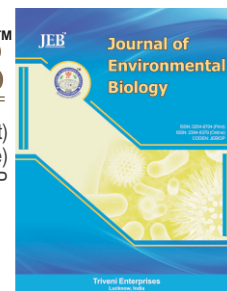




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# Strategies for sustainable landscape management in the Filyos river delta, Turkey

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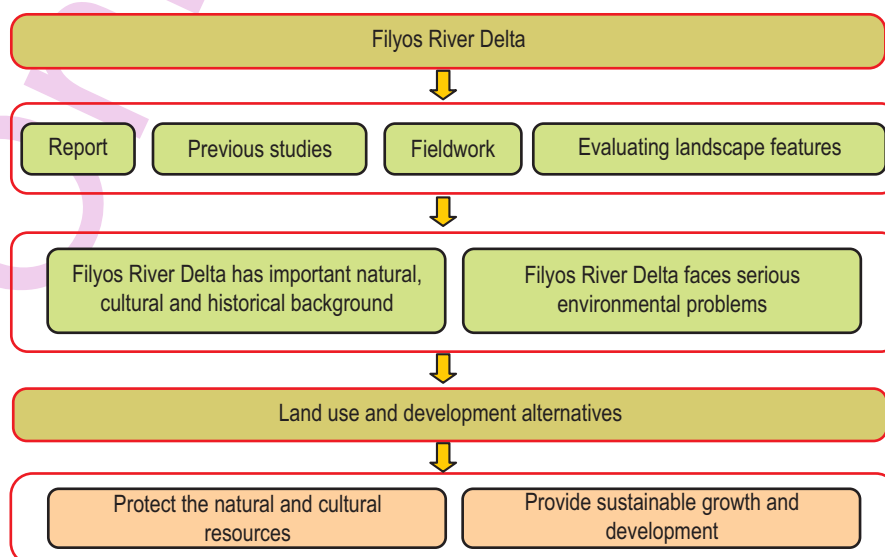
## Abstract

**Aim:** Filyos is the largest river basin in the Western Black Sea Region in Turkey. Filyos River Delta (FRD), is an important marshy ecosystem area that includes different habitats such as small lakes, sand dunes, reed beds etc. in the north of Çaycuma county in Zonguldak province. On the other hand, the Filyos Valley Project" is expected to become one of the most important public investment projects designed to ensure regional development since early 1990s. In this study, environmental strains on Filyos River Delta and near coastal areas were identified. Landscape management strategies were developed for sustainability of the Filyos River Delta.

**Methodology:** Information related to natural and cultural landscape features of Filyos River Delta were obtained through the analysis of report, previous studies and fieldwork. Landscape features of Filyos River Delta were evaluated for balanced land use and development.

**Results:** Filyos River Delta has important natural, cultural and historical background that faces serious environmental problems such as flood risk, unorganized industrialization, overwhelmed agricultural activities, loss of biodiversity, sand and gravel mining on the river bed. More significantly, constant increasing environmental impacts are likely to be permanent and to damage the health, safety and welfare of public before completion of the project which was originally envisioned to improve the infrastructure of the Filyos Valley and enhance the quality of life for its residents.

**Interpretation:** Land use and development alternatives that could protect the natural and cultural resources and provide sustainable growth and development were presented.



## Introduction

Delta wetlands are different ecosystems in terms of their formations and functions. Deltas include both aquatic and land ecosystems, making up the transition region between the sea and the land. Deltas are very important environments for living beings. Deltas form large fertile lands (Kara *et al.*, 2010). Deltas are undoubtedly the most important elements in coastal geomorphology in Turkey. These areas have very sensitive ecosystems where both land and marine systems exist together. However, exploitation and misuse of delta areas led to the disruption of the sensitive ecological balance. Agriculture, animal husbandry, settlement, tourism, industry, and transportation activities intensified, which consequently endangered the balance of the dynamic ecosystems in the delta areas (Efe, 2010; Atalay and Efe, 2015). Coastal use and planning should be carried out in a multidisciplinary manner in order to ensure the protection.

The deltas are important because of large diverse ecosystem as well as prevalent land use types. However, these areas face many problems which include loss of biological diversity and environmental degradation due to coastal settlements and pollution factors (Acar *et al.*, 2004).

The human impact increased on the coastal areas with growing population (Curebal *et al.*, 2015). The consequences of human activities are more visible in coastal areas, have attracted settlers since the ancient times.

The favourable natural conditions on coastal areas led to the establishment of large settlements and industrial areas. These features of coastal areas paved the way for the empowering effects of humans to be felt, rendering these places hotbeds of conflict for natural resources. Commonly preferred sections of coastal areas are low coasts and, in particular, delta regions. These regions host systems in which erosion-transportation events take place between the coast and the land, thus creating large deposits (Özşahin and Ekinci, 2012).

The excavations, landfill and engineering structures that increased in recent years changed the natural characteristics of coastal regions and cause irreversible damage. The filling and engineering structures built along the coast change the directions of coastal currents as well as the roles they play in shaping the coast line in addition to changing the morphological and ecological properties of the coast. As a result, the shaping of the coastline by natural processes is interrupted, which alters its position. Erosion that occurs especially in the regions where such incidents unforeseen poses serious risks to facilities located near the coastline (Şişman and Şişman, 2012)

This paper reports the environmental strains on the Filyos River Delta and near coastal areas together with landscape

management strategies developed for sustainability of this important delta.

## Materials and Methods

The Filyos River encompasses a section of the cities of Bartın, Bolu, Zonguldak, Karabük, Kastamonu, and Çankırı in the Western Black Sea region of Turkey (Fig. 1, Fig. 2 and Fig. 3). It covers an area of about 13305 km<sup>2</sup>. The Filyos River Basin makes up about 46% of the Western Black Sea basin. The basin is located between the latitudes of 40° 36' and 41° 36' and the longitudes of 30° 14' and 33° 42'. About 63% of the basin is covered with forests and approximately 1% with settlement areas. These settlements include Bolu, Karabük city centers along with the Gerede, Mengen, Dörtdivan, Yeniçağa districts of Bolu; Eflani, Eskipazar, Ovacık, Safranbolu, Yenice districts of Karabük; Çaycuma, Devrek, Gökçebey districts of Zonguldak; Araç, İhsangazi districts of Kastamonu and Atkaracalar, Bayramören and Çerkeş districts of Çankırı (Kaya *et al.*, 2007). The total discharge of the river is 3213,910 hm<sup>3</sup> per year, and average efficiency is 102,237 m<sup>3</sup> per sec with average seasonal flow rates of 135,470 m<sup>3</sup> per sec in spring, 31,070 m<sup>3</sup> per sec in summer, 67,140 m<sup>3</sup> per sec in autumn, and 127,370 m<sup>3</sup> per sec in winter (Demirci, 2008).

Information related to the natural and cultural landscape features of the FRD were obtained through the analysis of report, previous studies and fieldwork. Landscape features of the FRD were evaluated in terms of protection of its natural and cultural resources for balanced land use and development. Then, the causes of deterioration of delta ecosystems are presented, and certain solutions were offered in consideration of Landscape Architecture.

## Findings Geology and Geomorphology

The area of Filyos River between Karabük and Gökçebey is known as the Upper Filyos Basin whereas area between Gökçebey and Hisarönü is Lower Filyos Basin. Alluvial plain and valley floors, low plateaus and hills, and high plateaus and mountainous areas are three main geomorphological units in the study area. The Lower Filyos Basin is covered with materials formed in the Eocene period with the alteration of flysch, sandstones, marl, conglomerates, tuff and tuffites as well as lava and agglomerates. The differential resistance levels of rocks have led to distinct erosion patterns in the eastern and western sections of the river. Braided basin deposits are found on the river bed. Pebbles and sands have the form of lenticular deposits. Filyos River's flood plain surface is covered with fine sand, silt, and with a thickness of 2-5 m.

Landslides are the most important problems in the region, and they are caused by dominant geological and geomorphological properties. Landslides may occur in regions

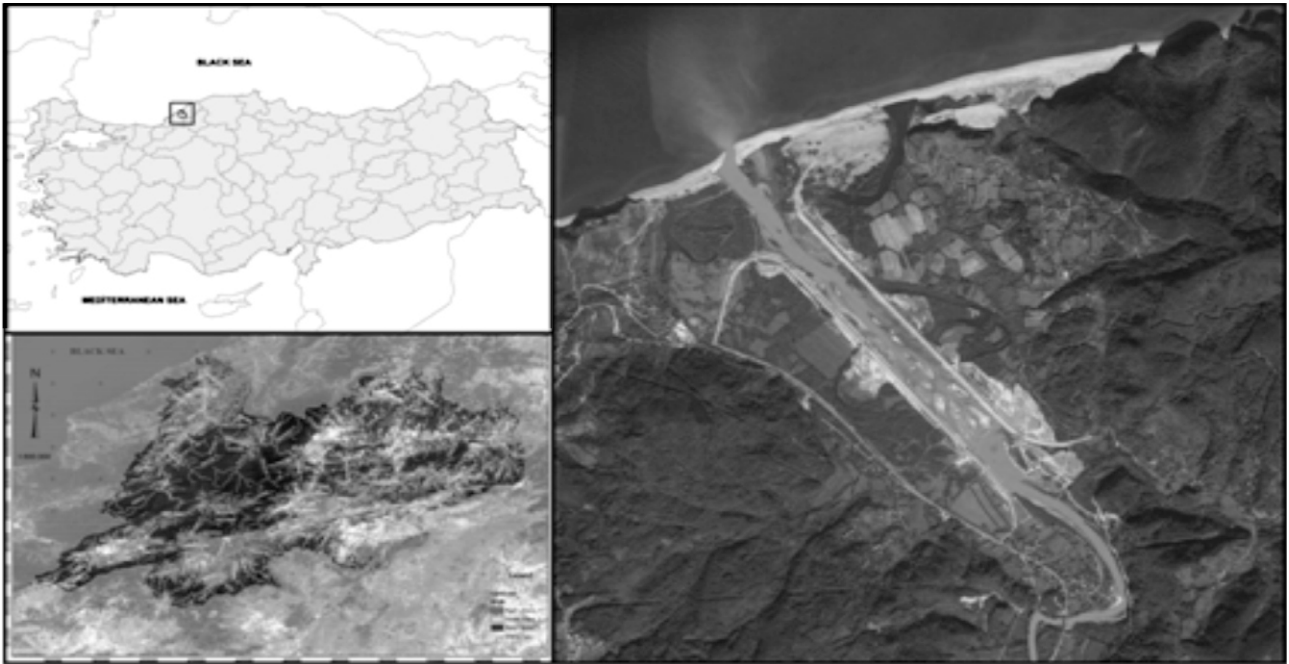


Fig. 1: Representative picture of study area (Kaya *et al.*, 2007)



Fig. 2 : General views of the research area

with high elevation and damaged vegetation since Eocene flysch gets slippery in rainy periods. In addition, the region is in the 2nd and 3rd level seismic belts as indicated on the Turkey Seismic Zone Map (Demirci, 2008).

The Filyos River meanders more freely as it approaches the Black Sea. As a result, the topography especially the coastal areas became swampy while relatively low fields made up of abandoned beds emerge as lagoons along with high areas formed as a consequence of the material deposition in periods when the flow rate and water level increase. These high areas cause the river to separate into beds, and the Filyos River sometimes flows into the Black Sea along with more than one tributary. Today, the Filyos River discharges its waters into the Black Sea only from its almost western mouth (Avcı and Avcı, 2001). In addition, by carrying out analyses via Geographic Information Systems, Büyüksalih *et al.* (2005) shed light on time-induced transformation of sand dunes on the delta formed along the Filyos River valley and in the area where it flows into the sea.

The sand dune area on the Filyos delta was formed not so long ago. These sand dunes can be examined in several sections due to their relief properties. The new sand dune area with a width of 20-25 m right behind the coastline stands out since it is a shifting dune. The shifting dunes interrupted by the old mouth of the Filyos River located in front of the Mezarbaşı Hill (56 m) are replaced by the old sand dune area running parallel to the coastline further back. Their elevation varies between 5 and 10 m, and this field is covered in part by species that represent the community of moist forests extending toward the south (Avcı and Avcı, 2001).

**Climate :** The annual average temperature data obtained from the Zonguldak, Bartın, Devrek, and Karabük Meteorological Stations were used to identify the climate properties of the region. Data demonstrate that temperature varied between 13.1-13.9°C. An examination of the isotherm maps reveal that valley floors at the Lower Filyos basin and the area around Karabük were warmer, while the areas with the lowest temperature are regions with higher elevations. Continentality increased from north to south. Regional rain maps indicate that coastal regions noticeably received more rain than inner regions, but that the amount of rain increased on higher plateaus and in mountainous areas of inner regions. The amount of rainfall exceeded 900 mm at coastal areas and decreased to 500 mm in Karabük. The total flow of the Filyos River was 3213,910 hm<sup>3</sup> per year, and its efficiency, on average 102,237 m<sup>3</sup> per sec with average seasonal flow rates of 135,470 m<sup>3</sup> sec<sup>-1</sup> in spring, 31,070 m<sup>3</sup> sec<sup>-1</sup> in summer, 67,140 m<sup>3</sup> sec<sup>-1</sup> in autumn, and 127,370 m<sup>3</sup> sec<sup>-1</sup> in winter. Average annual rainfall is 608,4 mm, and this is below Turkey's average of 643 mm (Kaya *et al.*, 2007).

**Soils:** The hills that surround the Filyos River basin from two sides are covered with brown and non-calcareous brown forest

soils. Alluvial soils occur on the valley floors have not yet been fully developed. However, they are fertile, and hence they constitute the most important agricultural areas for the settlements in the valley (Avcı and Avcı, 2001).

**Hydrology:** The rivers in Turkey transport about 43 km<sup>3</sup> fresh water and 24 million tons of sediment annually to the Black Sea. Filyos rank fifth among these rivers with a fresh water capacity of 7% (Demirci, 2008).

Considering that drinking water for the settlements in the region is provided from the Filyos River, the water quality of the river is of utmost importance. However, the river is polluted with domestic and industrial waste. Waste from the Karabük Iron-Steel Factory and Seka Çaycuma Paper Factory causes a significant amount of pollution in the Filyos River. What is even worse is that sewage and garbage from the settlement areas are deposited in the river, resulting in more contamination (Demirci, 2008).

The main tributaries of the Filyos River are Yenice, Soğanlı, Devrek, and Araç creeks. The flood flow rates of the Filyos River are as follows: Q<sub>10</sub>=1478 m<sup>3</sup> sec<sup>-1</sup>, Q<sub>25</sub>=1860 m<sup>3</sup> sec<sup>-1</sup>, Q<sub>50</sub>=2145 m<sup>3</sup> sec<sup>-1</sup>, Q<sub>100</sub>=2430 m<sup>3</sup> sec<sup>-1</sup> and Q<sub>500</sub>=3084 m<sup>3</sup> sec<sup>-1</sup> (Kaya *et al.*, 2007).

Data from the Derecikören flow monitoring station located close to the mouth of the Filyos River indicate that the annual flow amounts to around 102.0 m<sup>3</sup> sec<sup>-1</sup>. The lowest flow values were observed in September (23.3 m<sup>3</sup> sec<sup>-1</sup>), whereas the highest flow values were obtained in April (223.0 m<sup>3</sup> sec<sup>-1</sup>). The river is fed with snow even though the amount is low. The annual average water flow of the Filyos River equals 3237.8 million m<sup>3</sup> under normal circumstances (Avcı and Avcı, 2001). Even though the normal total flow rate of the Filyos River is 3213,910 hm<sup>3</sup> year<sup>-1</sup>, and its efficiency is 102,237 m<sup>3</sup> sec<sup>-1</sup> on average, the average flow rates are 135,470 m<sup>3</sup> sec<sup>-1</sup> in spring, 31,070 m<sup>3</sup> sec<sup>-1</sup> in summer, 67,140 m<sup>3</sup> sec<sup>-1</sup> in autumn, and 127,370 m<sup>3</sup> sec<sup>-1</sup> in winter (Demirci, 2008).

On the other hand, the Filyos Basin is one of the regions which is subjected to the highest number of flooding events in Turkey. The historical flood disaster of May 1998 had a grave impact on the cities and districts located along the Filyos River. It is noted that floods tremendously affect Karabük, Yenice, Devrek, and Çaycuma. The region is also prone to erosion because of flood effects. In particular, agricultural areas around the river beds are affected by pebbles and sand carried by erosion. Floods are known to damage vegetable and greenhouse products cultivated in these regions (Demirci, 2008).

**Filyos Valley Project :** The Filyos Valley Project is an integrated project that includes the Filyos free zone, Filyos industrial region, Filyos harbor project, and other industrial areas, storage areas, non-residential urban work areas and various flood protection structures in the Çaycuma district in Zonguldak. This regional



Fig. 3 : Natural and cultural values of the Filyos River Delta

A: Fishing activity; B: Animal breeding; C: Topography; D: Lagoons; E: Coastal dunes

**Location:** Zonguldak Province, Çaycuma District, Western Black Sea region of Turkey.

**Transportation:** Transportation is done by the local trains that serve between Zonguldak-Filyos and Çaycuma and the existing parkways. The town is located at the intersection of parkways, seaways and railroads. Its distance from Saltukova Airport is 15 km. (Cengiz *et al.*, 2012).

#### Natural Landscape Values

**Topography:** Filyos is located at the foothills of gently sloping hills. It has flat topographical features with a width ranging between 500 m and 1,500 m. (Cengiz *et al.*, 2012).

**Geomorphology:** Alluvial plain and valley floors, low plateaus and hills, high plateaus and mountainous areas.

**Hydrology:** The Filyos River Basin constitutes about 46% of the Western Black Sea basin.

**Climate:** Temperate climate of the Black Sea. The amount of rain exceeds 900 mm at coastal stations and decreases in inner sections.

**Soil:** Non-calcareous brown forest soils, brown forest soils and alluvial soil.

**Flora:** The research area is located in the sub-category Eux of Euro-Siberian Region according to the flora region of Turkey and in the A4 square according to the Davis grid system (Davis *et al.*, 1988).

#### Cultural Landscape Values

**Land uses:** Coastal dunes, swamp areas that are formed due to the transformation of the river mouth flowing into the sea, lagoons, the alluvial base of the Filyos valley and the hillsides, urban and rural settlement areas, railway.

**Population:** Currently, migration from rural to urban areas is slowing down.

**Livelihood sources:** Fishing, agriculture, animal breeding, forestry, tourism, reed cutting.

**Historical and archaeological values:** Filyos has a striking archaeological past and is home to ruins. Archaeological ruins in the ancient city of the town are regarded as cultural remnants that should be protected. To the west of the Filyos River Delta sits the Ancient City of Filyos (Tios). Some parts of the project area remain within the borders of priority-I and priority-II historic preservation sites established by Ankara Cultural and Natural Heritage Preservation Board (Cengiz *et al.*, 2012).

**Local cultural values:** Local foods, natural vegetation.

**Risks:** Landslide and flood.

project which includes public as well as private sector investments, aims to improve Karabük, Bartın and Zonguldak and offers a development plan. The Filyos Valley Project focuses on regional development in the TR81 Level 2 Region (Zonguldak, Karabük, and Bartın) and has a wide impact area; the project will contribute to the regional economy and transform the region into an important center of commerce and logistics (Çetinkaya, 2014).

The decisions made in order to put the Filyos Valley Project in action were published in the Official Gazette (decisions regarding the free zone and the industrial region). Thus, the first step was taken for the Filyos Project, which was set to take place in the district of Çaycuma in the city of Zonguldak since the reign of the Ottoman Sultan Abdülhamid II (1876-1909). The Filyos harbor, which will be one of the largest harbors of Turkey with a capacity of 25 million tons/year, is planned to be constructed as part of this long-term plan. The Filyos Valley is expected to be a center of attraction for investors with projects suggested by the government such as organized industrial regions, free zones, dams and power plants that will be built in addition to the harbor as well as projects developed by many entrepreneurs. These investments are expected to begin over the next few years at the Filyos Valley (Çetinkaya, 2014).

**Vegetation:** The area where the Filyos harbor will be built in the lower parts of the Filyos valley and the areas located behind the harbor stand out as distinct settlement areas that are especially rich in context of plant species. Partially transformed cultivation areas, coastal dunes, swamp areas formed due to the transformation of the river mouth which flows into the sea, lagoons, alluvial base of the Filyos valley, and hillsides that borders the valley from both sides is eye catching due to various plants (Table 1) (Avcı and Avcı, 2001).

**Social and economic status :** According to the census carried out in the year 2000, 1.1% of the population of Turkey lives in the Filyos Basin. The total population of the basin was determined to be 778,540 people, and about half of this population lives in nearby villages and district centers. The region includes the Karabük Iron Steel facilities, a number of sawmills of different sizes, the Bolu Cement factory and the brick, ceramic and paper factory. Other than these, the regional economy largely depends on agriculture and animal rearing (Kaya *et al.*, 2007).

**Current land uses:** Sand-pebble and crushed aggregates production used in the construction sector is carried out in the region between the valley formed by the Filyos River and the delta where it flows into the sea. Current geological formations in the valley affect the quality of sand-pebble and crushed aggregates. There are also sandy, milled and silted alluvia along the Filyos River which make up soils suited for agriculture with varying thickness (Büyüksalih *et al.*, 2005).

Proved sand-pebble reserve of about 33 million m<sup>3</sup> was calculated in the area between the Çaycuma district and the river delta along the Filyos valley with an average length of 15 km, width of 750 m and thickness of 3 m. In addition, a line of 15 km formed by the river up to this delta has been declared as a free zone, and the largest harbor of Turkey has been decided to be constructed on this delta. In addition, there is also a domestic airport, Zonguldak-Ankara railroad that runs parallel to the river coastline, and the Hisarönü-Çaycuma-Ankara highway in this region as well as the Filyos Fire Brick factory along with many crushed aggregate and pebble raw material factors in addition to many industrial raw material processing plants (Büyüksalih *et al.*, 2005).

The Filyos Ancient City-Hisarönü District is built on the rocky hillside that lies north between ancient Filyos located on the Zonguldak-Çaycuma railway, 21 km away from the Zonguldak center, northwest of the Çaycuma District near the seaside, the plain in the east of the Hisarönü Township and the Filyos (Villayos) River. The "1st Degree Archeological Protection Site", registered in 1996 by the Ankara Cultural and Natural Heritage Protection Regional Board, is located about 500 m west of the Filyos Delta. Excavation is underway in the Filyos Ancient City. Furthermore, a 3rd Degree Archeological Protection Site is also included within the rear service area of the Filyos Harbor that is planned to be built in the northeast region, outside the industrial area (Çetinkaya, 2014). The ancient harbor backwater stretching towards the Black Sea is under water. In addition, the remains of the "Castle" are in a location that overlooks the sea. The city contains the Fire Brick Factory and an open air theatre under soil. Also, remains of churches and aqueducts can be easily spotted. Back in the day, the Sümer bank fire brick factory was built upon the ancient city remains and ended up damaging them to a certain extent. Restoration and repair works for the Filyos Castle and ancient theater are carried out by the Ministry of Culture and Tourism and are still in progress (Environment Report, 2009).

## Results and Discussion

The interactions between human activities and the environment can fundamentally change coastal areas (Tixerant *et al.*, 2010). The development of ecologically based physical plans and active forms of coastal management that aim to accommodate environmental pressures and to manage and ameliorate their effects on coastal areas is vital for the sustainable development and management of these sensitive areas (Dale and Haeuber, 2001).

The Filyos River Delta has significant natural, cultural, and historical landscape features on a local, regional and even national scale. The delta is vital in that from home to river, wetland, forest, delta, coastal ecosystems and historical areas. Main environmental problems result from current land use, which creates increased flood risk, disorganized industrial growth, unwise

**Table 1** : Vegetation types of the Filyos River Delta (Avci and Avci, 2001).

<b>Coastal sand dunes</b>	<i>Pancratium maritimum</i> , <i>Juncus</i> sp., <i>Verbascum</i> sp., <i>Peucedanum obtusifolium</i> , <i>Xanthium</i> sp., <i>Trifolium</i> sp., <i>Equisetum arvense</i> , <i>Euphorbia</i> sp., <i>Ephedra major</i> , <i>Echium plantagineum</i> , <i>Polygonum maritimum</i> , <i>Aristolochia clematitidis</i> and <i>Glaucium flavum</i> .
<b>Old Flow Mouths</b>	<i>Schoenoplectus lacustris</i> and <i>Iris pseudocorus</i> .
<b>Alluvial base of the Filyos River Valley</b>	<i>Alnus glutinosa</i> subsp. <i>glutinosa</i> , <i>Tamarix</i> sp., <i>Euphorbia</i> sp., <i>Iris</i> sp. and <i>Alisma plantago-aquatica</i> .
<b>Hills that border the Filyos River Valley</b>	<p>The dominant elements within the moist forests that cover the hillside areas bordering the Filyos valley from two sides are deciduous broad leaved trees such as <i>Fagus orientalis</i>, <i>Carpinus betulus</i>, <i>Quercus petraea</i> sub sp. <i>iberica</i>, <i>Quercus frainetto</i>, <i>Tiliato mentosa</i>, <i>Castanea sativa</i>, <i>Fraxinus ornus</i>, <i>Acer campestre</i>, <i>Ulmus glabra</i>, <i>Ostrya carpinifolia</i>, <i>Buxus sempervirens</i>, <i>Rhododendron ponticum</i>, <i>Daphne pontica</i>, <i>Ilex aquifolium</i>, <i>Hedera helix</i>, <i>Sambucus nigra</i> and <i>Hypericum</i> sp.</p> <p>The scrub formation that covers the damage areas of moist forests is the pseudo-scrub formation. Some evergreen scrub elements and deciduous shrub species are included together in these formations. Species such as <i>Phillyrea latifolia</i>, <i>Juniperus oxycedrus</i>, <i>Cistus salviifolius</i>, <i>Cistus creticus</i>, <i>Laurus nobilis</i>, <i>Cornus mas</i>, <i>Cornus anguinea</i>, <i>Corylus avellana</i>, <i>Prunus spinosa</i>, <i>Prunus avium</i>, <i>Mespilus germanica</i>, <i>Paliurus aculeatus</i>, <i>Crataegus monogyna</i>, <i>Asparagus officinalis</i>, <i>Ruscus aculeatus</i>, <i>Viburnum lantana</i>, <i>Rosa canina</i>, <i>Staphylea pinnata</i>, <i>Frangula alnus</i>, <i>Pyrcantha coccinea</i>, <i>Ligustrum vulgare</i>, <i>Rhus cotinus</i>, <i>Jasminum fruticans</i> and <i>Helleborus orientalis</i>.</p> <p>The shrub formations that attract attention in forest damage areas are interrupted at certain regions. <i>Papaver rhoeas</i>, <i>Polypodium vulgare</i>, <i>Inulae pectoratum</i>, <i>Erygium</i> sp., <i>Anchusa</i> sp., <i>Cirsium</i> sp., <i>Psoralea bituminosa</i>, <i>Orchis</i> sp., <i>Ophrys</i> (<i>Ophrys apifera</i>, <i>O. oestriifera</i> and <i>O. umbilicata</i>), <i>Serapia</i> sp. and <i>Iris sintenisii</i>.</p>

and non-sustainable agricultural practices, road improvements and expansion at the expense of ecology, flora and fauna, uncontrolled sand and gravel extraction operations, and so on. More significantly, constant increasing environmental impacts are likely to be permanent and to damage the health, safety, and welfare of the public before the completion of the project which was originally envisioned to improve the infrastructure of the Filyos Valley and enhance the quality of the life for its residents. Therefore, it is crucial that the landscape features of the Filyos River Delta be assessed with regard to protection of its valuable natural and cultural resources for a balanced land use and development.

This paper aims to develop up-to-date and viable strategies drawing on successful examples regarding river landscape planning, design, and management in order to meet the needs of the people living in the area. The paper presents land use and development alternatives that could protect the natural and cultural resources and provide sustainable growth and development as well.

Following is the summary of the strategies developed for the Filyos River Delta: Determining the natural and cultural features of the Filyos River Delta using GIS and RS and creation of a database; Preparation of Environmental Impact Assessment report in order to contribute to the solution of the problems induced by current land use patterns; Determination of the criteria regarding evaluation of landscape features of the Filyos River Delta based on protection-usage balance; An alternative usage plan considering the flooding capacity of the area;

Planning process and the strategies concerning planning, design and management of the river landscapes.

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