Chapter 11

A Theoretical Framework on Retro-Fitting Process Based on Urban Ecology

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Additional information is available at the end of the chapter

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Abstract

Today, natural resources have been destroyed to make developed built environment. Furthermore, this destruction is on behalf of the creation of quality urban environments. It is necessary that dynamics of the planning, design, application processes which build urban environments should be taken into account and firstly these processes should be retrofitted. In this context, approaches, principles, action plans, and application tools from planning to architecture, from architecture to building material, from material to production and consumption technologies based on ecology should be ranked in a hierarchical row and this frame should be adopted. This ecological framework is the theoretical, legislative, administrative base for sustainable settlements, and sustainable and livable cities, in addition to the creation of the quality built environments in which the community has a chance for comfortable and quality living condition. In this chapter, urban ecology and ecosystems of the cities ,which can be embraced as living organisms, are mentioned. With the integrated approach, beginning ecological planning, importance and utilization of eco-technologies also are emphasized in the framework of ecological architecture and ecological urban design based on urban ecology.

Keywords: Ecological planning, ecological urban design, ecological architecture, eco-technologies, urban ecology

1. Introduction

In most of the cities of some countries, due to rapid urbanization, urban growth related to urban population growth has been seen. Rapid growth in built environment and land uses without planning and lack of ecological approach have natural environment make smaller

and have risen to ecological and biological destruction on natural resources. When the global population continues to grow, dramatic challenges in the early twenty-first century are those ecosystems are changing from the landscape to the global scales, due to increase in population and urbanization [1]. It is time to consider all decisions from planning strategies to architectural design and usage of technologic tools for retro-fitting ecological condition in the cities. The result to be occurred is to change the view point looking and taking into account or monitoring cities and settlements in which we live.

Adoption of the city as an ecosystem gives rise to protection and consideration of this ecosystem for spatial organizations at every scale and adoption of ecological balance in land use planning. Fictionalize of urban space is a process starting planning. If ecological approach guides not only in planning, but also in urban design and building design process, natural resources can be used without consumption and it can be enabled that people live in a healthy urban environment.

Urban ecology has become an expanding field of research during the last two decades. Various studies carried out on urban climate, soils, flora, fauna, urban habitats, and green space of cities [2]. Urban areas contain many land use types and every land-use type has a distinctive structure from vegetation perspective. The knowledge of characteristic vegetation structure of land-use types can help making a connection between urban areas and surrounding natural areas and taking advantage for studies building up urban open space systems [3].

Recently, although some issues like rational utilization of natural resources and energy efficiency in buildings have been taken place in legal legislation in some developing countries, still there are some issues to be added to the legislative frame and application process in order to decrease ecological footprint on the settlements and built environments, not only consume at minimum level of natural resource but take maximum advantage from them. Transformation of nonrenewable natural resources to the unique capital of socio-economic development and growth process is depend on adoption of the eco-economic policies and utilization of the eco-technologies enabling the life circle and increasing retrieval possibilities of wastes which occur in every steps of consumption process.

There is an increasing need to enable the transformation of our preferences from using nonrenewable resources to renewable energy, non-consumable resources in order to supply fundamental human requirements [4]. This will demand a large data source of ecological planning and design tools, indicators, case studies, and applicators.

For sustainable urbanization, as many scientists have pointed out, growing urban environment depend on human's increasing demands, it is time to consider planning, design, and producing strategies and to measure with indicators ecological footprints, CO_2 emissions, air and water pollution, degradation, deforestation, and unpredictable urban sprawl. To realize monitoring and controlling the issues mentioned above, there is a need for frameworks theoretically constituted and applicable.

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2. Ecological approach in organization process of urban space

On the one hand, urban growth and urbanization have caused built environment to expend, on the other hand, built environment growing together with the economic development has negative impacts on the natural resources. From planning perspective, in most of the settlements or cities, natural resources have not been taken into account during urban growth and economic development due to the lack of ecological approach in planning or decision-making process [5].

From planning to design, there are three dimensions of ecological approach for making cities livable. None of them has not priority but all of them should be considered and guide to spatial organization process of urban space for livable and sustainable cities and also sustainable urbanization. Human, nature and built environment trio and the relation among them should guide to planners, urban designers, architects, urban policies in planning process from the beginning to the end based on ecology. From people-oriented approach, basically and

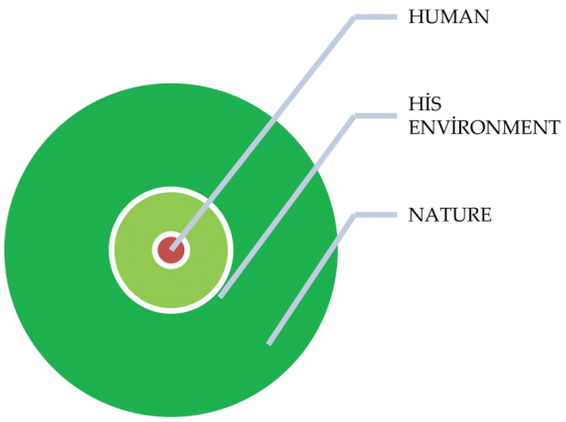

Figure 1. Human in the nature.

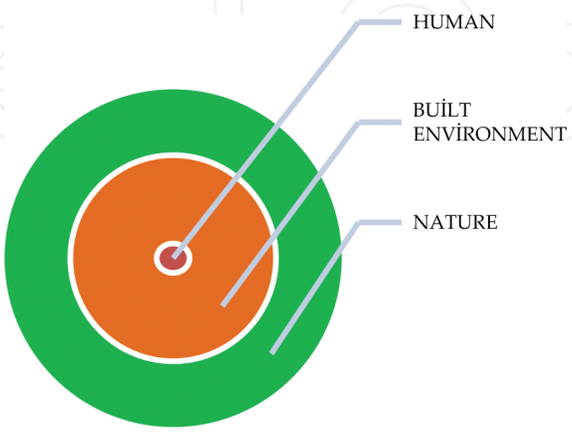

Figure 2. Human and growing built environment in the nature.

schematic presentation on the relation of human and nature is that human is a point in the nature (**Figure 1**).

There is an interaction between human and the nature, both human has an impact on the nature for his vital activities and the nature influences on the human. Once, it was an organic interaction among human, surroundings and nature (**Figure 1**). But negative and devastating effect on the other is coming from human (**Figure 2**). Human changes his environment for housing, recreational, commercial, or industrial activities. This is the beginning of his making nature destroyed when built environment occurs.

The simplified relation between human and built environment surrounded him, shown in **Figure 2**, is everywhere in which human groups or community live. From holistic approach to nature, built environment, which is the footprint of human in the nature, looks as if it is a kind of viral infection covered the whole body. Beginning ecological framework, it is of great importance that understanding human and urban environment from aspects based on ecology is necessary.

2.1. Human ecology

Originally coming from the Greek root oikos meaning "home", the term of ecology was the basis for the field of home economics. Then, it was changed to human ecology by many contemporary researches. Looking at humans as not only social beings, but also biological organism, human ecology theory focuses on interaction between human and their environments; thus, emphasized issues in this theory are utilization and management of resources for human development and sustainability [6].

Ecology is commonly defined as the study of the relation of organisms to their environment [7]. The position of human ecology in this context was determined primarily by the point of view cultivated initially sociologists, particularly to account for certain aspects of American cities in the first quarter of nineteenth century [7]. While the cities of that period were experiencing rapid and troubled growth, and therefore, the focus of human ecology changed direction to a concern with the humans' environment. This aspect added useful content to the issue of spatial analysis [7].

The city is a conspicuous example of a system of relationships among differentiated activities by means of which a population is able to occupy a unit of territory. Although ecology includes the relation between all living organisms and their environment, human ecology is on the relation between only humans and their environment. Quite clearly, therefore, human ecology is a sociological concern [7]. From this point, it is necessary to consider interaction between human and environment and as well interaction between the social system of humans and the rest of the ecosystem, because an ecosystem includes all built elements by humans as parts of the ecosystem [8].

Based on short definitions and approaches about human ecology mentioned above, this interaction and relationship should be taken into account as a system, in decision and policy making process on urban land, so that next generations can live sustainable settlements.

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2.2. Urban ecosystem

As outlined by most theorists, an ecosystem consists of three indicative components: humans, their environment, and the interactions between them. In urban ecosystems, high-density population, or the built structure of environment occupies a large place on the land [9]. There is now convincing proof on changing nearly all of the earth's ecosystems by humans [10]. With urbanization becoming a global phenomenon, urban population increased all over the world causing huge pressure on the environment [11]. Land consumption, habitat fragmentation, and biodiversity loss may have negative impacts on society and economic systems on a local scale, impacting urban sustainability [11].

In order to comprehend the impact of urbanization, a clear consideration of the temporal dynamics, although constantly missing, is vital for determination impacts on biodiversity in rapidly urbanizing landscapes [12]. While more than half of the natural resources are used by humans, whereas approximately half of the land cover has been changed by human actions causing important losses of biodiversity [10]. As a result of these activities, most ecosystems can argumentatively be taken into account human-dominated ecosystems; nevertheless, humans are also building different ecosystems particularly for residence as urban ecosystems [10].

Although city is a settlement in which people live and whose population exceeds the certain amount, urban ecosystem is a living organism with specific dynamics and components. If relation and interaction of the elements and components in this organism occur according to ecological principles, it is possible that livable and healthy urban spaces can be built up. Urban lands contain heterogeneous materials with a variety of lands and complex interactions. Excluding water surfaces, the combinations of impermeable surface materials, greenery plants, and soil are essential elements of the urban ecosystem [13]. An evaluated model contains above approaches "*in reference* [13]" which proposes a large content of data for urban ecosystem researches on physical and ecological characteristics of the nature and human disturbances.

Comprehension the relation and interaction between humans and natural components of urban ecosystems are major characteristics of the integrated model combining social qualifications of humans and their establishments [14]. As the emergent phenomena of local scale [15], cities are now recognized as ecosystems, and many of the concepts and theories considered central to ecosystem ecology can be modified for application to urban systems [16]. Long-term environmental changes in urban ecosystems have raised commitments among scientists, researchers across several disciplines, having a determining role in policies, plans, designs, and management strategies to reply to these changes. Integrating ecological researches with urban policies, planning, design, and management strategies is complex, yet it is one of the significant themes and research preferences in landscape ecology [17]. It is necessary that ecologists, social scientists, urban planners, urban designers, landscape architects, and whoever concerns urban issues to use such interdisciplinary knowledge for development of cities and sustainable settlements, they need to work in collaboration with interdisciplinary approaches in order to address this challenge.

2.3. Urban ecology

Urban areas and ecology are contrary to each other theoretically and as to substance, urban ecology connects with them. Urban ecology was originally developed as a part of human ecology in the 1920s by a small but influential group of sociologists at University of Chicago and they identified urban ecology as "the study of the relation between people and their urban environment" [18]. Urban ecology is a scientific field on the issue of effects on organisms, the interactions among them, and the transformation and flux of energy and matter in urban and urbanizing systems [16]. Urban ecology is ecological research conducted in cities, towns, and urban areas [19]. To understand the structure and dynamics of urban systems, they must be recognized as social-ecological systems that integrate socioeconomic drivers and responses with ecological structures and functions [16].

Basically, "urban" is a term identifying the land use on a place. A common comprehension of "urban" a densely populated urban space characterized by multifunctional land uses. This comprehension seems to be more useful for researches on urban ecology; yet, it is difficult to determine ecological thresholds surrounding urban space. Although ecology is a natural science concerned with the distribution and abundance of organisms, the word has many other meanings as well [19]. Urban ecology is not only a view to urban land from the science of ecology but may include concerns from the social sciences. Urban ecology is a research subject forming a continuum from "pure" ecology in the urban space to an integration of ecology and social sciences to investigate urban systems [19]. Today, the sociological approach to urban ecology continues to exist and evolve [18].

An explicit focus of researches about urban ecology is on sustainability, which includes biodiversity and ecosystem services, energy consumption and carbon footprint for climate change studies [20]. Implementation of nature conservation in the cities will be possible by means of arrangements make harmonic natural–cultural and social environment with each other. Although the conflicting approach on ecology of urban areas focused on ecological footprints, and summaries of citywide species richness, contemporaneous ecosystem approaches have begun to integrate physical environment of the nature, including urban climate, hydrology, soils, and energetic issues, and to indicate the necessity for comprehension the social dimensions of urban ecology [9]. Urban ecology has increasingly played a significant leading role to overcome the conflicts faced by urban ecosystems. The major focus in many studies about application of urban ecology was on urban green network and its connection to citizens [20]. Three main goals based on ecology "in reference [9]", "may be achieved in urban areas; Firstly, plant ecology can support to improved comprehension of the structure and function of urban ecosystems. Second, ecological function of urban areas must be increased. Third goal is to take advantages to humans of the vegetation elements of urban lands" [9].

As emphasized by many scientists and researchers, with an in-depth comprehension of ecology in cities, focusing on the ecology of cities is increasingly being more significant. A framework to put ecological information into practice in urban areas requires interdisciplinary approaches for enhancing social welfare and providing sustainability in urban areas.

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3. Tools for ecological retro-fitting of urban environment

Ecological approach should accompany to planners, urban designers, architects, landscape architects, builders, from beginning of the planning process to production of the urban elements and building materials [5].

From ecological point of view, to retro-fit our settlements and urban environments in which we live, to reduce ecological footprints on the settlements, it is essential that ecological approach and ecological decision making systematic should be adopted. This systematic begins with ecological planning and contains ecological urban design for urban landscape and ecological architecture and eco-technologies for livable and sustainable cities.

Figure 3 shows the hierarchic succession of the phases from planning to architecture and to the production technologies.

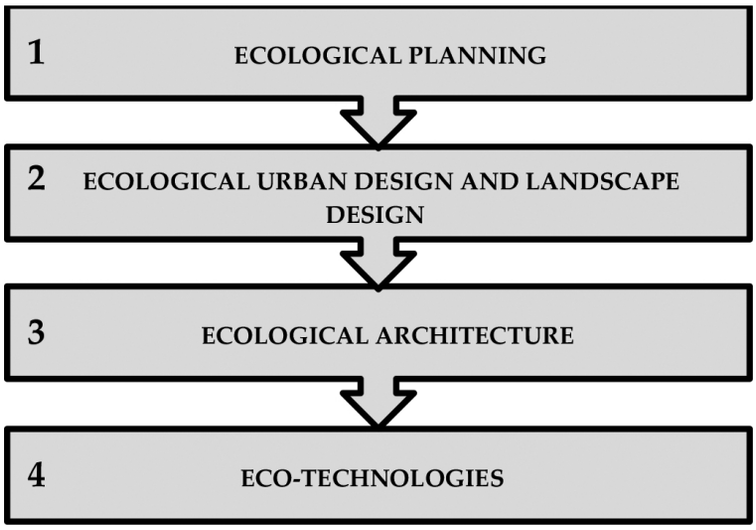

Figure 3. Tools for ecological retro-fitting of urban environment.

3.1. Ecological planning

Planning is a decision-making and spatial organization process connecting with human, nature, and life (**Figure 4**). In addition to this definition, planning also creates a system including connection and interaction among social, natural, and built environment. As the key issue of sustainable development, the principle of "using of the natural resources without exhausting them" was adopted nearly by the whole world and the space planning strategies gained a new dimension which considers natural resources [5, 21–23]. In the world, spatial planning strategies targeting sustainable development of cities gained ecological dimension guiding to both the regional and city planning process [21, 23]. Ecology should be the major theme to be considered from the beginning to the end of planning process [5]. Consideration of natural resources and ecological characteristics of an area is of great importance. In

ecological land-use planning process, strategic environmental assessments, impact assessments, and ecological risk analysis are of great importance as basic phases [5, 21, 22].

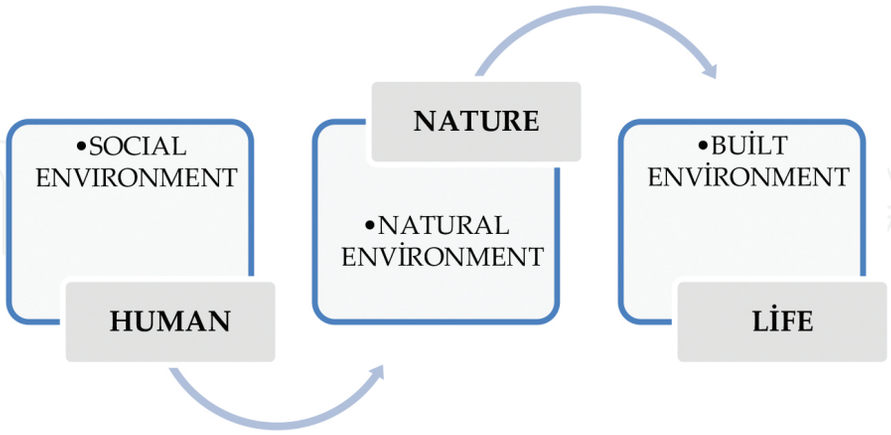

Figure 4. Function of planning.

Land use involves the process of biologically and technically reshaping, converting and managing land for socio-economic benefits [24]. Built environment growing together with the economic development has taken a toll on the natural resources [22, 23]. Overexploitation and utility of resources due to extensive economic growth have now become the common causes of environmental degradation [24]. One the one hand, land-use decisions on the settlements impact economic actions, this also affect the physical environment, land surface, soil, and natural biotopes, on the other hand, negative impacts of these actions on ecological structure cause environmental problems [23]. Furthermore, the interconnectivity of ecosystems is increasingly jeopardized by the uncontrolled development, land-use conversion, tourism activities, and endless disturbances caused by anthropogenic agents [24]. There is a need also for cost-benefit analysis in planning process, so that it can bring ecological benefit, besides of economic development in growth process of the cities. While some of land-use decisions economically benefit in the short run, whereas they cause ecological costs in the long run [21, 23].

Therefore, the land-use decisions should be defined by environmentally sensitive/ecological planning process, during which natural characteristics and potentials of the lands must be examined by ecological threshold analysis [21–23]. The aim of ecological planning was to protect of natural resources and to create ecological cities and settlements. Ecological planning is not only physical planning understanding, but also a planning process which aims sustainability of an integrative urban-nature development [23].

On the one hand, one of the most important approaches in the creation process of ecological cities is to utilize of natural resources efficiently and without consumption of them. On the other hand, one of the basic principles in ecological planning process is to create an integrated green network in the cities. The management of urban lands, namely adding green components to open spaces is an increasingly important subject. Urban biodiversity is essential for residents as recreational areas, and their presence in the neighborhood unit is an appreci-

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ated characteristic reflected in property prices [25]. Open and green spaces, which were planned, applied, directed with the ecological, and recreational aims, play an important role for controlling urban growth and shaping urban form, in addition to being important for residents [26]. Open and green lands in the cities can perform their functions if the practices are suited development projects and ecological planning rules.

Geographical information systems (GIS) are major tools for planning in order to make available to spatial outputs of land-use decisions. Thus, increasingly approaches using GIS for visualizing the spatial dimension and extent of change are being employed to ensure these spatial aspects [27].

3.2. Ecological urban design and landscape design

In rethinking the city as a "human ecosystem", urban design is emerging as one tool for adaptation as we face complex, wide-ranging issues from food security to sea-level rise. The practice of urban design is interdisciplinary in nature, often claimed by several professions and residing somewhere at the intersection of urban planning, architecture, and landscape architecture.

Urban design process is a period in which planning decisions change to applications. In this context, urban spaces are created adding third-dimensional to two-dimensional planning decisions. Urban design is both an interface and a bridge between planning and architecture. The aim in urban design process including designing of the streets, avenues, squares, public spaces, green areas, plants, and surface waters was to create healthy living areas, besides fictionalize of an aesthetic environment. The main issue of ecological urban design process is urban ecology. Green areas, plants, and water surface are ecological components of urban landscape surrounding buildings. With the ecological urban design and ecological landscape design approaches, urban design, landscape ecology, the knowledge of policy makers, and the demands of neighborhood dwellers are integrated for creation of new patterns of greenery areas, buildings, and land covers.

Recently, due to rapid urbanization, green infrastructure within the built environment has gained importance. Thus, most of the cities in the world have been designed adding green areas to public and open spaces. Plants as green elements make environment relaxing, green, and aesthetic in addition to healthy for city community. Linking plant ecology with urban design and landscape design can help to take advantage of urban design projects as useful tools for ecological researches [9]. Plants at the parcel scale including open spaces, multifunctional land uses, and pedestrian walkways are of great importance, namely in high-density neighborhood designs to enhance physical performance and improve citizens' life [28].

When the world's cities are becoming increasingly crowded and polluted, green spaces in urban areas provides a lot of ecosystem services that could help struggle with many urban ills and improve living for citizens, namely their health [29]. From urban ecology aspects, green and ecological networks have been important elements of urban planning in recent years and have been organized based on ecological and social services to provide regulated climate, recreational occasions, environmental conservation and biodiversity, while they also supply

social and psychological necessities of the community [30]. While residential landscapes have been taken into account for their aesthetic value, recently, residential landscapes, especially trees, have been interested, due to their role in ecosystem services, such as reducing air pollution, reducing energy use, and regulating microclimatic conditions in the cities [31].

There is a need to gain experience to make a bridge between human and nature from urban and landscape design aspects. Our neighborhoods and cities, as designed mess, face to the lack of practice of design, which concerns comprehension of ecology [32]. As emphasized by Ryn and Cowan "*in* [32]", "until our everyday activities keep ecological integration by design, their cumulative effect will keep to be destroying". Ecological planning, ecological urban design, and landscape design provides a framework for retrofitting and redesigning urban environments, streets, avenues, landscapes, buildings, and cities with the natural components, besides of physical elements. Urban designers imagine the future of the city, and point out their architectural and infrastructural perspectives from the neighborhood to the regional scale [9]. These approaches are essential principles for profession experts on architecture, landscape architecture, urban planning to plan and design in urban areas.

3.3. Ecological architecture/ecological design

Beginning planning process and keeping on urban and landscape design at urban scale, ecological principles, and indicators should be also taken into account at building design. Ecological principles in spatial planning can be realized when they are kept on architecture. This approach based on ecology is essential either for sustainability or sustainable urbanization.

Ecological design was defined "as any form of design that minimizes environmentally destroying effects by integrating itself with living processes" by Ryn and Cowan "*in reference* [32]". This integrative definition addresses ecologically responsible design, which is not only a style, but also a form integrated with nature. In the context of the definition, "ecological architecture is eco-design approach to policies that an enhanced thought systematic", enhancing the conservation and improvement of microclimate, the new buildings for green areas by improving the energy and ecological principles of old buildings, and is located in the renewal of ecological architecture thought systematics [33]. Based upon the principle of ecological architectural design, it discusses architectural ecological design strategy from water saving, energy saving, earth resource saving, humanistic environment, and greening ecological environment, so as to enhance the sustainability of urban development and realize the sustainable development of architectural industry.

With the ecological/sustainable design approach, the effects on the environment of the construction materials used in building should be examined [34]. The scope of ecological design embraces the study of architects rethinking their preferences of building materials [32]. The production process of building materials has negative effect on the nature; "harvesting trees could result in deforestation; mining mineral resources destroys the nature and causes environmental pollution" [34].

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As it should be in both planning and urban design-landscape design process, one of the ecological indicators of architecture is to integrate of architecture and greenery as a part of urban green network. Some researches on sustainability of cities have promoted the application and protection of green components in the urban context. At this point, green architecture and green planning are of great importance. The benefits of plants, which will improve the climate and ventilation, reduce energy and water usage, are not just environmental but recreational, aesthetic, and emotional. In the last 10 years, a lot of studies about the full benefits of plants in building and the role they play in the ecology of cities were conducted. In addition, many indicators were evaluated by researchers for measuring of ecological benefits of green components in architecture.

With the multiple expressions based on "design with nature" approach, recently, "ecological accounting" has become a major force in architecture and construction. The guidance of ecology in design, it creates new aspects to design to minimize energy and materials use, reduce pollution, improve climate, preserve habitat, and to increase community well-being.

3.4. Eco-technologies

Although technologic improvement and economic development have increased in most countries, the numbers of livable cities and healthy environments have decreased. It is time to exchange damaging behaviors of the human and to reduce ecological footprints on the earth and on the settlements [5]. The cities experienced unpredicted economic development in recent years, have faced severe challenges caused by ecological and environmental degradation due to over-consumption of natural resources. Although ecology and technology look as if they are contrary to each other, taking into account the connection between them makes cities livable and sustainable.

Despite susbstantial socioeconomic achievements, concerns are growing over water availability and pollution, land degredation, and depletion of exhaustible resources [35]. Rapid urbanization associated with economic development is thus considered to be unsustainable, and supporting the ambitious goals of building an economically livable and environmentally sustainable society is difficult over the long term [35]. Urbanization is an integral component of economic development and civil evolution, as observed in both developed and developing countries. Energy consumption and CO_2 emissions are a direct result of the urbanization and industrialization process. Urbanization planning must include purposeful CO_2 emission control through comprehensive and scientific design [36].

Ecological engineering and eco-technology can be defined "as the design of human society with its natural environment for the benefit of both" [37]. Eco-technology can also be identified "as the usage of technological methods for environmental management so as to minimize damage to the environment" [38]. However, as technology uses methods causes harmful impact on environment, eco-technology uses remediation techniques with the aim of a greenery environment and environmentally friendly products or processes [38].

The protection of natural environment resources, which are impossible regain, is bound up with eco-economic policies, adoption of eco-technologies and usage of them. Environmental

consequences of productions and services have also become a significant theme for enterprise management. Resent approach on enterprises' environmental precautions aims environmental performance of production process, especially, through eco-innovation [39]. In order to minimize environmental effects of a production and to realize its life cycle, design, and post-design processes should be organized in accordance with ecological principles.

4. Conclusion

In order to retrofit settlements and cities in which we live and make them more livable and sustainable, it is necessary that our point of view and approaches related to urban spatial arrangements should be retrofitted and be gained ecological dimension. Ecology should be the key issue in the spatial planning and design process at every scale.

This chapter proposed a theoretical framework on retrofitting process based on urban ecology for making cities, settlements, and the whole environment livable and sustainable. From planning to design and to production technologies of the building and landscaping materials, adoption of throughout process based on ecology and ecological principles is essential so that habitats for the next generation to live in the earth have not been destructed.

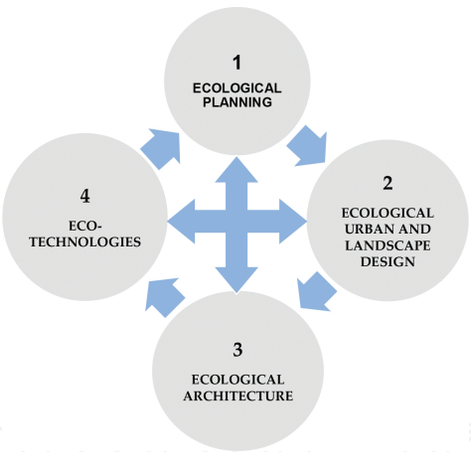

Figure 5. Ecology-based retro-fitting cycle in the framework.

With the guiding of the hierarchic succession on both creating and retro-fitting process urban environment shown in **Figure 3**, decisions, strategies, actions and studies conducted in every phase should consider the other phases' and should be integrated to each other. Thus, the framework emphasized in this chapter is an ecology-based cycle which contains integrated tools for ecological retro-fitting of urban environment (**Figure 5**).

Following this theoretical framework, it may not be remove ecological footprint of the human on the earth, but it would be reduced considering ecology from planning for human and making decisions for land uses in the urban areas to production processes of building and industrial materials. Thus, ecological and biological destruction on natural resources due to

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rapid urbanization would be stopped. With the sustainability of natural resources and ecologically balanced conservation-utilization strategies, livable and sustainable urban environment and cities can be realized.

As a summary of the retro-fitting framework based on ecology, the following checklist of which some items suggested by author [5], can be used for a guide to sustainability of natural and ecological resources for sustainable cities:

- At the beginning, ecological holistic approach and "planning–design–production based on ecology" should be adopted for integrated action plan
- As an inventory, data regarding natural resources in the planning area should be stored
- Ecological planning is the first process to determine suitable lands for new land uses
- As a strategic planning, ecological planning should begin with strategic environmental assessments
- Sensitivity of natural resources to negative impacts and possible effects caused by current land uses and activities on the lands should be investigated by ecological risk analysis
- With the help of ecological threshold analysis, new land uses suitable for natural ecological resources should be determined
- The balance between protection and utilization of the natural resources should be considered
- With the aim of sustainability of an integrative urban-nature development, an integrated green network in connection to the citizens should be created in the cities
- In urban design and landscape design process based on ecology, the demands of neighborhood residents should be combined to create a new pattern of vegetation, buildings, and surface covers
- Ecological architecture/ecological design should be major force on building
- From the planning to the building and production of the building materials, ecology based approach should guide to planner, architects, landscape architects, builders, and applicators
- Eco-technologies should be used for production of from building to industrial materials
- Environmentally sensitive local administration and environmentally sensitive community are also essential to create sustainable and livable environments, eco-cities, eco-tech settlements, or to retro-fit urban environments

From spatial planning and design point of view, eco-cities, eco-tech cities, smart cities, which are final phase of hierarchic succession of integrated retro-fitting tools, are ecology based settlements in which natural resources are not exhausted, technology is used for ecology (both human ecology and urban ecology), and there is a sustainable balance between economy and ecology.

Eco-tech has great influence on the construction of environment. The utilization of eco-tech is the necessary means of architecture to the aim of sustainable development [40]. Ecological and

technological design of new comfortable, healthy, environment-friendly, minimum carbon consuming, self-efficient settlements contribute to urban sustainability [41]. From design point of view, eco-technology can be identified as the design of human society with its natural environment for the benefit of both. Eco-tech planning/design for eco-cities considers energy, environment and ecology for human wellbeing.

The principles of eco-tech city can be explained as the following: "Eco-tech city, when planned in collaboration with local investor, local management and technical team, can decrease ecological footprint of that city by using high performance ecological building and city technologies" [42].

Among the various types of "eco-city" initiatives currently underway across different parts of the world, this tension is arguably particularly pronounced in the case of entirely new, large-scale cities. According to a recent global survey, of the 80 or so recent eco-city initiatives-which include the retro-fitting of existing cities and urban expansion through variously sized "eco-districts" and "eco-towns"—there are a dozen or so brand new cities in the process of being realized [43].

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