cities. In point of fact, by providing convenient pattern and activity plan, urban area can become more environmentally friendly areas; rather than mere threats to biodiversity.

It is important to highlight the need for an international frame of thought regarding urbanization, which has recently been experienced as a massive, unplanned course of action in landscape change in the world. Urbanization offers a diversity of altered types of land covers in residential, commercial, and industrial areas; they are generally interconnected by roads and railways, on which special green spaces are allocated. This diversity and similar structures are common all around the world; yet; how they affect biodiversity and ecosystem processes has yet to be determined. What is more, international and comparative research attempts are essential in order to develop the understanding of ecological effects of urbanization [8].

Sustainability of future can be maintained only if an ecosystem oriented approach is adopted in terms of urban planning; this approach should include equitable access to ecosystem services and proper planning [8].

5. The necessity of the ecological areas in the urban landscapes

The biodiversity in the cities are very much influenced by the presence of green spaces, green roofs and walls along with tree-lined streets. In order to maintain the different ecosystem services including wildlife and human populations, existence of landscapes with sufficient size, diversity and distribution is essential. The green infrastructure in the urban landscape consists of recreation parks and gardens, unmanaged natural open spaces, wetlands and rural lands. According to EEA [13], the quality of life for most urban dwellers is closely related to the amount of green areas where they live. Since these areas provide people with opportunities for social relations, recreation and experiencing nature which affect them both emotionally and physically. The structure of green spaces and biodiversity are quite different from each other in rural and urban areas as in Europe. Although different countries have different green zone policies, it is accepted that nature affects humans in a very positive way by reducing blood pressure, improving cognitive abilities and increasing happiness. Meanwhile, green areas and biodiversity are also beneficial in filtering particles, purifying water, reducing noise, and buffering climate extremes like heat waves. This means that the green areas in the cities help to reduce the temperatures which are especially important in adopting the future climate changes for the landscapes which are likely to experience high temperatures and heat waves [13]. The English Garden in Munich, Germany is a good sample for this subject (Fig 3-4).

The presence of natural flora in the cities, the establishment of habitats suitable to the animals adapted to the urban conditions and ecological studies for the protection and development of ecosystems are considered as environmentally ethical studies, as they protect the natural resources. Meanwhile, these areas are places which are increasing the quality of life in the city and allowing the social interaction of the residents [20].



Figure 3. The English Garden in Munich-Germany (Original 2011).



Figure 4. View of the English Garden in Munich-Germany (Original 2011).

Ecological studies and designs are significantly important for the sustainability of the mankind and natural environment. The ecological studies carried out for the establishment of the sustainability in the urban areas as well as the for the protection of the resources involve not only the construction-scale efforts performed in the urban areas but also the

works conducted in the rural areas. In the construction-scale, the studies comprise efforts such as taking precautions for the extensive use of solar energy, recycling of the domestic waste etc [20].

6. Urban climate

The examination of the climatic conditions for lands differ from that of water. The complex combination of the elements of the lands, such as topography, land form, water and plants, strongly influences the climatic conditions related with solar radiation, wind precipitation, temperature and humidity. For example, the movement of air masses are strongly influenced by land forms and their topography, which are basically considered as obstacles (when they are tall) or routers (when they are in the valley-shaped) for air flow. A variety of air flow dynamics, from simple to complex, could be observed in many circumstances. Not only airflow but also humidity, temperature and absorption of solar energy are strongly affected by the properties of landscapes. The windward and leeward sides of hills affect the humidity, while height of the landscapes strongly influences the temperature. Additionally, higher levels of solar energy are absorbed at the south-facing slopes, giving small micro-variations in the climate and changing the vegetation patterns [24].

Cities are generally warmer than open lands and forests as walls and roofs of the buildings and asphalt pavements have higher radiation surface than open lands yielding higher amount of solar energy absorbed. Meanwhile, the precipitation falls into the cities flow away to the sewage system through asphalt roads and squares quickly. As a result of this, the solar radiation is more effective on these surfaces than humid ground in the open lands and heat up more yielding higher degree of warming. As the terrestrial radiative heat loss from these city structures is slower, the temperature of the cities is higher. Meanwhile, evaporation of the water in the open lands also results in energy loss. For these reasons, in calm weather and invariable weather conditions, the temperature of a city could be 0.5-1.5 °C higher than that of its surrounding landscape. This difference could reach to 4-5°C in the night period and even up to 10 °C in the first few hours of the winter nights. Additionally the minimum temperature values could be 0.8 – 1.5°C higher than what is observed in the rural landscape. As a result of this a city can be termed as heat island. The number of frost and icy days are lower for cities. The warmer climatic conditions of the cities allow a long vegetation period for vegetables and reduce the freezing damages especially observed in the frozen nights. For this reason, the plants that do not grow normally in the climatic conditions of the open land of that region could grow in the city. The heat production in the cities and being warmer compared to their surroundings produce a low pressure region in the atmosphere. This causes a continuous flow of a wind from rural areas to the urban ones. The amounts of the dust and artificial gases in the atmosphere present on the cities are much higher than those present on the open lands and forests. Thus, these artificial materials hinder the sunshine arriving to the city. It was determined that the polluted air reduces the solar radiation by 15- 20 %. When the plantation is performed in the cities, the level of solar radiation increases as trees filter the polluted air and dust is partially captured by the long trees [22].

The effects of the elements present in the urban areas on the flow of the energy. As depicted above, a city can be considered as a hot-spot or heat island compared to its surrounding rural landscape, see Table 1 [12]. In fact, the climatic characteristics of a city can be considered for smaller scales, such that the effect of each element in the city, e.g., streets, buildings, parks etc., could be evaluated individually.

Element	Compared to rural environs
Contaminants	
Condensation nuclei	10 times more
Particulates	50 times more
Gaseous admixtures	5-25 times more
Radiation	
Total on horizontal surface	0-20% less
Ultraviolet, winter	30% less
Ultraviolet, summer	5% less
Sunshine duration	5-15% less
Cloudiness	
Clouds	5-10% more
Fog, winter	100% more
Fog, summer	30% more
Precipitation	
Amounts	5-15% more
Days with less than 5 mm	10% more
Snowfall, inner city	5-10% less
Snowfall, lee of city	10% more
Thunderstorms	10-15% more
Temperature	
Annual mean	0.5-3.0° C more
Winter minimums (average)	1-2° C more
Summer maximums	1-3° C more
Heating degree days	10% less
Relative Humidity	
Annual mean	6% less
Winter	2% less
Summer	8% less
Wind Speed	
Annual mean	20-30% less
Extreme gusts	10-20% less
Calm	5-20% more

Source: Landsberg [23]

Table 1. The variation of the climatic conditions in the cities [12]

According to Marsh [14], the following factors affect the temperature of the urban areas:

1. The man-made solid-structures, walls, roofs, roads, paved areas etc., have higher heat conductivities, heat capacities and reflection capabilities than natural soils.
2. The surface area of these structures with vertical faces increases the total surface area of the landscape giving higher degree of energy, mass and momentum conversion.
3. The heat is continuously produced by equipments, such as machinery, vehicles, heating and cooling systems.
4. The amount of evaporation and the energy used for that process decreases in the cities effecting the humidity and heat of the urban areas.
5. Exposure to long-wave radiation varies due to the pollutants and dusts are given off to the atmosphere by human activity.

Urban landscapes change the direction and speed of the winds coming from surrounding. For that reason, differences occur between air flow on the cities and on the forests as well as open fields. The buildings in cities which are much taller than the average height increase the number of the calm days in the city and worsen the ventilation. These tall structures are the sources of the calm air, increased temperature and vapor pressure. In fact, this has a negative effect on the living conditions of the city resident. However, tall buildings do not always reduce the speed of the winds, on the contrary, it is stated that they may improve the circulation of the wind. For this, the large brows (facades) of the buildings should be perpendicular and their narrow brows should be parallel to the direction of the wind. Meanwhile, the distance between buildings should be long enough so that they do not block the motion of the wind [22].

According to Barner [24], based on the wind profile and wind tunnel experiments, the following characteristics related to wind flow are apparent [22]:

1. Depending on the height profile of the building, the speed of the wind increases at the windward brow of the building.
2. The highest value of the wind pressure, which is directly related to the speed of the wind, appears at the $2/3$ height of the building.
3. However, within the $2/3$ height of the windward brow of the building, the speed of the wind was reduced, while the turbulent flow forms due to spinning wind flow.
4. The calm air at the windward side of the building is separated from that at the opposite brow while it flows away from top and bottom parts which forms a strong air flow at the lower levels.

The effect of the buildings on the wind flow could be explained by three different examples, which represent simple and complex situations separately. The first case investigates the airflow towards an individual building. Here, when the airflow reaches to the building, an obstacle on route the airflow, its speed should increase according to the continuity of flow laws. A 2D model could clearly show that the speed of the wind on the different parts of the building is different being the highest on the windward brow of the building and across the roof. Meanwhile, air is also deflected from the brow down the face of the building (labeled

as A in Fig. 5). Additional to those, speeds decrease and streamlines of wind spread out on the leeward side, with some descending toward the ground [14]. In the second case, two buildings of similar heights are located close to each other. Different from the first case, the streamlines of fast wind do not descend to the ground but they were maintained by the roof of the building. The direct consequence of this event is the formation of small pockets of calm air between buildings and limited intermixing of the air in between the buildings with the atmosphere (labeled B in Fig. 5). The properties of air in such pockets could be different than that of surrounding atmosphere. In the last case, the most complex one, buildings and streets are aligned such that the structure is similar to that of canyon forming channels for airflow when the wind is strong. This formation, apparently, increases the speed of the wind and yields turbulence along the walls of the canyon (labeled as C in Fig. 5) [14].



Figure 5. The flow of air in an urban area. The figure demonstrates the airflow around different structures, such as tall and short buildings, streets and their different combinations. Different cases are given here: (A) The strong flow is deflected down the building, (B) calm zone develops between buildings and (C) combination of large buildings with streets form canyons yield accelerated airflow [14].

Other than windflows, water also significantly affects the urban climate in a way that solar energy is stored by masses of water. As the temperature of water varies much slowly than that of lands, they adjust the temperature of the lands through breezes. Meanwhile, the evaporation of water consumes energy and reduces the temperature of air, which might be called as a natural-air conditioning [21].

The Urban Heat Island as a Climatic Effect of Urbanization

There are different climatic effects of urbanization: formation of urban heat islands, increasing cloudiness, fog, dust, precipitation and downwind urban heat plume, while decreasing humidity. Apart from these small-scale effects, activities held in the boundaries

of urban areas are the main sources of greenhouse gases, mainly CO₂ and fluorocarbons, which may influence the global climate and sea levels in the following decades [12].

Among different climatic effects of urbanization, formation of heat island is one of the most apparent one. It is known that the temperature of the air in the cities is relatively higher than their surrounding rural areas, defining the urban heat islands [21]. Man-made structures, i.e. buildings, paving, vegetation and other physical elements of the city, form as active thermal elements between the ground and atmosphere. The properties of the elements in the land-covering layer, e.g., height, distribution, determine the thermal behavior of the city and the distribution of the warm air within the urban region.

There are many factors affecting the formation of the thermal heat islands, primarily, radiation and heat flows, urban boundary layer, surface heating and heat loss [14]. A sharp decrease in the temperature profile occurs on the perimeter of the city, defining the boundaries of the urban heat island which is shown in the Fig. 6 by a cliff in the profile. While the temperature may fluctuate in the heat island, which is a factor of the type of the man-made structures, beyond the boundaries of the heat island, rural landscape with much lower temperature values than those observed in the heat island emerges [14]. Such variations in the heat island are clearly shown in the Fig. 6 in a way that cool regions formed by parks and riverside while warmer parts appear as a result of the shopping centers and industrial zones.

According to Leopold [25], the use of the local-land has four distinguishable effects on the hydrology, which are relevant to each other: changes in peak-flow characteristics; changes in total runoff; changes in water quality; and changes in hydrologic amenities. It is known that stream flows, which are rainstorms characterized by heat islands, expands and becomes stronger with the growth of the cities, while stronger winds are necessary to overcome them [12].

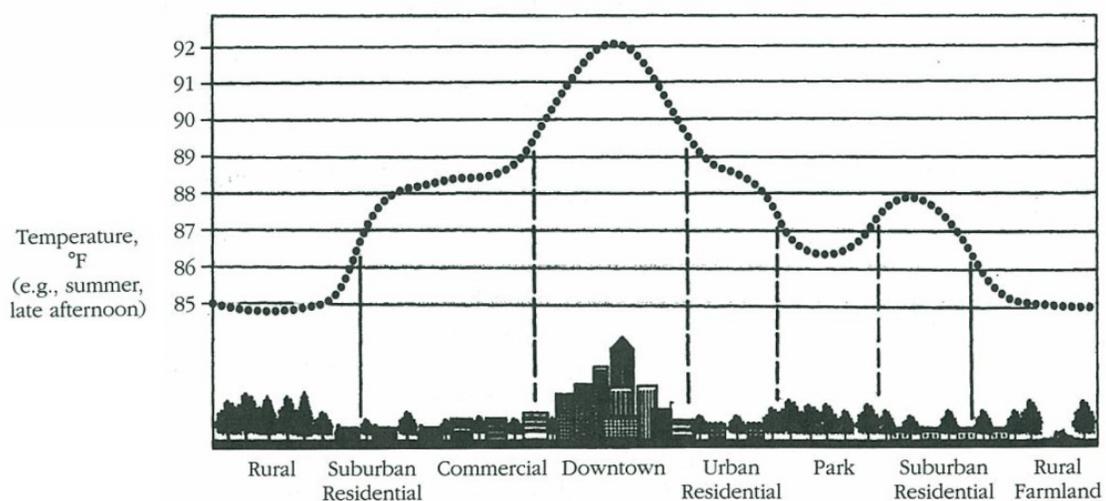


Figure 6. The schematic representation of the temperature profile of the urban heat island and its variation with the type of the elements in the urban area [14].

In fact, a lot of urban planners accept climate as a fundamental factor of urban planning and design; on the other hand, only few of them are able to combine variables like wind, heat, and solar radiation with decision making processes. The level of scientific understanding of microclimate is one of the most significant factors responsible for building the environment [14]. Climate is an important element for pollution control boards and regional transportation policies; whereas, for urban planner, landscape architect, and architect small-scale climatic variations are important. One can refer to the solar radiation around high buildings as an example of variation; other parameters like temperature, wind, fog, and pollution can also be seen as other variations in urban landscapes (Fig. 7).

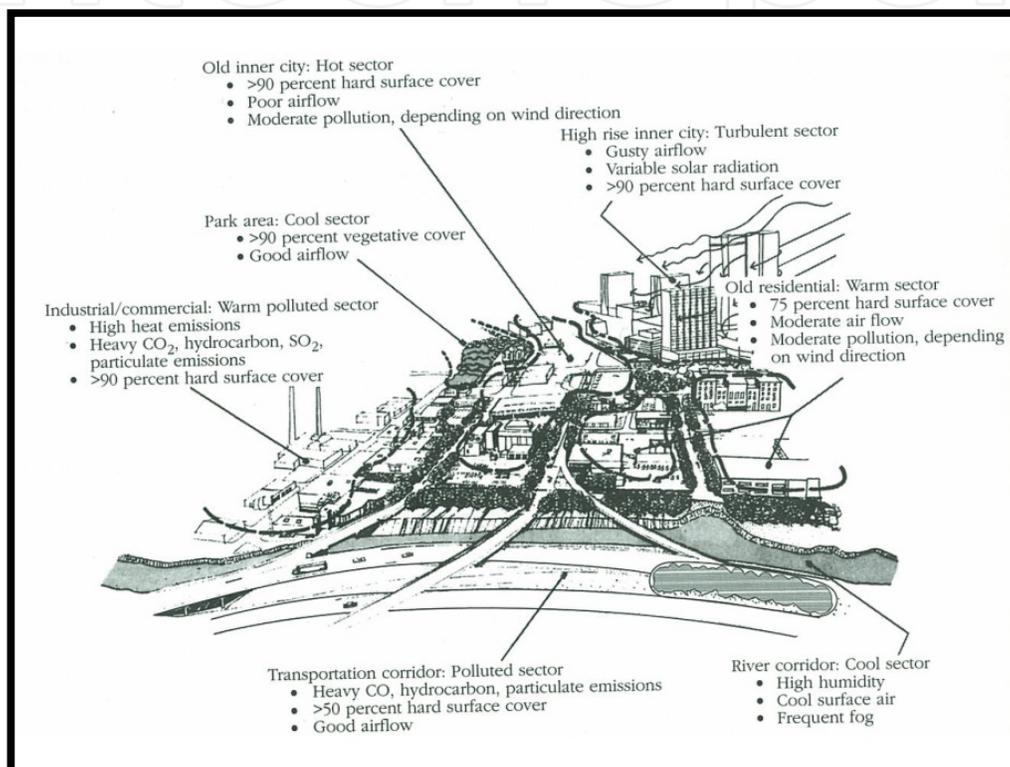


Figure 7. Climatic conditions near the ground in different sectors of a city. Conditions vary with surface cover, solar radiation, airflow, and air pollution, among other things [14]

7. Urban hydrology

In urban design, groundwater relations and surface flow characteristics of water collection basins are of vital importance for the city's water requirement. Water economy affects heat economy as well. In cities, precipitation falling on building roofs and asphalt roads as well as city centers, are all lost because they go to sewer system through surface fall. As a result, inside the cities get dry and warmer very soon. Because precipitation waters are carried outside of the city, the level of humidity in cities is lesser than forest design. However, fog comes down frequently due to high quantity of solid structures [22].

Within the framework of urban hydrologic processes, trees as well as soils can act as an important role in terms of intercepting and retaining or slowing the flow of precipitation

reaching the ground. It is possible that these can decrease the frequency and volume of storm water runoff, flooding damage, storm water treatment costs, and other problems in terms of water quality. According to the runoff estimates, which were conducted for an intensive storm in Dayton/OH, the tree canopy (22%) decreased runoff by 7%, and a decent increase in canopy (around 29%) can decrease runoff by almost 12% (Sanders [26] from Nowak and Dwyer [27]). In addition, it was revealed that tree cover on pervious surfaces decreased runoff, total of 40 %; its effect on runoff was lesser on impervious surfaces [27].

In Europe, according to the findings obtained from research, low level humidity and more frequent fogs cause torrential rainfall repetition to increase. For this reason, it was determined that the number of days of torrential rainfall in the city is between 13 and 63% more than the open area and forest designs. Therefore, it was revealed that the city's annual rainfall is around 5 – 31% higher than open area and forest designs, depending on the land surface shape, height, climate characteristics, the size of the structures [24]. However, torrential rainfall and impervious surfaces inside the city cause this precipitation water to be lost in a short time; rain water does not contribute to the water economy efficiently [22].

For Bai [28], increased impervious cover is among the most significant modifications affecting streams in urban sites; it transforms hydrology and funnels accumulated pollutants from buildings, roadways, and parking lots into streams. In United States point source pollution was reduced by regulations; yet it is still an important problem in several developing countries [16]. It is crucial to remember that industrial discharges and sewage contaminate both rivers and lakes. In new design cities storm water infrastructure is separate from wastewater discharges; this is not the case in older European and American cities, where two streams are mixed and causing to acute pollution in recipient systems. The storms and low flow-discharge of cities lead to local, even regional pollution downstream, which are particularly caused by pesticides and persistent organic pollutants [16].

Urban hydrology has been altered to develop a way to manage urban runoff against flood, and to protect health and the environment. In recent years there have been important developments regarding the measurement and prediction of urban rainfall by using technologic devices such as radar and microwave networks. The predictability of urban hydrology has been improved also in order to provide models convenient with small temporal and spatial scales typical to urban and peri urban applications. Urban storm water management has started to take into account the needs of environment and human beings. There is a strict trend towards restoring pre-development flow-regimes and water quality; also, it is believed that restoring more natural water balance would not only be an advantage to environment, but support the livability of the urban landscape. Although it was regarded as a trouble, today storm water is increasingly seen as a resource [29].

Urban runoff management has evolved with the understanding of its environmental impacts. Referred approach developed many terms such as, Sustainable Urban Drainage Systems (SUDS) [30], Water Sensitive Urban Design (WSUD) [31-32] and Low Impact Development (LID) [33].

These approaches have similar objectives:

1. To manage urban water cycle in a sustainable fashion (by taking into account both surface and ground water, flooding and impacts on waterways erosion),
2. To maintain or return the flow regime as much as possible back to its natural level,
3. To protect and restore, if possible, water quality (for both surface and ground water),
4. To protect and restore, if possible, the health of receiving water,
5. To conserve water resources as a resource rather than a nuisance (like, storm water),
6. To enhance urban landscape and amenity by incorporating storm water management measures, which offer multiple benefits, into the landscape [29].

8. Urban soil

Analyzing and determining the soil features are important in urban design for two reasons. First, it is important in terms of geologic basis for structure projects like edifice, tunnel, subway, etc. Second, it is mandatory to know the soil characteristic in growing plant. Physical features of soil, which can be listed as depth, mechanical structure, general characteristics, level of ground water, and geological basis; are not only important for tunnels and edifices, but also for all urban structures (road system, sewage, cesspool, etc). Soil is the natural environment for plants. Hence, determining soil features is of particular importance for the planned green areas in the city. For this reason, in establishing cities, favorable soils for structures should be found through soil analysis and marked on maps, and the relations between soil characteristic and how to benefit from the soil should be analyzed [22].

The soil in the areas that were left to make greenery near the building has lost its genetic characteristic and mixed with construction leftovers, cement, and concrete. Therefore, to those spots, on which green areas will be built, soil from other places are carried on trucks; they do not include concrete, but organic materials; and they are generally spread in a thin layer. For this reason, natural soil features, which are main factors of growing plant in cities, have rarely survived. As for the plants that will be grown in cities, shadows of buildings and windbreak, negative effects of salts sprayed onto the city roads in winter, and flue gas should be prior factors to consider. In this sense, plant species that will be used in urban design should have a broad ecologic tolerance; in other words, they should be durable against negative anthropogenic effects [22].

9. Urban biodiversity

Biodiversity provides an ecosystem system, on which the standard of living on European citizens depends, urban setting proves this successfully. Urbanites benefit from recreational, social and inspirational services of the nature, both inside and outside of cities. Yet, ecosystems are also crucial in terms of basic living conditions in cities. Thanks to its positive climatic effects, urban greenery will play an important role in adapting strategies to deal with climate change, which is expected to intensify or alter the specific urban climatic

conditions. Urban greenery makes cities attraction centers; it prevents urban sprawl and saves space for biodiversity. In addition, as in-city services increase, the city's footprint is decreased; as a result, potential negative effects on biodiversity and environment is destroyed [13].

In addition to ecologic services, green areas –in which biologic diversity is supported- are also gaining favor in terms of public health, maintaining social cohesion, economic benefit (like the increase in real estate market thanks to the green areas), and low maintenance cost (less irrigation and fertilization by creating ecologically sustainable urban designs) [34].

Local and regional authorities have the legal power to designate conservation areas; to advocate EU's Natura 2000 networks; and, to bring biodiversity concerns urban and spatial planning agendas. Cities share the responsibility to select Natura 2000 sites. The scale of public commitment can be traced in Local Agenda 21 processes, which aim to establish sustainable societies identifying biodiversity as a precondition to build resilient cities. European Union supports advanced commitment and increased awareness by honoring the most sustainable cities, the European Green Capital Award (see the box below), and establishing a legal framework to protect biodiversity through, Natura 2000 network under the EU Habitats and Birds Directives, Air Quality Directives, the Water Framework Directive and the development of a Soil Directive [13].

Cities are crucial in terms of sheltering some rare and endangered species and habitats, which are considered to be important at the European level as well. There are a total of 97 Natura 200 sites are located in 32 major European cities. Of these cities, sixteen are capitals (for example, London, Paris, Prague, Rome and Tallinn). In addition, one or more harbors in more than half of the EU's capitals are Natura 2000 sites. Although Berlin has 15 Natura 2000 sites, most of the others have one or two. A new City Biodiversity Index (CBI) has been developed by favor of Convention on Biological Diversity (CBD) and contributions of Governments for Sustainability (ICLEI) [13].

In cities, the value of biodiversity is closely related to societies' cultural and social preferences. Biodiversity not only offers quite an amount of ecosystem services to urbanites, it also modifies negative perceptions created by cities [35].

As Walker and Salt [36] put, it is possible to perceive urban diversity within the framework of response diversity, which is the case when species and ecosystems respond differently to external interventions, even though they function collectively. For instance, urban trees intercept large amounts of precipitation, and prevent flooding; therefore, tree diversity contributes to precipitation interception's response diversity function [37]. As a result, strong biodiversity guarantees lower risk for the entire function, despite local extinction. As the cities continue to face the effects of climate change, response diversity will be an important capacity building factor in terms of resistance [37].

From the perspective of urban planning, protection of biodiversity in cities is a high-priority for both stakeholders and decision-makers. Still, when it comes to put the issue at the top priority list during the planning process, it is left behind of anthropocentric objectives such as economic development, transportation, land use and recreation [37].

Extensive use of native species is essential for the sake of urban biodiversity. By doing so it could be possible to carry out more successful landscape projects with minimum maintenance work and cost. Furthermore, a breeding and feeding environment can be created through increasing biodiversity and by using native species. Regarding sustainable cities, floristic diversity is an important topic [38].

Biotic, physical and social factors along with processes are related to biodiversity in urban ecosystems. On the other hand, ecology itself is insufficient to delineate urban ecosystems. As a result, it is advised to establish an interdisciplinary approach, including natural and social sciences, that will discuss ecology-related inputs in terms of urban planning [38].

10. Urban wildlife

Wildlife in cities is generally undervalued. In recent years urban wetlands, abandoned industrial sites, roadside verges, vacant lots and derelict lands, ruins, allotment gardens and cemeteries - together with arboreta, residential gardens and villas, botanic gardens and individual balconies have begun to be seen as potential conservation areas for urban biodiversity [21, 39]. Dense population and infrastructure are two factors putting pressure on biodiversity in cities. What is necessary is to establish a balance between the urban green and tailor made green areas. At this point, 'double inner city development' can be used; this means to combine the existing 'made' areas with conservation, supporting the presence, character and availability of green spots and vacant spaces; and, strengthening the green infrastructure like street-trees, green walls and roofs. These will facilitate the way to access green areas in and out the city [13].

Wild fauna inside the cities can be a positive demonstration of the richness of the 'green'; on the other hand, this can be a challenge in some cases (e.g. foxes or seagulls) [13]

Rich diversities in urban landscapes can come to the fore as original communities. Urban green is an important part of urban landscape, which offers the opportunity to contact with wildlife in addition to environmental and socio-ecological benefits, regarding the quality of human life. Urban green areas are ecologically complex structures; their values can be defined in terms of goods and services within society. What is essential is to pick bio-indicators that can be accessed and relied with regards to create a proper/balanced urban ecosystem, through integrating wildlife and biological parameters to human well-being [40].

11. Discussion

What is more, it is important to highlight that urban ecosystems do have contributions to the well-being of urban life; however, urbanites depend on global ecosystems to survive. There are some services provided by urban ecosystems in order to improve the quality of life; accordingly, air quality, lower level noise were all provided, these could not be done from distant ecosystems. The causes of these problems have yet to be solved, but their effects have been reduced. Both should be the main aim [11].

At the end of the day, the hope is that the awareness of ecosystem services will be raised, which will help to maintain a more resource-efficient city structure and design. Only then

urban ecosystems will be respected for their contributions to life in urban areas, and gained priority when the area faces exploitation. In addition, the idea of significance of ecosystem services could result in protection of unexploited urban areas, even expanding them. One of the most important key objectives is that ecosystem services in urban areas and ecosystems are appreciated by political authorities and city planners as the cities grow in future [11].

In urban ecology studies, natural and social sciences were intermingled; the aim is to research these radically altered local environments in terms of their regional and global effects. In this rapidly urbanized world cities are the center of problems as well as solutions regarding sustainability challenges [16].

Ecologists can approach to cities as real-world laboratories; therefore, they can better understand the basic patterns and processes; and, work in collaboration with city planners, engineers, and architects in order to actualize urban policies that enhance and protect biodiversity and ecosystem function [16].

The main characteristics of cities –dense population, center of production and consumption, and waste disposal- cause the land to change and bring a number of environmental problems. These problems can be seen as sample microcosms of global environmental change addressing to the chance to develop ecology as well as global-change science. As known, human-induced activities take place on Earth, a biophysically constrained planet, and it is strongly believed that urban ecology can clarify the connection between urbanites and the biogeophysical environment they live. Ecological footprints are expanding; in this sense, the perception of issues with greater extent beyond human understanding should expand along with the broader effect of individual and collective life forms, preferences, and acts. As a consequence, it is hoped that industry and creativity, which have been located in urban centers throughout the history of man, would also be discussed as remedy, rather than problem. Last but not least, as a priority area, urban ecology has a significant mission to find solutions and develop the future of urban in a sustainable way [16].

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