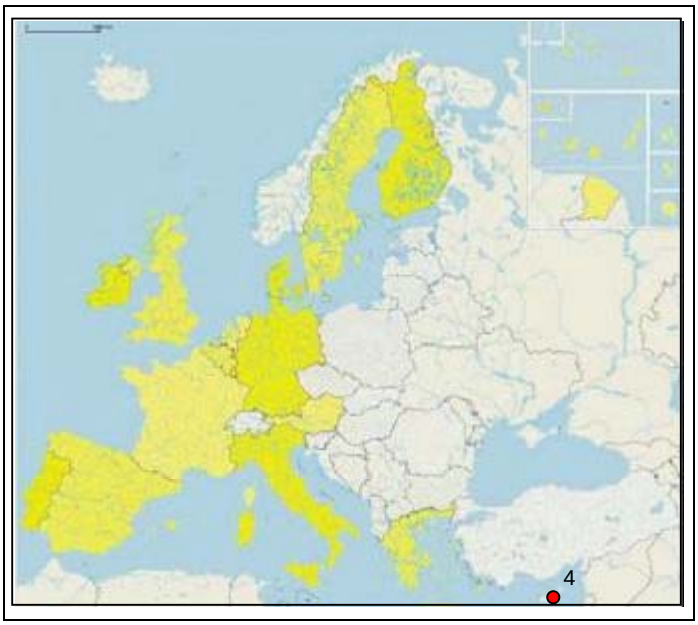
DOLOS-KITI
(CYPRUS)



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1. GENERAL DESCRIPTION OF THE AREA

The Dolos-Kiti coastal area is located in Larnaka District, at the south coast of Cyprus. The studied area stretches some 36km between Cape Dolos in the west and Cape Kiti in the east.

Fig. 1: Location map of the of the Dolos-Kiti area (Magellan Geographix, 1992).

1.1 Physical process level

1.1.1 Classification

- General: gravel beaches
- CORINE: beaches
- Coastal guide: coastal plain (recent sedimentary)

1.1.2 Geology

The south-east coast of Cyprus is characterised a Mesozoic to Tertiary basement of calcareous and igneous materials. The coastal area, which is often rocky, is characterised by accumulations of pebble and gravels with few tiny and poor sandy beaches. The material that has accumulated at these beaches originates either from nearby rocks or from the inland bedrock. The elevated marine terraces are composed of conglomerate with well-rounded pebbles, mostly of igneous origin.

The coastal sediments have a characteristic grey colour (see Figure 2) while the shape of the pebbles and grains range from well rounded to subangular. About 50 % of the grains studied were identified as igneous rocks and 10 % as sedimentary rocks. Bioclastics were also observed (less than 5 %).

Fig. 2: Sediment characteristics of the coastal area of Dolos-Kiti, Cyprus.

1.1.3 Morphology

The studied area is generally relatively low and flat, largely consisting of elevated marine sedimentary terraces or “raised beaches” containing sand and gravel deposits. The coastline forms a chain of four shallow bights separate by slightly protruding rocky headlands or gravel deltas, with an ENE to WSW orientation.

The bathymetry shows a gentle slope from the coastline to approximately the 20m depth contour. The distance between the coastline and the 20m depth contour is about 1,600m indicating a fairly gentle overall slope of approximately 1:80. Slightly over -20m a steeper drop occurs to a depth over 500m. No bathymetry maps are available.

1.1.4 Physical processes

The coastal area of Dolos-Kiti is exposed to waves from east and southwest, and these are the major transport agent of the coastal sediment. The most frequent waves have southwesterly directions. The highest waves come from the southsouthwest. The total wave impact for the area of Zygi is slightly larger than for the area of Pervolia. This is caused by the more sheltered location of Pervolia for waves from the west.

Nearshore currents are wave induced. At many locations there were clear signs of an eastward littoral drift during inspection in the summer.

It is expected that tidal influences around Cyprus are rather small. According to the British Admiralty tide tables, tidal fluctuations are not over 0.5m (microtidal regime).

1.1.5 Erosion

Erosion type

The net potential longshore transport along the coast at Zygi is eastward directed with a rate of 22,000m^3/yr. The gross transport rate to the east is considerably higher, indicating the significant importance of waves from east to southeastern directions for the longshore transport process. During winter eastern waves occur more frequently and the transport direction is expected to be temporarily reversed.

In this area the most sever coastline recession of Cyprus occurs: a total coast length of 6.25km has receded with a mean rate of more than 0.5m per year. In some areas the erosion rate exceeds 1m/yr. The Coastal Unit made a comparison between the coastline position of 1977 and the coastline profiles of 1993. This comparison involved the coastline position in 54 coastal profiles. Of these profiles 13 showed accretion, 23 showed erosion and 18 showed no difference at all. The largest accretion (17m) occurred updrift of an (illegally constructed) groyne just east of Pendashkinos river outlet. The largest erosion (23m) occurred on a gravel beach near Perivolia, just west of Cape Kiti.

Erosion cause

The major causes for the erosion are: river damming and sand mining. The two major rivers, Pentashinos and Tremithos, have been dammed. It is estimated that the two dams cut off approximately 87,000 m^3/yr of river sediments, which, otherwise, would have contributed to the coastal system.

Sand and gravel mining was permitted in coastal areas until the early 1970s, when it was prohibited by law. Estimations based on the data from the Mines Service of Cyprus give the figure of 300,000 m^3 within the period from 1955 to 1970. Illegal mining in continued long after the prohibition of 1970. It maybe the most important reason for beach erosion.

1.2 Socio-economic aspects

1.2.1 Population rate

There are 10 villages in the coastal area with a total population of 9137.

1.2.2 Major functions of the coastal zone

- **Tourism and recreation**: 57% of the population is employed in this sector. Rapid tourist development took place in the area during the last 10 years. Recently, the use of the coastal areas shifted from agricultural to tourist.
- **Industry, transport and energy**: the area of Vassilikon is an industrial area with a cement factory, agricultural pesticides factory, and a power plant. The percentage of employment in this sector is about 39.5%.
- **Fisheries and aquaculture**: according to the official data 1% of the active population is employed in the fishing industry. We have also to consider the “amateur” fishermen, who have another source of income. These people fish regularly and most of them have fishing as their main source of income.

1.2.3 Land use

The 36km of the coast are covered by 11 Zoning Maps. The last change of the zones in the area took place in 1999, where a large part of agricultural land was characterised as tourist. Land uses, construction coefficients and height of construction are defined in the Zoning Maps. Touristic Zones cover the 75% (in length) of the 36km coastal pilot site of Dolos-Kiti. The coastal tourist zone is interrupted by areas where the zone is industrial (Vasilikon), agricultural (west of Zygi village, Agios Teodoros and Petounda Point), and protected (Maroni, Pervolia Bay and Cape Kiti).

1.2.4 Assessment of capital risk

No estimations on the value of endangered properties are available. However, some private properties, like houses, are seriously under threat of erosion (see Figures 3 & 4).

Fig. 3 & 4: Private properties under risk of destruction due to severe erosion. The owners constructed the sea defences illegally (rocky revetments and wooden pile revetments).

2. PROBLEM DESCRIPTION

2.1 Eroding sites

- **Governors Bay***:* is characterised by high rocky cliffs and narrow sandy beaches at the base of the cliffs. It is stable with no indications of recent coastal erosion.
- **Cape Vassilikon to Point Pentashinos:** in the west part, the coast is mainly low and flat, largely consisting of elevated marine sedimentary terraces, which are under severe and active erosion. In the last 20 years the beach has receded about 20m. In the east part, the coast is partly rocky and partly consists of eroding sedimentary cliffs that suffer from erosion; The coastal deposits of the delta of Pentashinos are receding. The recession rate was estimated to be 10m from 1993 to 2000.
- **Point Pentashinos to Point Pedounda***:* along the first 2km, the coastal area is has sedimentary eroding cliffs with similar characteristics as the east part of the previous coastal area. Eastwards of the 2km, the coast is dominated by high rocky cliffs for 1.5km. For the nest 3 km the coast becomes low and flat again and then, for the last 2km eastward, it is rocky.
- **Agios Theodoros beach***:* the area suffered from severe cliff erosion. In order to protect their constructions, the owners illegally constructed two groins, creating a highly protected pocket beach.
- **Pervolia Bay***:* the main characteristics of this area are the low, eroding sedimentary cliffs and the gravel beaches. A particular characteristic of this area is a submerged sandy berm of about 0.3m height, located 10m from the coastline. The berm runs all along the entire bay and is quite stable. A lot of different defence structures have been constructed in the area by private initiative, mainly wooden or rock revetments but also groins.

2.2 Impacts

The land use of this coastal area has been traditionally agriculture. Since 1996 most of the agricultural areas has been transformed into tourist zones. Because the value of the coastal land has risen significantly due to the land uses change, coastal defence actions have become a necessity: erosion is causing a significant loss to the owners of coastal land and has negative impacts on beach quality.

3. SOLUTIONS / MEASURES

3.1 Policy options

The policy adopted is “do nothing”.

For thee coastal areas with a largely natural character, the policy is to “preserve and improve the conditions for the natural coastline”. The guidelines for the coastal areas of major tourist concentration are to “protect the coastline and improve the beach and shoreline quality by applying environmentally sound principles of coastal engineering”. In those areas, where ports, harbours, industry facilities, etc., are present, the guidelines are to “minimize or eliminate the negative impacts of these structures on the coastline”.

3.2 Strategy

3.2.1 Approach related to the problem

The strategy has an environmental friendly character. Special priority was given to “soft” techniques, such as beach nourishment using sand and gravel, and non-engineering measures, such as retreat management and the “do nothing” option. An ad-hock committee, with representatives of all the stakeholders, was organized. The Committee would actively participate in all the steps of the shoreline management study, carried out by Delft Hydraulics, supported and working together with the staff of the Coastal Unit of the Public Works Department of the government of Cyprus.

A monitoring system of the coast was established, based on a network of semi-permanent benchmarks. The benchmarks were installed around the island: one bench-mark was installed every 500 meters of soft coastline. The benchmarks were connected to the National Coordinates System of Cyprus (ie coordinates-position and height from Mean Sea Level). Each benchmark defines a cross section, a coastal profile, which is used as reference for a series of field measurements.

Annual field work

- **Bathymetric survey of coastal profiles**: once a year at the same period (every summer) there is a bathymetric survey covering all the coastal profiles. The measurements cover the whole length of each coastal profile: from approximately +0.5m (height above MSL) down to a water depth of –20.0 m (below MSL).
- **Sediment sampling**: at the same time with the bathymetric survey, sediment samples are taken (with Van Veen grabs) from specified points on specified coastal profiles, covering the entire length of the profile. The samples are treated (granulometric analysis) at the Laboratories of the Geological Survey Department and the Public Works Department.
- **Photographic survey**: once a year, four photographs are taken at each benchmark, which show the condition of the coast. This is an extremely valuable source of information, since the evolution of the coastline can be documented visually.
- **Vegetation inventory**: every a couple of years, there is a sampling of the sea bed vegetation, at the same time with sediment sampling.

Field work in areas of morphological interest

In addition to the above, areas of morphological interest are monitored more frequent . Areas with special morphological interest are:

- River deltas
- Eroded areas after a storm
- Areas where coastal defence structures are going to be constructed. In these cases the area is monitored in detail before the construction, in order to have reference data, and for some years after the construction.
- Areas where coastal structures have been constructed before 1993

The Data Bank of the Coastal Unit hosts all the results of the fieldwork and documents with reference to the historic evolution of the coastline.

3.3. Technical measures

3.2.2 Historic measures

Until now, nothing official has been done in this coastal area in terms of coastal defence structure. Some groins have been constructed illegally by owners of coastal land. A series of offshore breakwaters in Alaminos area has been constructed legally.

3.2.3 Type / Technical details

Some infrastructure wase built:

- A water intake has been constructed in front of the Vassilikon Power Plant, for the cooling system of the plant.
- The commercial harbour of Vassilikon was constructed by the Cement Factory (Figure 5).
- A small illegal marina has been constructed recently by a developer who is going to construct a tourist village on the coastal area of Alaminos (see Figure 9).

Fig. 5: Cement factory in Vassilikon, with the harbour pier at the end of the photo.

Coastal defences as:

- Groins, illegally constructed by the owners of the coastal land in order to protect their properties from coastal erosion (Figures 6 & 7).
- Revetments with natural rock - these are also illegal and have been constructed by the owners of the coastal land to protect the eroding cliffs and their properties (Figure 8).
- 4 offshore breakwaters legally constructed in 1999 (Figures 9 & 10).

Fig. 6: Groins illegally constructed to protect private property (Agios Teodoros).

Fig. 7: Groins illegally constructed in Mazotos.

Fig. 8: Rock revetment.

Fig. 9: Offshore breakwaters in Alaminos – view west. An harbour is being illegally constructed at the right bottom of the photo.

Fig. 10: Offshore breakwaters in Alaminos – view East.

4. EFFECTS AND LESSONS LEARNT

4.1 Effects related to erosion

The Coastal unit has systematically measured coastal profiles every year since 1993. No evaluation of the results has been undertaken to show the effects of interventions on erosion.

4.2 Effects related to socio-economic aspects

The protection of the coastline and the improvement of the beach quality promote tourism.

4.3 Effects in neighbouring regions

No studies about effects of the coastal defence structures have been carried out. The major part has been constructed without bearing in mind the possible effects on neighbour regions.

4.4 Relation with ICZM

The first effort to implement ICZM in Cyprus was thought the project "Costal Zone Management of Cyprus". The project was co-founded by European Union, through the MEDSPA Program and the Government of Cyprus. The project was carried out by Delft Hydraulics, supported and working together with the staff of the Coastal Unit of the Public Works Department (Ministry of Communication and Works). The project started on January 1993 and finished on December 1995. A very important activity of the project was the formulation of an ad-hock committee, with the participation of all the governmental departments/organisations involved with coastal zone. By the end of the Project, the capacity of the Coastal Unit was significantly enforced; the personnel trained and could act, until today, as the agency responsible for coastal protection and improvement works.

4.5 Conclusions

Effectiveness

Until now, nothing official has been done in this coastal area in terms of coastal defence structures. Effectiveness of the groins is not studied, because they are constructed illegally by the private owners. "Hard" engineering structures are the most well known and they have direct effects: sediment is trapped in front of them and sandy beaches are quickly developed. Time and well set-up awareness raising campaigns are needed to inform people about new "soft" approaches and persuade them for the effectiveness of this "modern" way of coastal defense.

The environment includes a large number of parameters which are involved in the coastal system. All these environmental parameters have to be introduced as an inherent part of the coastal system, and have to be assessed together with the hydrodynamics, the sediment transport and budgets, and the morphodynamic processes. Through this procedure, the environmental parameters become established, better defined, and more concrete. The coastal management schemes will include environmental parameters, and the management

process refers to the entire integrated coastal system. Protection and management becomes thus more straight forward.

Gaps in information

There are three major deficiencies in existing information:

- The complications due to the dispersion of the data in many sources.
- There is no index for interested stakeholders to check whether and where information is available.
- The delay of the Departments to have digital Data Bases. Most of the data are available on paper only, which makes analysis and application difficult, especially when dealing with maps.

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