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# Plant cover and land degradation relationship on Aegean coastal zone

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**Abstract:** Karaburun Peninsula is one of the least disturbed areas on the Aegean coastal zone. Two different areas were selected on the basis of variability of natural characteristics, demographic developments, settlements and land use on the peninsula. The aim was to determine plant cover and land degradation relationships on eastern and western sides. Supervised and unsupervised classifications were used to obtain land cover data. LANDSAT 7 image recorded in September 2000, together with ancillary data were used to create land cover maps for the study area. ERDAS Imagine 8.4 and Arc View 8 were used to interpret the image and to integrate it into geographical information system.

The methodology consists of computer-assisted photo interpretation of satellite data by using ancillary data and field observations. The land cover classes on the created maps were obtained according to the CORINE standards (CORINE Land Cover Nomenclature). Distribution of land cover in western and eastern study areas were obtained on the basis of artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, water bodies and other uses. Plant communities, showing dominant distribution characteristics and other accompanying taxa were identified in areas where GPS points were taken.

More than 50% of the area is covered with forests and semi-natural areas. 30.9% of the natural protection sites lie in the western part and 7.9% in the east. The main factor for land degradation appear to be the second house constructions. There is an urgent need for enlargement of natural protection sites using the obtained land/plant cover data.

**Keywords**: Land Cover, LANDSAT TM, CORINE Standards, Karaburun Peninsula

**Resumé:** La péninsule de Karaburun est une région paisible de la côte égéenne. Deux différentes sections de terrain ont été choisies à cause de la diversité des caractéristiques naturelles, de la structure démographique, des constructions et de l'utilisation du terrain. L'étude a eu pour but de déterminer les relations entre la végétation et la dégradation du sol sur les régions d'Est et d'Ouest. Des classifications supervisées et non supervisées ont été utilisées afin de décrire la couche végétale de la région. Les images LANDSAT 7 enregistrées en septembre 2000 ont été utilisées avec des données auxiliaires pour créer des cartes de la faune pour la région étudiée. ERDAS Imagine 8.4 et Arc View 8 ont également été employés afin d'interpréter les images et de les intégrer dans un système d'information géographique.

La méthodologie consiste en l'interprétation photographique assistée par ordinateur des données satellite en utilisant les données auxiliaires et les observations de terrain. Les classes de végétation sur les cartes créees ont été obtenues selon les standards CORINE (nomenclature d'occupation du territorie CORINE). Tandis que la distribution de cette occupation du territoire a éte établie selon plusieurs catégories, à savoir territoires artificialisés, territoires agricoles, forêts et zones semi-naturels, milieux humides, surfaces en eau et autres. Les communautés de plantes montrant des caractéristiques de distribution dominante et autres taxas accompagnants ont été identifiés dans les régions où des coordonnées GPS ont été prises.

Plus de 50% des régions étudiées sont couvertes de forêts et de régions semi naturelles. Avec 30.9% en Ouest et 7.9% en Est de sites naturels protégés, toute la région nous montre que le principal facteur de dégradation s'avère être le problème de résidence secondaire. Les sites naturels protégés devraient être élargis en utilisant les données concernant la land cover data obtenu lors de cette étude.

**Mots-clés** : Land Cover, LANDSAT TM, Standards CORINE, Péninsule de Karaburun

## Introduction

Ecological imbalances created by anthropogenic factors such as; rapid population growth, urbanisation, and wrong land use on the coastal landscape of the Aegean Sea are leading towards severe land degradation as well as destruction of natural plant cover (Oztürk, 1995; 1999; Türkmen et al., 1996; Oztürk *et al.*, 2002; Feoli *et al.*, 2003). The favorable climatic conditions and coastline facilities along the 2805 km long coast act as additive forces in this direction. The halophytes and psammophytes are getting the maximum share from such environmental pressures (Güvensen, 1994). In the Aegean Region 83 percent of arable land is under a threat of medium and severe erosion (Ozturk et al., 1996). As a result, some parts along the coastline have been announced as protection sites (Nurlu *et al.*, 1998). For vulnerable sites Environmental Land Use plans have been prepared aiming to protect the environment.

In this study, one of the least disturbed coastal sites along the Aegean Sea namely Karaburun Peninsula has been selected to analyse the land cover. The necessity for creation of the land cover map for this semi-virgin Peninsula emerges not only from the need to generate information that would be useful for policy purposes but also to control development at local and regional levels in tourism and conservation of natural resources.

## Study Area

Karaburun Peninsula (Fig. 1) is one of the major undisturbed sites in the Aegean Region, covering an area of 426 $km^2$ and embodying a population of 10. 332 heads (Anonymous, 1999). There are two municipalities and 13 villages in the area. The coastline of the Peninsula has high cliffs penetrating into the sea with shores of various dimensions. It enjoys typical Mediterranean climate.

Variability of natural characteristics; such as topographic features, vegetation, demographic distribution, settlements and land use on the peninsula lead us to choose two different areas for this study; one in the east (Gerence Bay) and the other in the west (Gulbahce Bay). Former covers 11532.13 ha and later 7724.62 ha (Fig. 1).

The area shows a rich Mediterranean plant cover (Bekat, 1980). It is also a breeding area for internationally protected sea mammals including the Eurasian Otter, *Lutra lutra*, and the Mediterranean Monk Seal, *Monachus monachus* (Veryeri *et al.*, 2002)

## Materials and Methods

Mainly data of the satellite Landsat 7 image (remotely sensed data), together with ancillary data (topographic maps, environmental land use plans, etc.) were used to create the 1:25 000 scaled land cover map of the study area. Landsat 7 satellite image, that was utilised in this study for image processing and interpretation, was taken in September 2000. It includes six reflective channels (TM bands 1,2,3,4,5,7 and panchromatic) and was georeferenced (UTM).

To improve and verify the accuracy of the image; environmental land use plan of 1:25000 scale covering the study area, showing the main landscape features such as natural and archaeological protection areas, forests, macchia, shrubs, wetlands, agriculturally protected areas, camping areas etc., and topographic map of 1:25 000 scale showing contours, road networks and settlements were used. In addition, together with field observations and

interviews with concerned institutions and individuals, plant cover data, photographs, slides and other documents related to the areas were used as study materials.

During the interpretations of the satellite image, the image analyst software ERDAS Imagine 8.4 was used. The interpretation of the satellite image Landsat 7 was carried out at the Trieste University in Department of Biology. These interpretations were superposed with the sample points determined by Global Position System (GPS)in Centre for Environmental Studies labs at Ege University . In comparing the ancillary data of the area and the image, the GIS software Arc View 8 was used.

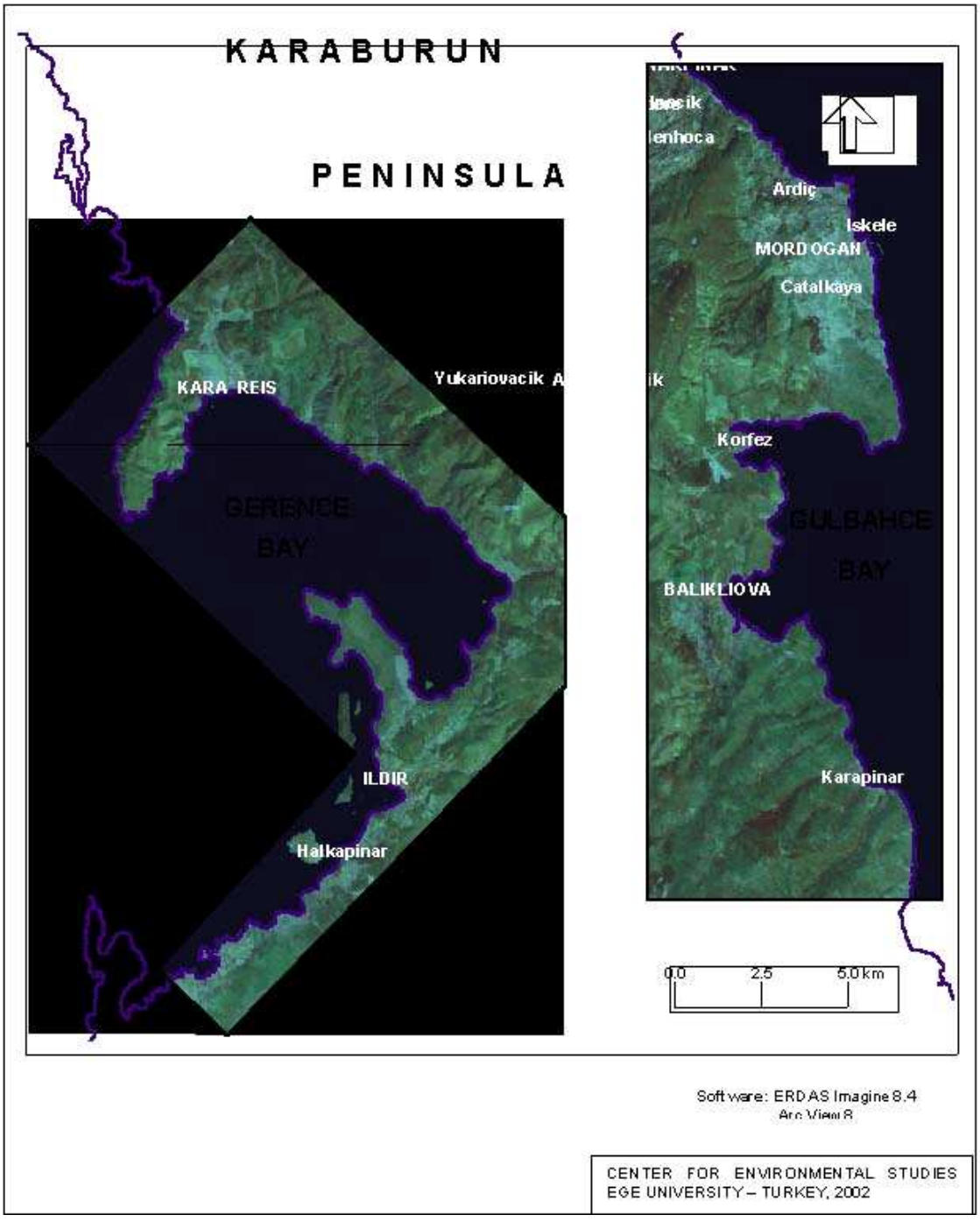


**Fig.ure 1.** Landsat TM scene from study areas in Karaburun Peninsula.

The method of this study is based on the sequence of steps required for rural planning as developed by Golley and Bellot (1999). To organize and evaluate ground surface data remotely sensed information and GIS were used. Inventory of relevant information and diagnosis of the problem, involved computer-assisted photo interpretation of satellite data by using ancillary data (topographical and environmental land use maps, statistics, local knowledge, etc.) and field observations mainly based on field surveys and computer aided lab works. The unsupervised and supervised classifications were used to derive land cover of the study area. Prior to the whole process land covers of both areas were defined using triple combinations of TM bands 1,2,3,4,5 and 7 of LANDSAT 2000.

While classifying the image; further knowledge of the study area was obtained both through the use of field surveys and ancillary data. More than 100 ground control points using Global Position System (GPS) were determined during field observations. The dominant plant communities their distribution characteristics and accompanying taxa were identified in areas where GPS points were taken. The land cover classes on the created maps were obtained according to the CORINE standards, which are the European standards used in land cover mapping. Ancillary data were used to refine interpretation and the assignment of the territory into the categories of the CORINE Land Cover Nomenclature, which consists of 44 different land cover types organised hierarchically in three levels. Other supplementary data were incorporated to improve the accuracy and the quality of the derived land cover classification information.

The accuracy of the final map was checked after conduction of a field survey. Finally the interpretation of the results was scanned and integrated into a geographical information system. For this purposes 1: 25 000 scale topographic maps were digitalized using Arc View 8 GIS software.

## Results and Discussion

Settlements within the study area are on the coast line. An urban fabric of 948.96 ha in the east and 731.43 ha in the west cover the peninsula. According to CORINE Land Cover Nomenclature, an important part of urban fabric are summer houses classified as discontinuous urban fabric. In the west these lie around Ildiri and Karareis villages, in the east around Balikliova, Mordogan and Kaynarpinar (Fig. 1).

Land covers of both selected areas were obtained by supervised classification of LANDSAT 7 image and field surveys. Supervised classification was completed according to CORINE Land Cover Nomenclature. The results obtained by using supervised classification showed that in the western study area; 9.46% of the total area are artificial surfaces, 21.66% agricultural areas, 61.93% forests and semi-natural areas, 6.9% wetlands and 0.05% water bodies and others (Fig. 2). In the eastern study area; 8.22% of the total area are artificial surfaces, 32.27% agricultural areas, 54.17% forests and semi-natural areas, 4.77% wetlands and 0.57% water bodies etc. (Fig. 3).

In addition, during the field surveys vegetation inventories of study areas were prepared and incorporated according to CORINE Nomenclature (agricultural areas, forests and semi-natural areas, wetlands) (Table 1; 2; 3). Field surveys in the western section have shown that 61.93% of the area is covered with forests and semi-natural areas including coniferous forests (*Pinus brutia*) and secondarily shrub and/or herbaceous vegetation associations as sclerophyllous vegetation (*Juniperus oxycedrus subsp. macrocarpa*, *J. phoenicia*, *Quercus coccifera*, *Cistus creticus*, *Pistacia lentiscus*, P. *terebinthus* ssp. *palaestina* etc.) (Table 2) (Fig. 4). In the eastern section 54.17%

is covered by forests of Pinus brutia and semi-natural areas mostly sclerrophyllous vegetation (*Juniperus oxycedrus subsp. macrocarpa, J. phoenicia, Quercus coccifera, Cistus creticus, Pistacia lentiscus, P. terebinthus ssp. palaestina* etc.) and such species as *Sarcopoterium spinosum, Bellis perennis, Helichrysum stoechas* ssp. *barrelieri, Cirsium vulgare* etc. (Table 2 ) (Fig. 5).

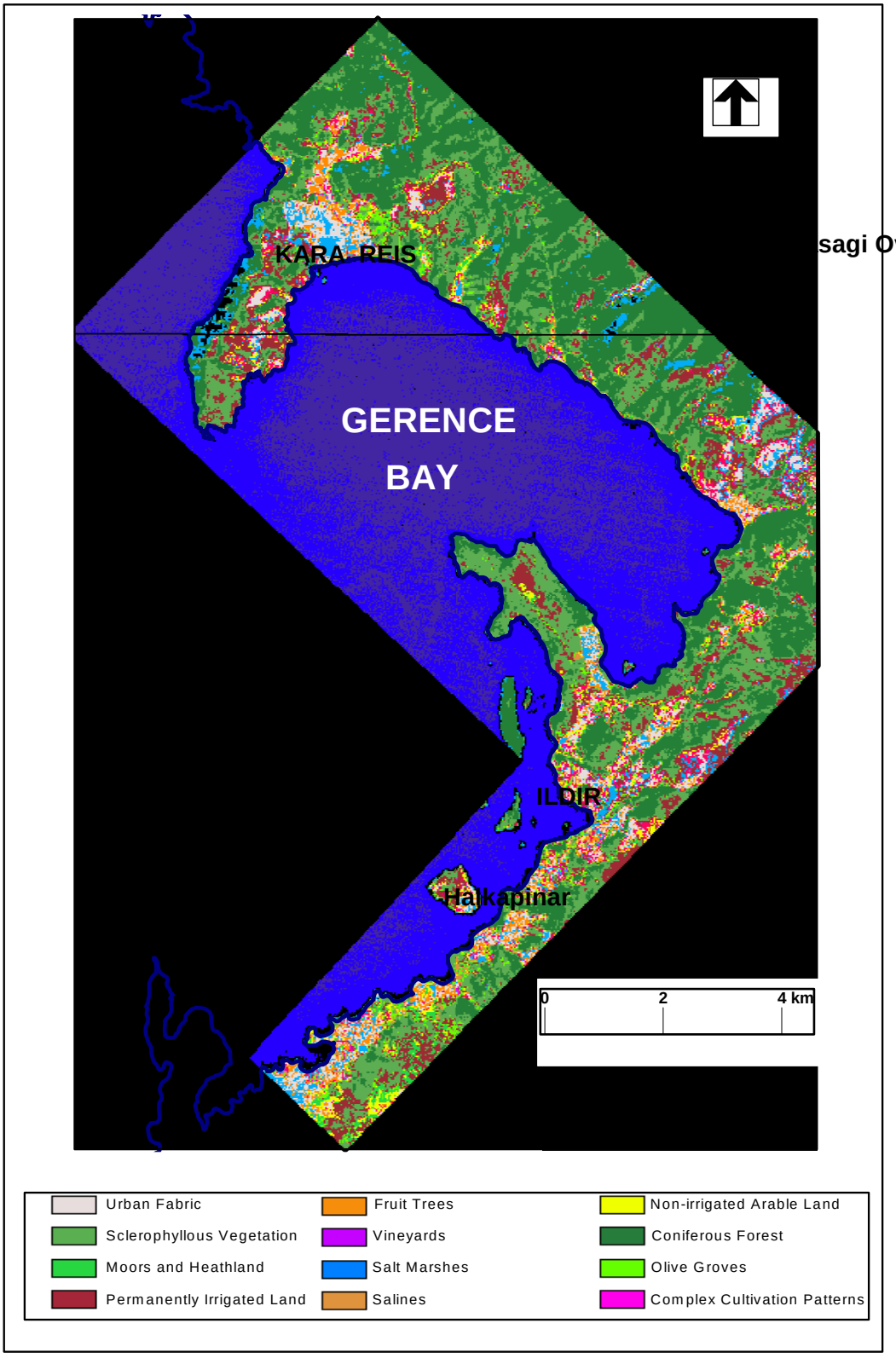


**Figure 2.** Land cover map of western study area.

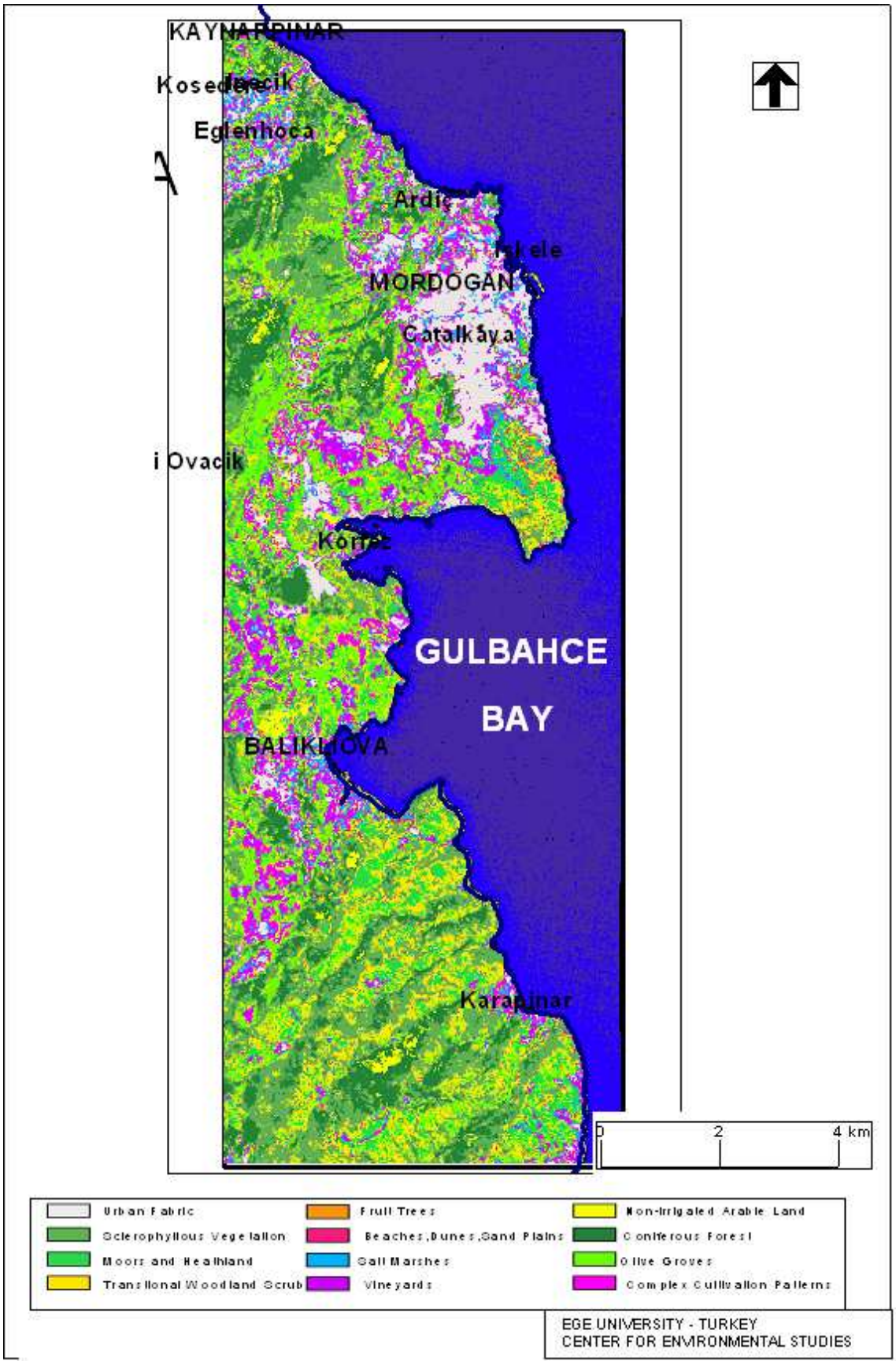


**Figure 3.** Land cover map of eastern study area.

**Table 1.** Plant species according to the CORINE nomenclature in agricultural areas in both study areas.

| Level 1 | Level 2 | Level 3 |
|---|---|---|
| AGRICULTURAL AREAS | Arable Land | **Non-irrigated Arable Land** Olive, Wheat, Fig, Walnut, Pine nut, Barley, Oat, Melon, Watermelon |
| | | **Permanently Irrigated Land** Mandarin, Tomato, Melon, Watermelon, Black eye pea, Pepper, Corn, Onion, Artichoke, Citrus trees, Cherry, Plum, Oleaster, Lemon trees, Pomegranate tree |
| | Permanent Crops | **Vineyards** Grape |
| | | **Fruit Trees** Almond, Plum, Cherry, Lemon trees, Mandarin, Orange, Fig |
| | | **Olive Groves** Olive |
| | Heterogeneous Agricultural Areas | **Complex Cultivation Patterns** Tomato, Mandarin, Wheat, Watermelon, Onion, Pepper, Artichoke |

**Table 2.** Plant species according to the CORINE nomenclature in forests and semi-natural areas in both study areas.

| Level 1 | Level 2 | Level 3 |
|---|---|---|
| FORESTS AND SEMI-NATURAL AREAS | Forests | **Coniferous Forest** *Pinus brutia* (Pinaceae) |
| | Shrub and/or Herbaceous Vegetation Associations | **Moors and Heathland** *Sarcopoterium spinosum** (Rosaceae); *Bellis perennis, Calendula arvensis, Cardopatium corymbosum, Chondrilla juncea, Cirsium vulgare, Helichrysum stoechas ssp. barrelieri, Inula viscosa, Senecio vulgaris, Xanthium strumarium ssp. strumarium, Xeranthemum annuum* (Compositae); *Fumaria officinalis* (Papaveraceae); *Capsella bursa-pastoris, Cardaria draba ssp. draba, Hirschfeldia incana* (Cruciferae); *Medicago polymorpha var. vulgaris, Ononis viscosa, Trifolium angustifolium var. angustifolium, T. stellatum var. adpressum, Vicia hybrida* (Leguminosae); *Lamium amplexicaule* (Labiatae); *Echium angustifolium, E. italicum, Heliotropium hirsutissimum* (Boraginaceae); *Galium murale* (Rubiaceae); *Bellardia trixago* (Scrophulariaceae); *Anagallis arvensis var arvensis* (Primulaceae); *Anemone coronaria* (Ranunculaceae); *Plantago lagopus* (Plantaginaceae); *Leontice leontopetalum* (Berberidaceae); *Hypericum perforatum, H. triquetrifolium* (Guttiferae); *Capparis ovata var. canescens* (Capparaceae); *Papaver rhoeas* (Papaveraceae); *Pistacia lentiscus** (Anacardiaceae); *Centaurium erythrae* (Gentianaceae); *Malva sylvestris* (Malvaceae); *Rumex bucephalophorus* (Polygonaceae); *Ecbalium elaterium* (Cucurbitaceae); *Amaranthus albus* (Amaranthaceae); *Erodium cicutarium ssp. cicutarium, Geranium tuberosum* (Geraniaceae); *Eryngium campestre, Daucus carota* (Umbelliferae); *Aegilops biuncialis, Avena barbata, Bromus diandrus, B. hordeaceus ssp. hordeaceus, Cynodon dactylon var. dactylon, Dactylis glomerata ssp. hispanica, Elymus farctus, Hordeum bulbosum, Lagurus ovatus, Lolium temulentum var. temulentum, Poa bulbosa* (Gramineae);<br><br>**Sclerophyllous Vegetation** *Juniperus oxycedrus subsp. macrocarpa**, *Juniperus phoenicia* (Cupressaceae); *Quercus coccifera** *(Fagaceae); Cistus creticus**, *C. salviifolius, Helianthemum aegyptiacum* (Cistaceae); *Pistacia lentiscus**, *P. terebinthus ssp. palaestina* (Anacardiaceae) *Olea europaea var. sylvestris**, *Phillyrea latifolia (Oleaceae); Anagyris foetida, Anthyllis hermanniae, Calicotome villosa, Ceratonia siliqua, Genista anatolica, Spartium junceum* (Leguminosae); *Arbutus unedo**, *Erica arborea* (Ericaceae); *Ruscus aculeatus, Urginea maritima* (Liliaceae); *Crateagus monogyna, Pyrus amygdaliformis , Rosa canina, Rubus canescens var. canescens* (Rosaceae); *Thymelaea hirsuta* (Thymelaeaceae); *Coridothymus capitatus, Lavandula stoechas ssp. stoechas, Origanum onites, Salvia verbenaca, Thymus zygioides* (Labiatae); *Myrtus communis** (Myrtaceae); |

| Level 1 | Level 2 | Level 3 |
|---|---|---|
| | | **Transitional Woodland Scrub** *Juniperus phoenicia, Juniperus oxycedrus subsp. macrocarpa* (Cupressaceae); *Pinus brutia** (Pinaceae); *Olea europaea var. sylvestris** (Oleaceae); |
| | **Open Spaces with little or no Vegetation** | **Beaches, Dunes, Sand Plains** *Centaurea spinosa var. spinosa, Inula viscosa* (Compositae); *Teucrium polium* (Labiatae); *Juncus maritimus** (Juncaceae); *Amaranthus albus* (Amaranthaceae); *Calystegia soldanella* (Convolvulaceae); *Polygonum arenastrum* (Polygonaceae); *Euphorbia peplis* (Euphorbiaceae); *Frankenia hirsuta* (Frankeniaceae); *Tribulus terrestris* (Zygophyllaceae); *Heliotropium hirsutissimum* (Boraginaceae); *Petrosimonia brachiata, Salsola ruthenica, S. kali* (Chenopodiaceae); *Imparata cylindrica var. cylindrica* (Gramineaea); |
| | | **Burnt Areas** *Quercus coccifera** (Fagaceae); *Genista anatolica* (Leguminosae); *Cistus creticus**, *C. salviifolius** (Cistaceae); *Sarcopoterium spinosum** (Rosaceae); *Phillyrea latifolia* (Oleaceae); *Pistacia lentiscus**, *P. terebinthus ssp. palaestina** (Anacardiaceae); *Arbutus andrachne** (Ericaceae); *Avena barbata, Bromus hordeaceus ssp. Hordeaceus, Cynodon dactylon var. dactylon, Dactylis glomerata ssp. Hispanica, Hordeum bulbosum, Lolium temulentum var. temulentum, Poa bulbosa* (Gramineae); |

* Dominant plant taxa

**Table 3.** Plant species according to the CORINE nomenclature in wetlands in both study areas.

| Level 1 | Level 2 | Level 3 |
|---|---|---|
| **WETLANDS** | **Coastal Wetlands** | **Salt Marshes** *Carex divisa* (Cyperaceae); *Juncus acutus**, *J. maritimus* (Juncaceae); *Phragmites australis** (Gramineae); *Tamarix smyrnensis* (Tamaricaceae); |
| | | **Salines** *Artrochnemum fruticosum**, *Halimione portulacoides, Halocnemum strobilaceum**, *Salicornia europaea* (Chenopodiaceae); *Limonium bellidifolium**, *L. sinuatum* (Plumbaginaceae); *Hordeum marinum, Phragmites australis* (Gramineae); *Juncus acutus**, *J. maritimus* (Juncaceae); *Tamarix parviflora* (Tamaricaceae); |

* Dominant plant taxa

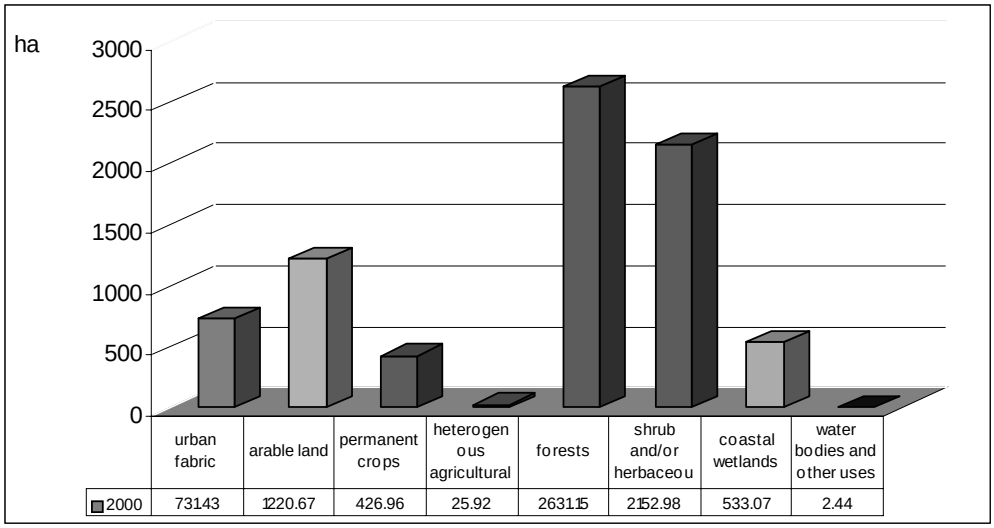


**Figure 4.** Areas obtained through supervised classification of western study area.

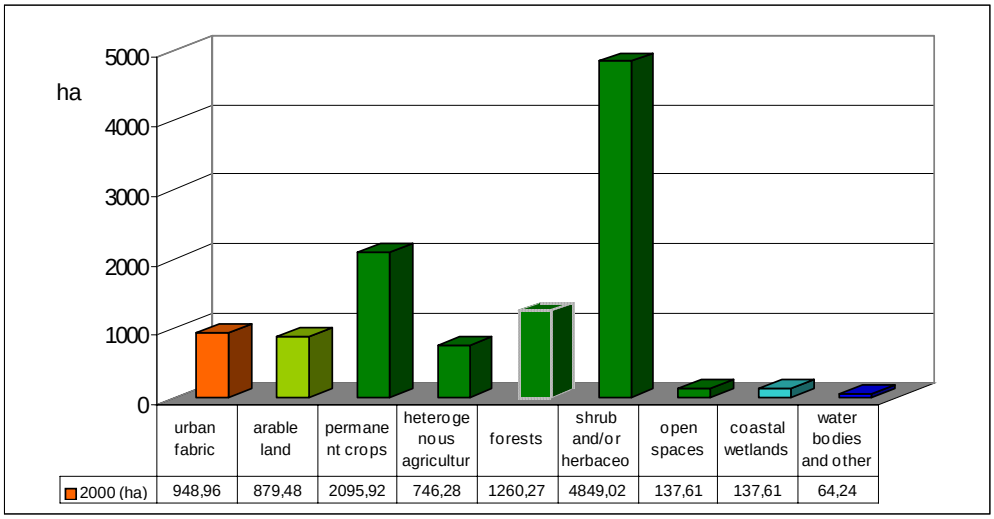


**Figure 5.** Areas obtained through supervised classification of eastern study area.

Results of supervised classifications were compared with ancillary data (1: 25 000 scale topographic maps, environmental land use maps, results of field surveys) and confirmed. According to environmental land use plans 30.9% of the western section has been announced as natural protection site (2391.38 ha).Out of this 1453.44 ha of the total belong to class-I, 670. 29 ha class-II and the rest (267.65 ha) as class-III . In the eastern section 7.9% has been announced as natural protection site (906.84 ha), out of which 513.83 ha are of class-I value, 301.67 ha class-II and 91.34 ha class-III (Fig. 6).

Digital land use maps show that western section possesses larger area of protection sites than eastern. Class-I protection sites too are more. Results obtained by supervised classification showed that first class natural protection sites on the coast line are protected well enough. In these areas sclerophyllous vegetation as well as herbaceous associations are dominant. The coniferous forests, permanent olive groves, irrigated and non-irrigated lands, moors and heathlands are partly observed (Fig. 6). Class-II natural protection sites lying on the coast line are however facing a pressure from summer homes especially around Gerence Bay. In these sites sclerophyllous vegetation is dominant with a sparse cover of moors and heathlands and coniferous forests.Although Class-III natural protection sites are surrounded by first class natural protection sites they are fully open to housing (Fig. 6). The western site faces pressures from intentional fires like whole of West Anatolia (Ozturk et al., 1991, 1995; Ozturk, 1995). In this area some patches destroyed by fires were observed damaging a rich macchia plant cover composed of *Quercus coccifera*, *Cistus creticus*, *Pistacia lentiscus*, *P. terebinthus* ssp. *palaestina*, and *Arbutus andrachne*.

In the study areas average ratio of forests and natural areas was measured as 55-60% and agricultural areas as 20-30%. Especially in the section classified as area with artificial uses(9%)second houses are abundant. Results of both interpretations and field surveys proved that main reason for land degradation in the peninsula are human settlements (urbanisation). According to Nurlu et al., (2002) number of houses in 2020 in the Peninsula will lie around 50.000, while current number of houses is around 10.000. In the coastal areas of western study site, especially sclerrophyllous vegetation area need be protected as a natural site. Only possibility to protect this semivirgin area is to allow future constructions not exceeding over 10% for settlements as proposed by Erdem *et al.*, (1995) for some other areas.

Land degradation does not only disturb the coastal terrestrial ecosystem but also marine ecosystem because this area embodies an endangered species Mediterranean Monk Seal (*Monachus monachus*), which is trying to survive here.

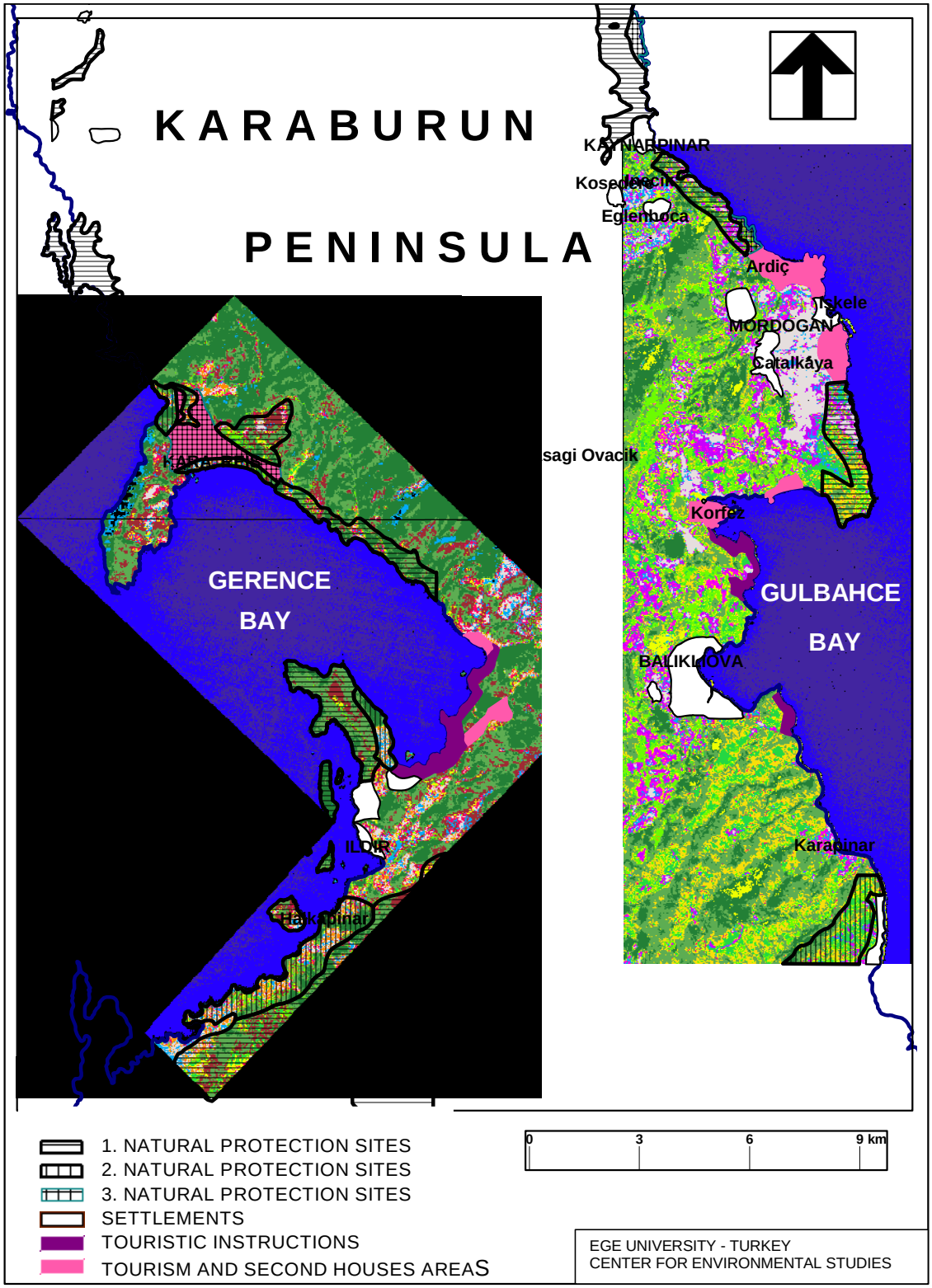


**Figure 6.** Tourism areas of study area on the land cover map.

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