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Ecological corridors and clusters for environmental master plan and environmental management studies of Istanbul

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Abstract:
One of the driving forces for the sustainable development of a sub-region, region or a country is the effective development of environmental masterplans and environmental management plans. These studies are complementary to sustainable policies in order to ensure effective executive implementation of such plans and management proposals. These guiding studies have naturally to be in line with scientific knowledge, given natural areas are finite and human-kind's impact is profound. Therefore landscape ecology and ecologically based studies are becoming increasingly important. This study examines ways of looking at Istanbul, the biggest metropolis of Turkey, in terms of its ecological clusters and corridors and current environmental master plans and management plans.

Keywords: *Environmental master plan, environmental management, sustainability, landscape ecology, environmental clusters, ecological corridor.*

1. Introduction

Environmental master plans guide determination of settlement and land use decisions such as housing, industry, agriculture, transportation, etc. in accordance with country and regional planning policies (Official Gazette, 11 November 2008, Number: 27051, "Regulation on Environmental Plans"). Environment master plans are defined in the Regulation on Environment plans as:

a) enabling rational natural resource usage on the basis of development plans and regional plans,
b) defining goals, principles, strategies and policies and setting land usage decisions for achieving these targets in order to prevent pollution and create a healthy environment,
c) defining broader goals, principles, strategies and policies for protection and development of historical, cultural and natural environment,
d) guiding smaller scale planning decisions and provisions, and
e) enabling ecosystem integrity and land usage sustainability in terms of

planning decisions,

f) being prepared with the participation of experts from different professions because of the diversity of the data forming the basis of planning,
g) having a feedback process enabling returning back to previous phases in every phase of the planning process for making evaluations,
h) having a standard database that can be compared, evaluated, interrogated, developed and updated,
i) setting policies and strategies for the fields that are required to be protected for enabling consideration of both the ecological and the economical decisions in accordance with sustainable development goals and have the characteristics of an strategic (literally "upper scale") plan.

In the light of these definitions, these plans are critical firstly in terms of sustainable spatial planning and secondly for sustainable development. Within this structure environmental master plans play a vital role under the spatial planning umbrella in Turkey.

The concept of planning will continue to be used in a broad perspective. Spatial planning is broader than traditional town and country planning focusing solely on the physical form and design of specific development projects (Anonymous, 2004).

Handling environmental master plan studies together with environmental management studies in an integrated manner is critical to the preservation and improvement of quality of life in the natural environment, the built environment and the transition zones between the two.

This integrated approach needs spatial reference bases which could be taken from the nature. Landscape ecology gives an in dispensable contribution to this need.

Landscape ecology is defined as a problem-oriented science. It has developed from the growing awareness of environmental problems since the 1970s. Spatial planning and landscape design are disciplines which transfer the knowledge developed in landscape ecology to planning and development applications. To optimize this process of knowledge transfer, landscape ecology must co-evolve with spatial planning. The development of ecologically sustainable landscapes requires that patterns of future landscapes sustain the necessary ecological processes of the landscape (Opdam, P., Foppen, R., Vos, C.,2002).

For this reason, differentiation of space the ecological aspects of spatial planning have to be defined. This differentiation can be according to the sensitivity levels of nature and also to the total assessment of ecosystem groups which are of vital importance for ensuring continuity of the integrity of natural systems. They can be considered as corridors or foci of natural change. To improve and develop a sustainable landscape, this approach should be handled through clusters and corridors.

Ecological clusters have an internal integrity due to their natural or cultural characteristics and they define the focuses that have to be managed as a whole, whereas ecological corridors are defined as guarantees for energy flow and biological diversity in system integrity and they describe the structures whose sustainability are vital for persistence of life-support systems.

Definition and integral management of ecological clusters and corridors reinforce the health and sustainability of both natural, urban and transition ecologies.

Ecological corridors can be landscape structures of various size, shape and habitat composition that maintain, establish or re-establish natural landscape connectivity. They can have continuous or interrupted structure or a structure of stepping-stones and they can have many functions. Ecological corridors have always existed in natural landscapes. Most obvious are migration routes for birds, ant routs, badger routs and river corridors for fish migration (Jongman R., Kamphorst D. 2002).

In landscapes that are dominated by human land use, such as intensive agriculture, urbanization and infrastructure, ecological corridors change according to the type of land use. Ecological corridors in a man-made landscape require a planning approach. Ecological corridors are mostly not mono-functional in an ecological and also in a societal sense. They are not core areas but function in the wider landscape. They can encompass natural landscape features as well as a variety of human landscape features and are from more natural to more cultural classified as (Jongman R., Kamphorst D. 2002) and are characterized by:

- landscape linkages, large linear protected areas between large ecosystems including undisturbed rivers;
- conservation corridors, less protected and in many cases with recreational functions, often along rivers;
- greenbelts, protected natural lands surrounding cities to balance urban and suburban growth;
- recreational corridors, linear open spaces with intensive recreational use;
- scenic corridors, primarily protected for its scenic quality;
- utilitarian corridors, canals, powerlines that have an utilitarian function but serve natural and recreational functions as well; and
- trails, designed routs for hikers, outdoor recreation that can have function as natural corridor as well.

Ecological corridors and the conservation of cultural landscapes; is linked to the development of cultural landscapes in many senses (Jongman R., Kamphorst D. 2002).

Studies derived from landscape ecology, under the roof of spatial planning and environment plans, have an indispensable importance in combating the gradually deteriorating quality of in Istanbul, which is the biggest metropolis of Turkey and carries the chief role in Turkey in terms economical, social and cultural development. In this context definition of ecological groups and corridors are required for understanding metropolis development borders and limitations and creating an environmentally conscious structure for development strategies. In these studies, how this can be incorporated in spatial planning and definition of management strategies are also covered.

2. Study area

Istanbul has a specialized geographical location, connecting Asia to Europe and the Black sea to the Marmara Sea. By the geographical position,

topography and the geological structure, the natural resources of Istanbul also bring along the biological varieties with them.

Istanbul has last heath land species of East-Europe with Mediterranean and Black sea local flora zone. Although Istanbul has a fairly small area of 5,400 km2 it is at the intersection of different flora, and hosts over 2,000 kinds of flowered plants. Istanbul Forests are one of the 100 forest zones called "Most Ecologically Hot Spots of Europe". In addition, Istanbul is on one of the important migration paths of birds and contains the six "Important Bird Area" of Turkey (http://www.wwf.org.tr, Bayfield,A.J. and Özhatay N. 1997).
Istanbul, besides having abundant natural resources, is the biggest metropolitan area in Turkey with a population of 13,120,596 and dominates Turkey culturally, historically, socially and economically. Indeed its hinterland extends up the Danube, around the Black Sea and through the Eastern Mediterranean. It was European Capital of Culture in 2010.

Given such factors and given the continuing growth of the Turkish economy (GDP grew 4.7% in 2009) despite the European Recession, Istanbul and its region is subject to negative and uncontrollable growth primarily related to immigration and this is a significant threat for the landscape of Istanbul.
Being mostly affected by fast urbanization particularly since the 1950s, Istanbul has over 15% of Turkey's population in its limited geographical area. With only 0.7 % of the country's land area and a population of 12.5 million it has the 17.22% of the total population of Turkey.

The fast population growth and urbanization in Istanbul has given rise to the loss of natural resources. Housing and industrial developments, tourism and recreation activities, open cast (aka strip) mining operations, development of roads have led to serious destruction of forest zones, wetlands, sand dunes.

Unforeseen developments and alterations in the projections upon which Istanbul's strategic planning have been based have led to a serious destruction of natural resources.

The natural borders and constraints of Istanbul have to be defined if further destruction is to be avoided and development should be in accordance with the land's ecological bearing capacity. This is necessary for management of the future development of the Istanbul Metropolis and also has lessons for the sustainable development and management of both the region and the entire country.

3. Dataset, data processing and data evaluation

The methodology of the study process is seen in Figure 1.

3.1. Dataset

The dataset used in this research was as follow;

- 1:25,000 scale ground water resources map (General Command of Mapping),
- 1:25,000 scale soil capability map (Provincial Directorate of Agriculture),
- 1:25,000 scale forest cadastral map,
- 1:25,000 scale ecologic values and natural protection area map (produced by Istanbul Metropolitan Planning Centre)

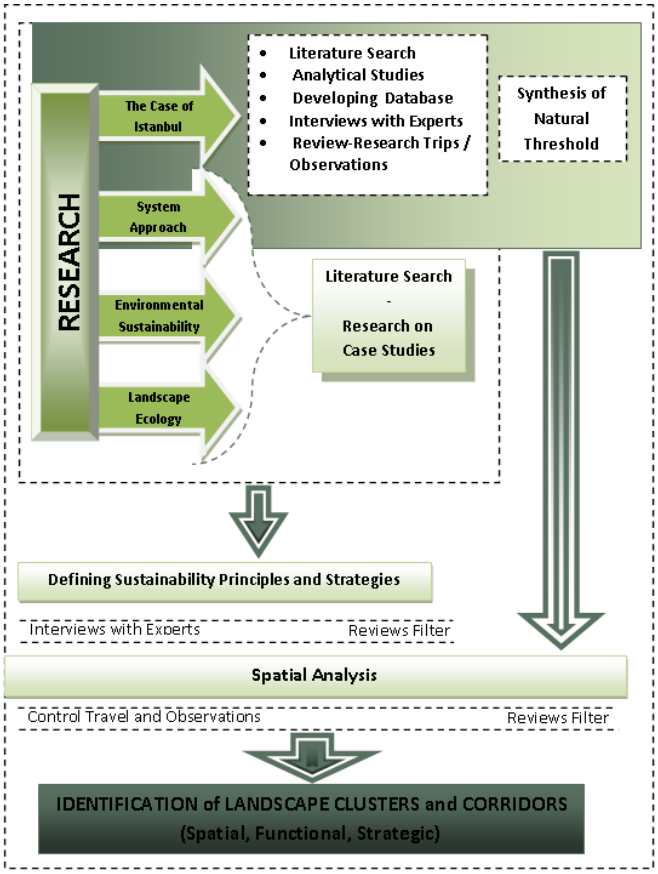

Figure 1. *The flow diagram of the methodology*

- 1:25,000 scale geological risks map (produced by Istanbul Metropolitan Planning Centre, Natural Structure Study Group)
- 1:500,000 scale underground water basins and aquifers map (General Directorate of State Hydraulic Works)
- 1:25,000 scale settlement areas map (produced by Istanbul Metropolitan Planning Centre, Quality of Life Study Group)
- 1:25,000 scale transportation system map (produced by Istanbul Metropolitan Planning Centre, Transportation Study Group
- 1:25,000 scale mining areas map (produced by Istanbul Metropolitan Planning Centre, Natural Structure Study Group)

Besides these maps, administrative (district) boundaries information, and data layers like natural drainage diagram, slope analyses, private forest area evaluations and earthquake zones evaluation data layers have been produced and used. Satellite images; Geocover satellite image of 2000 Marmara and Ikonos Satellite Image of the 2005 Istanbul have also used for matching.

Other material used has included academic studies into the related natural resources within Istanbul; natural resource research reports by public and non public foundations, information gained from the meetings with the directors of municipalities and people who are expert in these study areas; numerical land data that are used as a material in evaluations. The statistical and other data has been updated and checked by survey trips, and web based air photographic data.

3.2. Data processing

Data processing process has been conducted in two stages. Studies focusing on natural thresholds were the first stage and landscape ecologies were the second stage and these studies have been used to produce a base for sustainable spatial planning or environmental master plan goals.

The first stage of data processing has included the study of the analytic bases for natural thresholds, determining the conservation priorities for natural resources based on agricultural areas and soil resources, forest and ecological values, geology, subsurface resources separately and also the definition of natural risks that are important redirectors of natural thresholds.

As part of the study process; the flora and fauna species in the biotopes (the ecosystems) having natural vital places that have ecological and biological importance in Istanbul, have been specified and transferred to the maps and

to the reports. The endemic flora zones and the faunas which are important for the international agreements and the biological variety have also been specified. In addition to these, natural area ecosystem evaluations have been done for the Çatalca and Kocaeli peninsulas which form Istanbul city. The Analysis of the Natural, Cultural, Recreational Landscape Resource Values, has separately considered sustainable conservation of biological varieties, natural and cultural resources. The earth science studies which include the city of Istanbul cover all the analyses on earthquake hazard, engineering geology, hydrogeology, hydrology, geomorphology and geology and the holistic evaluations. Within the context of "the analytical studies of ground water", all the areas which are related to mining operation and the areas which showed the characteristics of potential source have been analyzed.

At the first stage, the evaluation of the natural thresholds as a whole gives a direction to the study. All natural resource criteria and statistical data has been analyzed in three categories:

- natural resources that need unrestricted protection,
- natural resources that need priority protection,
- limited natural resource potential areas.

In the process following the completion of all the studies on each of the natural resource elements, the natural resources studied with the headlines of agriculture, forest, earth science, underground resources are assessed within the context of the approach presented in Table 1. Assessments have been used as the base of Figure 2 and so the synthesis of natural threshold has been obtained (IBB-BIMTAS-2 (2006)).

Table 1. *The resources used as the data for the synthesis of natural threshold*

Agriculture	Forest	Earth science	Underground Resources
The areas which must inevitably be preserved			
Dry farming 1+2 Wet farming + Inadequate watering 1+2+3+4 Gardening areas 1+2+3+4+5+6 Meadow and pasture 1+2+3+4+5+6+7	Forest and cadastral areas Protection forests Picnic areas in the forests	The areas which are not suitable to reside on The absolute and short distance areas of the dams Stream protection lines Active landslide areas The areas where there is the potential of falling rock Spring water operation areas	Sand-gravel Broken stone Silica sand Quartz Ceramic Bentonit Coal Building stone
The areas which have the priority of preservation			
Dry farming 3	Private forest areas Non-cadastral forests	The areas high in and ground water The areas which carry the risk of tsunami Filled areas Potential or improved sliding, flooding and liquefaction areas	Broken stones Building stones Sand gravel Coal
The areas which have limited underground resources			
Dry farming 4+5+6	2B areas the natural values of which have been lost	The areas which require a through geological study	Coal Building stones Broken stones

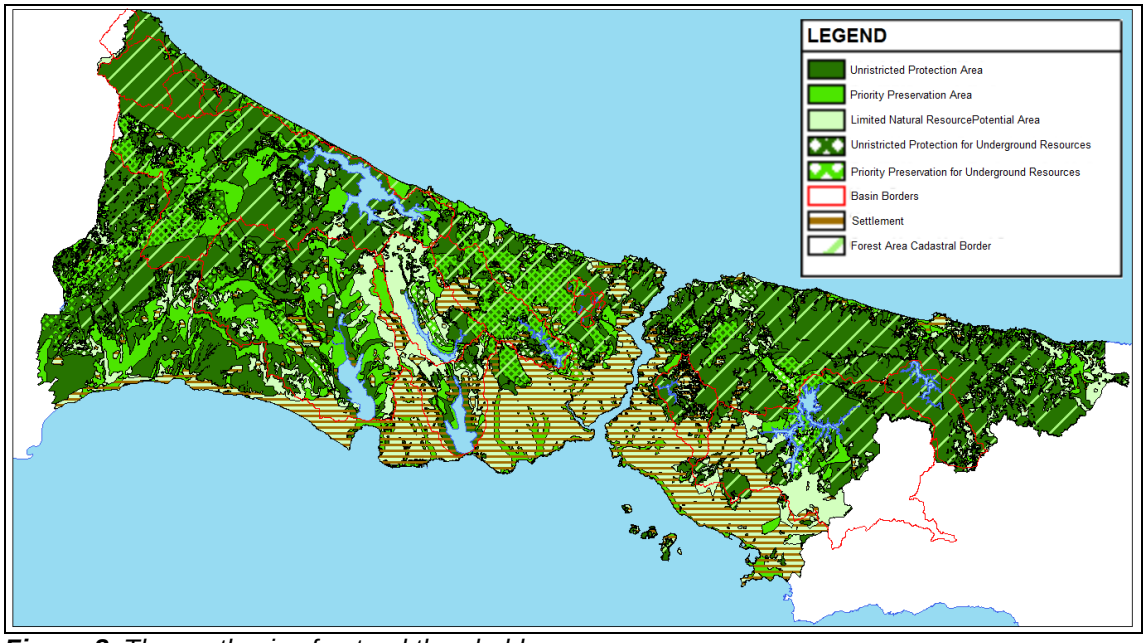

Figure 2. *The synthesis of natural threshold*

As the findings developed during the second phase of the study fulfilled sustainable spatial planning and environmental master plan expectations, this led to definition of a new line of enquiry into sustainable landscapes. This approach has been developed by taking into consideration multi-criteria decision analysis techniques and principles of design with nature, sustainability and ecology.

The studies carried on at this phase can be gathered under three headings:

- to set up the concept and the principals of sustainability,
- the spatial assessment and the definition of strategies within the framework of landscape sustainability, and
- the establishment and definition of ecological clusters and corridors based on the environmental sustainability.

In this phase, the sustainability concept and principles were defined as available for sustainability assessment and definition of strategies and establishment of a common language (IBB-BIMTAS-2 (2006)). These definitions have established the principles of spatial assessment in Istanbul and life support systems (protective concept) which cover the ecological corridors and sensitive ecosystems and natural risk areas defining geological risks like earthquake, land slide, flood plain, filled ground were considered as main points in the next stages of the study.

During the study the analysis of natural/ecological structure sensitivity was done, the areas showing the natural/ecological integrity were determined, data which related natural risk areas were taken into consideration, and the ecological corridors were defined by life support systems. The method followed in the studies which were important to identify a healthy macroform and develop planning decisions for sustainability and main stages of the study are explained below in details.

Natural/ecological structure sensitivity analysis; was realized by considering the natural functionality and integrity and the fragile ecosystems and

structures on which the pressure on natural structure leaves irreversible effects. Analyses were realized within the framework of factors necessary for environmental sustainability, in spite of the some lacks and restrictions such as time. These elements are related to water resources (hydro electrical structure analysis, surface waters and river basin), land resources (land utilization classes, topography, and slope analysis) and biological varieties and ecological structure.

According to Mc Harg's (1992) classification and Malchewsky's (1999) multi-criteria decision making approach the sub-layers forming each data layers were transferred to the "Natural Structure Assessment Matrix" which forms the framework of the study. Grading which is the basis of assessment is made on five steps:

1- less important
2- medium important
3- strong importance
4- very strong importance
5- extremely strong importance

In order to ensure the objectivity of the assessment, the thoughts of the experts and national criteria's which are established by Ministry of Environment and Forestry (Anonymous-2, 2004) was also applied to the natural structure assessment matrix. By this way, the known spatial points were questioned based on the geographical knowledge. During this process, the sub-data related to the natural structure has been transferred to an ArcGIS environment and the ones which are suitable for up-to-dateness, functionality, adequacy and interrogateability has been selected and the places have been classified according to their ecological characteristics such as integrity, functionality and vulnerability. After the classification and the points determined by the matrix have been given to each data layer, the total values layer which is the based on the borders of the region has been produced. The layers have been categorized in five main groups after applying the natural break method.

As a result of this evaluation, it was understood that the data layer, which would be an input for sub scaled planning and administrative studies and be effective to develop the decisions to use the spatial administrative clusters, and which includes a classification consisting of five main groups is too many detailed for a 1/100,000 scale study. Therefore, the areas that have very strong importance and extremely strong importance were grouped, while the areas that have less importance or medium importance were separately group.

The data layer, defined as the natural structure sensitivity analysis, covers the gradual steps of sensitivity which includes the areas with inevitable importance from the viewpoint of total natural productivity including the variety of natural resources and should definitely be preserved. By contrast areas that can tolerate the development of further human activities have been separately identified.

The areas with a total value of 36.00-54.00 are defined as areas that have very powerful and extremely powerful importance; 27.00-36.00 points indicate areas that have powerful importance and 9.00-27.00 points show areas which have less or medium importance . The areas which have 1-9

points usually reflect the established residential areas which have inadequate natural structure data. High points reflect high sensitivity and the low points reflect low sensibility.

3.3. Data evaluation

Defining the vital life support systems and the ecological structure of Istanbul with the help of geographic base evaluations, data layers matched with forest zones, soil resources and natural risk zones. According to these evaluations Istanbul is divided into clusters with the headings mentioned below:

- areas that should have their functions preserved,
- sustainable development areas with special measures,
- areas to be sustainably developed,
- problem areas in terms of environmental sustainability,
- existing settlements, and
- natural areas which will be rehabilitated.

As a result of interpreting and assessing all of the layers used during the analysis, the "Ecological Clusters and Corridors" (Figure 3) which are a basis for making decisions on the habitation, protection, rehabilitation, transformation etc. have been produced and by this way "Spatial and Administrative Clusters Based on the Environmental Sustainability" were defined. This data layer has not only laid a groundwork for urban landscape planning studies based on the natural thresholds of Istanbul but also has role as a main director to be used in all sub scale studies.

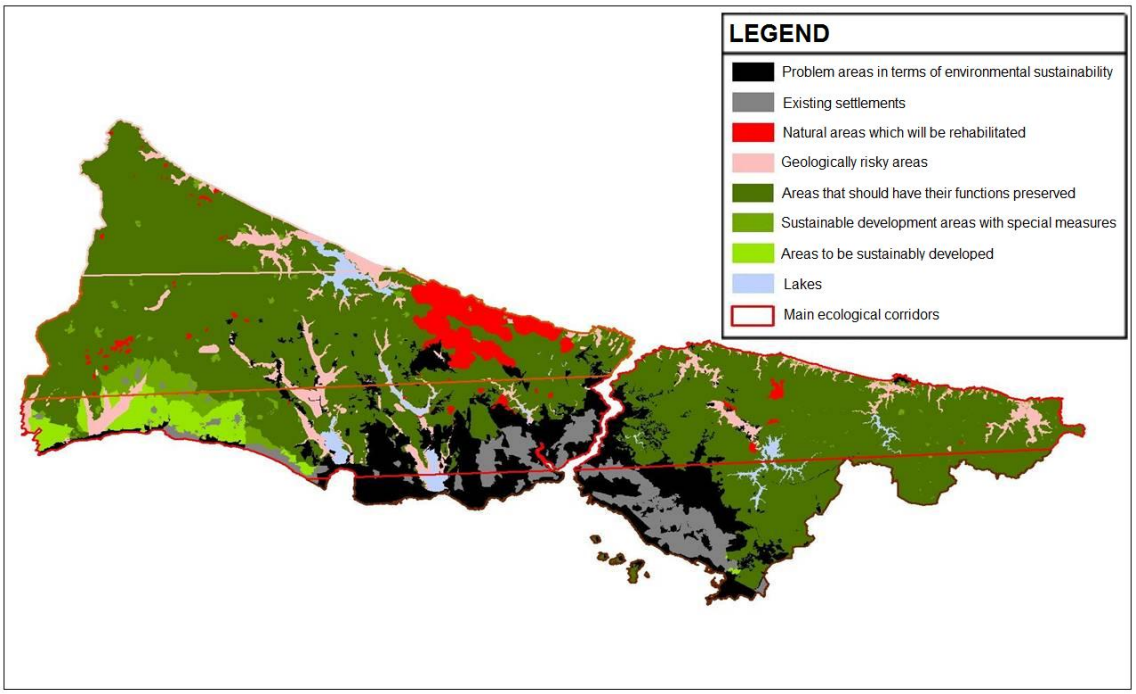

Figure 3. *Main ecological corridors and clusters of Istanbul*

4. Findings

The strategic principles which should be followed within the context of "Ecological Clusters and Corridors of Istanbul" based on the sustainability of

Istanbul and its natural environment, and thereby increasing the life standards of citizens are;

- protection of the natural areas and ecological resources,
- decrease the unit energy consumption and emissions,
- closing natural waste cycles,
- improvement of the human environment,
- take the measurements for the risks created by human or nature,
- costing of the natural feature,
- monitoring the environment and
- the expansion of environmental consciousness and the realization of environmental management.

In this study “Ecological Clusters and Corridors of Istanbul” are defined as below.

Areas that should have their functions preserved

These are the areas that will not have natural functionalities when distorted by human factors. And it will be very costly to setup the original functionalities, but these areas will never have the initial (original) functionalities. These areas ensure the life quality within the metropolitan area, and they have crucial importance for the self-sufficiency of the Metropolitan. In order to sustain the functionalities of other life-support systems, supporting ecological corridors should be created and protected. And these corridors have to be considered in the context of the areas that should have preserved functionalities. Based on the geographic locations and structural properties, ecological corridors contain natural risk areas in certain sections.

The approach to planning these areas should aim to preserve their functions, should be aligned with the strategy of "preserving the natural areas and resources". In order to balance urban development pressure, precautions should be taken to protect the nature and environment. Also, when determining spatial planning, damages to these areas should be minimized. In other words, areas that should have their function preserved have to be considered as part of "protected metropolitan land".

Sustainable development areas with special measures

These areas have a lower total natural productivity than areas that should have their function preserved. One of the important properties of these areas is to reduce and delay the impact of human pressure. As a result, these areas have a buffer zone mission between protected land and currently-developing settlements. Preserving the natural areas and resources, closed environmental cycles, reducing the unit energy consumption and emission are the important principles when designing and planning the activities in these areas. As part of "The cost of Nature" principle, it is important to realize the "polluter pay" procedures to reduce the impact of certain activities on these areas. These are activities which create added burdens for nature and environment.

Areas to be sustainably developed

These are the areas which might have urban development, but these developments should be aligned with sustainable development principles. The following are the important factors when designing the planning approach for these areas:

- closed environmental cycles,

- reduction of the unit energy consumption and emissions,
- improving the human habitat and life quality,
- preservation of natural areas and resources.

Since these areas are planned for urban development, certain strategies should be taken in to consideration to prevent natural disasters like earthquake and flood.

Problem areas in terms of environmental sustainability

These are the areas that shows improvement on the areas that should have their function preserved and include life support systems and ecological corridors or natural risk areas and areas that will have sustainable development areas with special measures or has shown the clues of improvement and has emphasized urban structure. If these improvements are maintained, some irreversible damage may occur in the natural systems related to this area directly or indirectly, this kind of areas is evaluated under a different headline from the present residential areas. These are the areas for which we should take emergency precautions in order to provide for environmental sustainability and reduce the human impact. The strategies of closed environmental cycles, preserving the natural areas and recourses, improving the human habitat and life quality form the framework of these precautions.

Existing settlements

Apart from the areas which are problematic in terms of sustainability, important reasons such as the need for improving the structure of existing settlements, the greatness of the natural disasters threatening the Metropolis and inadequate technical city infrastructure to guard against these disasters determine the core for taking the residential areas into consideration. Within the context of environmental sustainability we should apply the strategies regarding closed environmental cycles, reducing the unit energy consumption and emission, improving the human habitat and life quality and taking the measurements for the risks created by human or the nature in these cultural landscapes.

Natural areas which will be rehabilitated

Natural areas which will be rehabilitated are the areas where open mining is operated and the areas where the natural structure is destroyed beyond repair. The aim of improvement is to take safety precautions for the risks such as landslide and help the region re-establish it natural functions. For this reason, the improvement region on the coast of Black Sea is only suitable for low density activities which will not dramatically interfere with natural systems and are in accordance with the principle of taking the measurements for the risks created by human or the nature.

5. Conclusion

This study, aims to preserve Istanbul's genuine natural structure, to increase the environmental life quality, and to enable spatial planning consonant with natural limits and in accordance with the principles of environmental sustainability as part of the process of planned improvement. Taking this present improvement tendency into consideration, we have developed an analysis of macro forms which will help Istanbul develop in an ecologically a healthy and sustainable way and which will provide answers to the demands. This contrasts with a more conservative protective attitude which

does not take demographic and socio-economic dynamics into consideration.

All the analyses and evaluations made during the research argue that the policies which will be adapted in Istanbul in the following years should:

- improve the present situation and ensure the increase of quality more than finding places which are suitable to inhabit in the city,
- protect the life support systems from human beings,
- take the technical measurements to protect people from the natural disasters
- to give life to the principal of environmental sustainability, and
- decrease the pressure on the natural resources.

In summary, these researches based on natural resources, natural limits such as protection priorities, life support systems, ecological corridors and avoidance areas have been taken as the base of physical planning studies related to Istanbul. This approach has played an important role as both a macro scale plan as an important component in defining a healthy overall form and as a way of defining the process of transforming each landscape cluster and corridor into a healthy and sustainable structure.

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