

## The coastline of Albania : morphology, evolution and coastal management issues

by

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### ABSTRACT

The Albanian coastline, with a length of about 380 km, consists of sandy beaches for 70 % of its total, most of them facing the Adriatic Sea. The coastal zone has a low degree of occupation and man-made coastal structures appear only close to the main ports of Shëngjini, Vlorë and Saranda. Coastal wetlands are present along several lagoons which cover a large part of the coastal zone (about 15,000 hectares) and have an important function for the economy of the country because of fishing, salt extraction and other activities. The presence of low-lying coastal landscapes is strongly related to the large sediment load presently discharged by rivers into the sea (in the order of  $65 \times 10^6$  tons/year). Despite the fact that some form of human intervention has taken place, the evolution of the Albanian coast in recent years did not suffer from the large man-made changes that affected the coastline of nearby countries. The economic importance of the coastal zone will grow in the years to come, leading to an increase in pressure for urbanization and development. This growing interest will produce artificial modifications, often irreversible and leading to negative side-effects on the ecological and sociological aspects of the coastal zone. In this context, it seems essential to produce an inventory of historical coastal changes and improve the understanding of related physical and sedimentological processes.

## RÉSUMÉ

La côte albanaise, longue d'environ 380 kilomètres, est constituée à 70 % de plages de sable qui majoritairement bordent la mer Adriatique. La bande côtière est faiblement occupée et les infrastructures apparaissent seulement à proximité des principaux ports de Shëngjini, Vlërë et Saranda. Des zones humides lagunaires couvrent une large part du littoral (environ 15 000 ha) et jouent un rôle important dans l'économie du pays : pêche, extraction de sel, etc. Le faible relief des paysages côtiers est lié à l'important apport de sédiments, charriés par les fleuves (de l'ordre de  $65 \times 10^6$  tons par an). En dépit de quelques interventions humaines, la côte albanaise n'a pas souffert des grands changements anthropogéniques qui ont affecté le littoral des pays voisins. L'importance économique de la zone côtière devrait croître dans les années à venir avec une pression accrue de l'urbanisation et du développement. Cet intérêt grandissant produira des modifications artificielles, souvent irréversibles, qui auront des effets négatifs sur le plan écologique et sociologique. Dans ce contexte, il semble essentiel de dresser un inventaire des changements côtiers dans l'histoire et d'améliorer la compréhension des processus physiques et sédimentologiques sous-jacents.

## INTRODUCTION

The Albanian coastline has a total length of about 380 km (excluding the internal shore of coastal lagoons), with about 284 km stretching along the Adriatic Sea (Figure 1a) and the remaining 96 km facing the Ionian Sea (Figure 1b). The two seas have quite distinct physical and chemical characteristics: the Adriatic Sea shows large seasonal variations in temperature and productivity, with levels of nutrients and salinity largely controlled by freshwater inputs.

The Ionian Sea has instead a more uniform physical and chemical oceanography throughout the year. Sea water salinity varies between 30 and 39.1 ‰ (PANO, 1984), while the mean water temperature at the surface is 19.2 °C at Saranda (Ionian Sea) and 17.7 °C at Shëngjini (Adriatic Sea). The maximum recorded value is 29.8 °C while the minimum is 7.7 °C. Maximum wave heights are in the order of 3.5 m within bays and 7-8 m in the open sea (PANO and SELENICA, 1967). Open-sea currents flow in a northward direction at a speed of 0.3-0.5 m/sec (SHUISKY, 1985) while tidal range varies between 20 and 30 cm. Tracer experiments indicate that wave-driven sand transport occurs down to a maximum water depth of 8 m.

Generally the littoral environment is not polluted and there are large areas free from human occupation. However, water quality is poor in the bay of Vlërë and at the mouth of the rivers Semani, Shkumbini and Mati due to the presence of industrial discharges (GJIKNURI, 1995). From a biological point of view, the sea bed is highly diverse. A recent study undertaken by GJIKNURI (1995) identified 131 species of pluricellular algae, 251 species of fish, 46 species of echinoids, 104 species of decapods and 84 species of molluscs.

The coastline (about 70 % sandy beaches) is almost free from artificial structures, that are present only near the ports of Shëngjini, Durrës, Vlërë and Saranda. The only man-made structures that are scattered almost everywhere along the coastal zone are military bunkers, built to prevent invasion

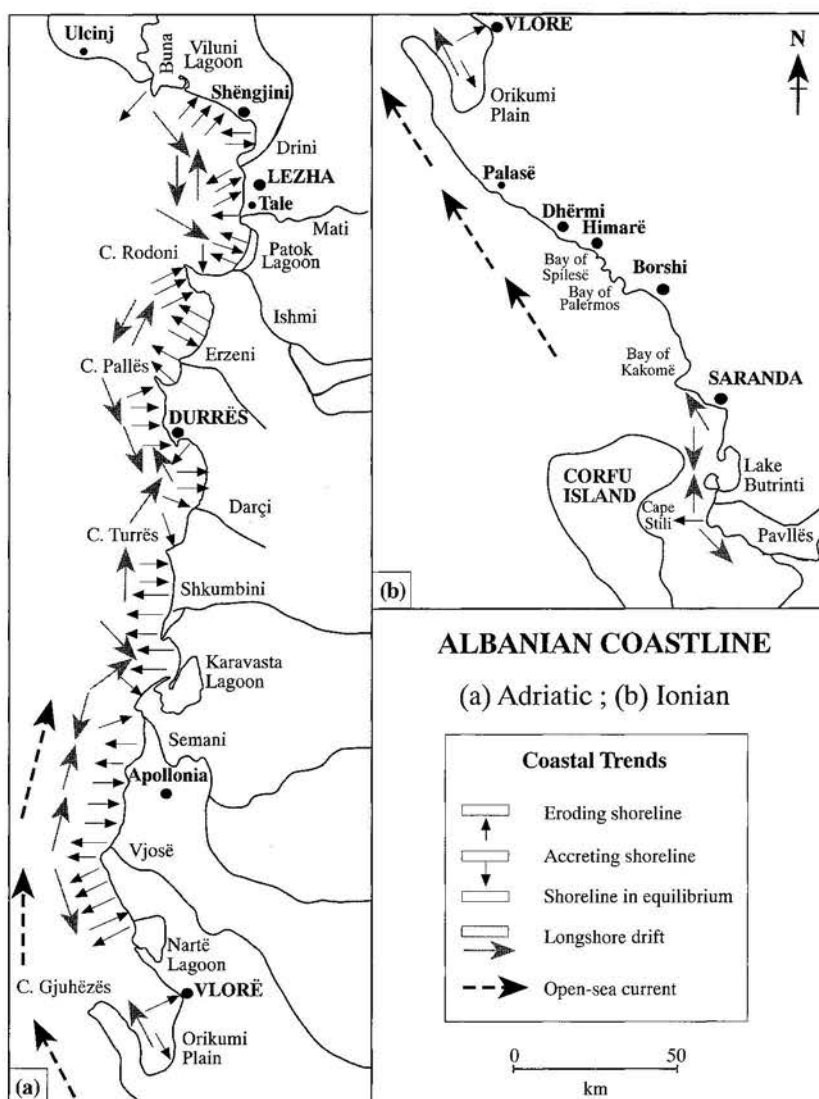


Figure 1 – Index map of the coast of Albania with indications of eroding and accreting sectors : (a) Adriatic Coast, (b) Ionian Coast.

of troops from the sea. However, the evolution of the coastline in recent years cannot be considered completely natural, since river engineering works in the hinterland have significantly altered sediment discharge. There are several coastal lagoons of importance (GJIKNURI, 1995) in terms of extension (in total equivalent to about 15,000 hectares), fishing activities (producing about 8,000 kg/year) and salt extraction (particularly at Nartë that produces about 120,000 tons/year).



The development of the Albanian coastal zone will be one of the key elements for the future economical growth of the country. Development in tourism activities will inevitably lead to an increase in urbanization of the coastal zone, causing ecological and sociological changes. Future coastal zone management plans at a national, regional and local level will have to ensure the development of economical activities in harmony with the biological and physical environment. It is necessary for the country to produce an inventory of historical coastal changes, geological and geomorphological information in support of these environmental management needs.

## COASTAL SETTING

### Geomorphology

From a geological point of view the Albanian coastline is quite young. Its northern part, located between the boundary with the former Yugoslavia and Shëngjini, can be considered the continuation of the Dalmatian coast southwards. The WNW-ESE orientation of the coastline is produced by the structural control given by the axis of anticlines in Cretaceous limestones. The slopes of Mount Rency delimit the southern edge of a wide alluvial plain built by the Quaternary deposits of the Buna River, which flows south-eastwards of Shkodër. Between Shëngjini and Cape Turrës the coastline trends NE-SW. Geological structures, oriented NW-SE, determine the formation of three headlands orthogonal to the coastline.

The headland of Rodoni consists of sandy clays of Tortonian (upper Miocene) age, while Cape Pallës and Cape Turrës are built in Pliocene sandstones, clays and sandy conglomerates of Tortonian age. These headlands delimit four wide bays (Drini, Rodoni, Lalëzi and Durrës) filled by alluvial deposits of the rivers Drini, Mati, Ishmi, Erzeni and to a smaller extent by the Darçi River. With regard to the Kavaja Plain in the Bay of Durrës, its origin is probably related to an old course of the Shkumbini River, that at present outflows southwards of Cape Turrës. The peculiar orientation of the bay, compared with the adjacent coastline, is due to the sheltering effect of the Pallës headland, for wave motion from the NW.

From Cape Turrës to the Gulf of Vlorë there is a low-lying coastline, with orientation NNE-SSW, related to the presence of the vast Myzeq coastal plain. In this area there are no rocky headlands and the only parts of the coastline with different orientation are deltas, active or abandoned. The sediments discharged by the rivers Shkumbini, Semani and Vjosë have built up the coastal plain where at present the two largest lagoons of Albania (Karavasta and Nartë) are found.

The Gulf of Vlorë has a structural origin (PASKOFF, 1985), since it is the flank of a faulted syncline delimited at each side by anticlines in the Cretaceous limestones of the Lungara and Karaburun formations that stretch out at sea towards Sazani Island. In the inner part of the gulf lies the small Dukati Bay with the adjacent coastal plain of Orikumi formed by deposition of Quaternary marine deposits and alluvium.

Coastal cliffs are mainly cut into carbonates of Cretaceous-Eocene and Lower Jurassic age (INSTITUTI I STUDIMEVE DHE I PROJEKTIMEVE TE GJELOGJISE, 1983), where karstic landforms (caves, wells, etc.) are pre-

sent. The tectonic style is influenced by the active Hellenian Margin and Ionian Plate, whose edges are quite close to the Albanian Coast. The area is subjected to foreland tectonic uplift, that produce erosive profiles in rivers and continuous lateral migration of river courses in search of equilibrium conditions. Because of the geological setting mentioned above, the area is seismically active, with a coastline cut in active cliffs with steep profiles. The Ionian coast is characterized by anticlinal structures (KABO, 1988) and has a simple surface hydrography due to karsism in limestones. The small streams present generally have torrential regimes and built up with time quite large alluvial fans along the coastline.

Small headlands delimit the bays of Spilesë, Palermos, Kakomë and Saranda. Small pocket beaches are present, generally consisting of gravel, such as Lukova Beach and Spile Beach near Himarë. The largest beaches are located where alluvial fans of small torrents are present, such as those near Palasë and Borsh. Between Cape Gjuhëzës and Saranda, rocky cliffs, oriented NNW-SSE, are present at the base of steep coastal slopes. Within small distances from the coastline the relief of the hinterland reaches heights in excess of 1000 m. The morphology of coastal cliffs and the narrow continental shelf identify a coast of tectonic origin (PASKOFF, 1985).

The coast of the Albanian Epireous, from Saranda to Cape Stili, is oriented N-S and stretches down to Corfu Island. PASKOFF (1985) explains its origin as related to a recent submergence. The landscape is characterized by hills in the hinterland and the Vurgu coastal plain in the Gulf of Butrinti, built by alluvium deposited from the rivers Bistrica and Pavllës. Within this coastal sector the lagoon of Butrinti is found, the only coastal wetland of the Ionian coast of Albania.

### Climate

The climate of the Albanian littoral lowlands is typically Mediterranean. Annual precipitation rates range from 930 to 2,200 mm (PANO and ZORBA, in press), mean annual temperatures vary between 15-16.5 °C, increasing from north to south and from west to east. The number of frosty days is 5-30 every year, maximum temperatures are 42.2-43.9 °C and minimum ones range from -3.5 to -7.2 °C. The growing season is 240-310 days long, with a precipitation rate of 500-700 mm.

From October to March the coastal area receives about 70-75 % of the annual rainfall. The number of rainy days (rainfall > 0.1 mm) in this area varies between 90-120 days in a year, and the intensity of precipitation is high. Snow is a rare phenomenon (2-6 days in a year) and the maximum layer is generally 10-40 mm thick. Mean annual wind speeds oscillate from 1.5 to 3.5 m/s. Strong winds are observed near the coast, where wind speed reaches up to 40-45 m/s.

### Hydrology

The current sediment input from rivers into the Mediterranean has been estimated in the order of  $50 \times 10^6$  tons/ year, approximately equivalent to an area of 2,800 hectares of 1 m thickness (BOÇI, 1994). Data published by PANO (1984, 1992) for the period 1948-1990, indicate that the mean total sediment discharge of Albanian rivers was in the order of  $65.7 \times 10^6$  tons/ year. The same author indicates for the same period a mean water discharge of  $41.27 \times 10^6$  m<sup>3</sup>/year, equivalent to 1,308 m<sup>3</sup>/sec.



The relatively low water discharge of Albanian rivers is contrasted by high sediment loads. It is interesting to compare data from Albanian rivers (PANO, 1992) with Italian rivers outflowing in the Adriatic such as the Po (DAL CIN, 1983) and the Ofanto (SIMEONI, 1992). The Drini, despite a catchment basin five times smaller than the Po (Figure 2), a water discharge four times smaller (Figure 3), but has a total sediment load 20 % larger than the main Italian river (Figure 4).

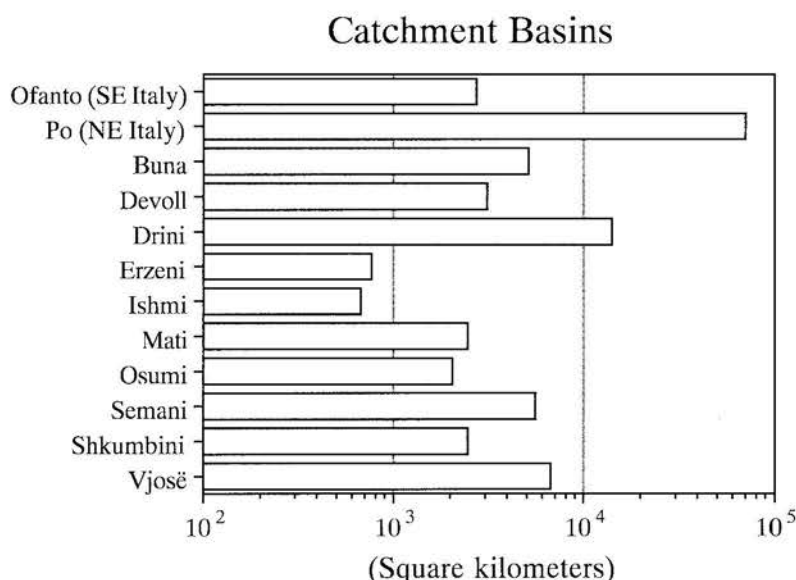


Figure 2 – Catchment basins of Albanian rivers compared with two case studies from northern (Po River) and southern (Ofanto) Italy.

A similar pattern is observed for the Semani, with a catchment twelve times smaller than the Po (Figure 2), a water discharge eight times smaller (Figure 3), a sediment load 20 % larger (Figure 4). The magnitude of hydrological processes of the Albanian rivers becomes even clearer if a comparison is made with the Ofanto River in the Puglia Region of southern Italy, which has a mean water discharge of 13.9 m³/sec (Figure 3) and an average sediment load of about 958.7 x 10³ tons/year (Figure 4). Another important aspect in the hydrology of Albanian rivers is the percentage of sediment transported as bedload, generally considered as an indicator of the net input into the coastal sediment budget. Published data (PANO, 1992) indicate that about 16-23 % of sediment is transported as bedload, thus more than the 15 % indicated for the Po River (DAL CIN, 1983).

Despite the intensity of the processes described above, the quantity of sediment reaching the sea is only a part of the transported load, since several dams and engineering works are present on many of the rivers such as the Drini, Mati and Bistrica. According to PANO (1992), these sinks capture about 60-70 % of the total sediment transported. Other man-made effects on the hydrological regimes have been caused by water extraction for irriga-

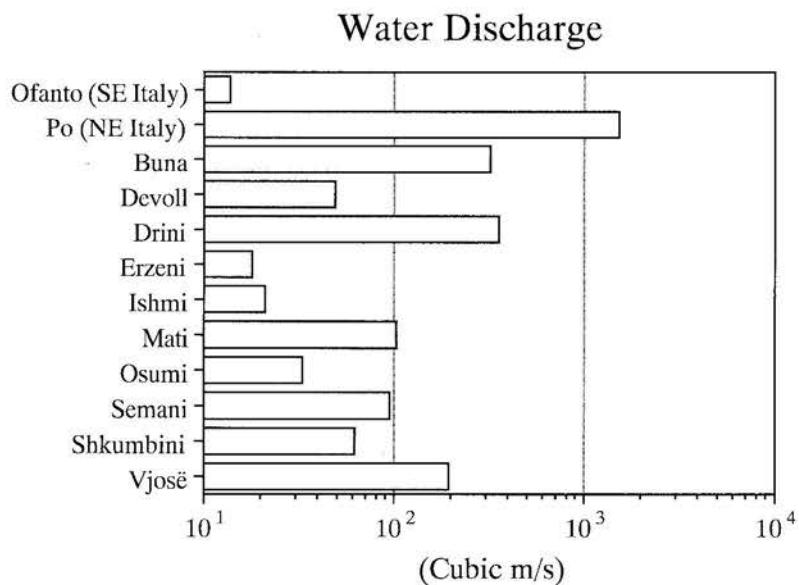


Figure 3 – Water discharges of major Albanian rivers (1948-1990 data from PANO, 1992) compared with the Po (1918-1981 data from DAL CIN, 1983) and Ofanto rivers (1932-1985 data from SIMEONI, 1992).

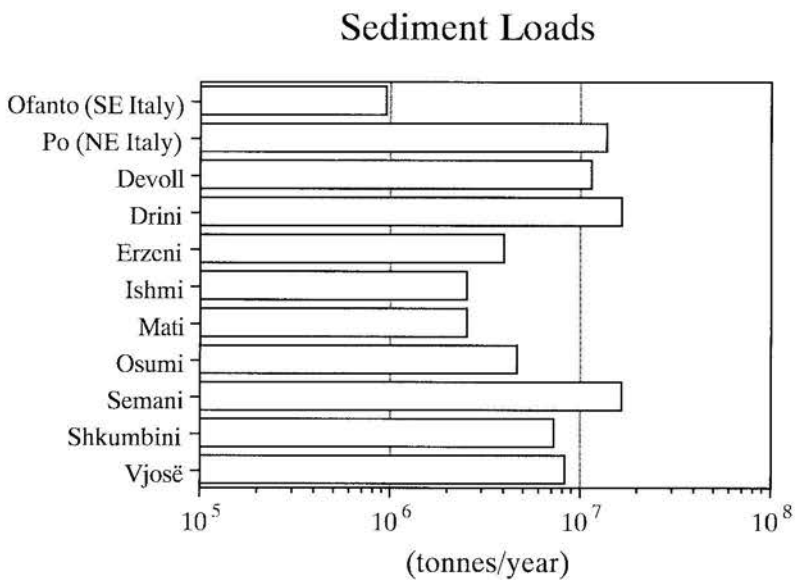


Figure 4 – Average sediment load carried by major Albanian rivers (1948-1990 data from PANO, 1992) compared with the Po (1956-1973 data from DAL CIN, 1983) and Ofanto rivers (1932-1985 data from SIMEONI, 1992).

tion, reclamation of wetlands along the floodplains and opening of river bed quarries on the lower courses. Recent coastal evolution has also been controlled by other factors, such as river diversion in the cases of the Drini, Gjadri and Ishmi. Furthermore, coastal change has been influenced by lateral migration of river mouths and abandonment of delta channels (Semani, Vjosë, etc.).

The evolution of the Buna and Drini rivers is strictly interconnected. Independently of any human intervention, throughout the centuries the Drini was at times outflowing directly into the sea and at times a tributary of the Buna. At the moment the Drini is connected to the Buna and has a limited sediment load due to the construction of large water reservoirs such as the Fierza reservoir on the mid course, the Vau i Dejës and Koman reservoirs on the lower course. It is therefore impossible to consider the two rivers as independent. The hydrological literature often groups them together (PANO, 1992), considering a total catchment of 19,582 km<sup>2</sup>, an average water discharge of 672 m<sup>3</sup>/sec and a total yearly water discharge of 21,444 x 10<sup>6</sup> m<sup>3</sup>, equivalent to about 50 % of the total freshwater input from Albania rivers into the Mediterranean.

Changes in the hydrology of the Mati resulted from the construction of hydroelectric power stations at Ulëza and Uraka on the Ulëza Lake which trapped a large part of its sediment load. Comparing data from the Mati and the Ishmi (Figure 4), both flowing out at sea in the Gulf of Rodoni, it emerges that they have a similar sediment load, despite the fact that the catchment basin of the former is 3.5 times larger than the latter, as is larger (five times) the water discharge.

The Erzeni, with a catchment of 760 km<sup>2</sup>, is at present the only river that provides sediment to the beaches in the Gulf of Lülezi. It has the lowest mean yearly water discharge (18 m<sup>3</sup>/sec) of all Albanian rivers (Figure 3) and an average sediment load of 4 x 10<sup>6</sup> tons/year (Figure 4). When related to the catchment area (Figure 2), it has a sediment load per km<sup>2</sup> of 4.2 x 10<sup>3</sup> tons, of which 20 % is transported as bedload (PANO, 1992).

The Shkumbini has a catchment of about 2,444 km<sup>2</sup>, with an average altitude of 753 m. It has an average water discharge of 61.5 m<sup>3</sup>/sec and an average sediment load of 7.2 x 10<sup>6</sup> tons/year. The river mouth controls a total length of about 15 km.

The Semani has a catchment surface of 5,649 km<sup>2</sup>, with an average altitude of 863 m above sea-level. The average water discharge is 95.7 m<sup>3</sup>/sec and the total sediment load is 16.5 x 10<sup>6</sup> tons/year (PANO, 1992), a smaller value than the 30 x 10<sup>6</sup> tons/year proposed by SHUISKY (1985). It is quite likely that in recent years the sediment load decreased following sand and gravel extraction and dam construction. Distinctive features of this river are the numerous secondary channels flowing out at sea and the dramatic changes in hydrologic regime observed during recent years.

The southernmost river in the country is the Vjosë, which is one of the main rivers in Albania. It has a catchment of 6,706 km<sup>2</sup> with an average altitude of 855 m. Average water discharge is 195 m<sup>3</sup>/sec, while the average yearly sediment load is 8.3 x 10<sup>6</sup> tons, *i.e.* 3.5 times smaller than that estimated by SHUISKY (1985). This decline is probably due to the construction in 1991 of the Baja Reservoir on one of its main tributaries, the Devoll.



## COASTAL EVOLUTION

The coastline is a rapidly changing environment, continuously modifying its shape as a result of changes in forcing parameters. If it is true that there are natural conditions of equilibrium and instability, it is equally believable that human intervention can alter such dynamics in an irreversible way. For example, the construction of groynes or breakwaters has large impacts on littoral transport; sand and gravel extraction from river floodplains decreases total sediment loads; excessive exploitation of aquifers can cause subsidence in low-lying coastal areas. In order to maintain uniformity and simplicity in the description of coastal landforms, it is therefore necessary to define a coastal cell, as a section of a coastline where the overall pattern of sediment transport is distinct and there are no sediment exchanges with adjacent parts of the coast.

In order to describe the Albanian coastline, it is useful to divide it into two broad sectors, the Adriatic and the Ionian coasts (Figures 1a and 1b). The first sector, northwards from the Gulf of Vlorë, consists almost entirely of beaches, while the second, located southwards, consists of a rocky cliff coast.

### The Adriatic Coast

Along the Adriatic coast it is possible to identify four main physiographic units, with borders that correspond to the headlands of Rodoni, Pallës, Turrës and Gjuhëzës. Larger water depths in front of headlands allow to consider sediment exchange between units almost negligible.

#### *From the mouth of the Buna to Cape Rodoni*

The unit has a length of about 60 km and consists for almost 90 % of beaches fed by fluvial inputs. The remaining 10 % is cliffs located at Cape Rodoni and near Shëngjini. The northern edge of this unit is located outside the Albanian territory, probably coinciding with the area near Ulcinj in the former Yugoslavia.

Four rivers outflow within this physiographic unit: from north to south they are the Buna, the Drini, the Mati and the Ishmi. All together they discharge on average 796 m<sup>3</sup>/sec of water. The total solid load of the last three rivers, since there are limited information on the Buna, is about 21,680 x 10<sup>3</sup> tons/year, of which about 17.5 % is transported as bedload (PANO, 1992). Wide coastal plains point towards a general trend of coastal accretion as testified by historical sources which describe the town of Lezha up to 1000 A.D. as a coastal town, a site that is now at about 8 km from the sea. (SHUISKY, 1985). These rivers often changed position naturally, as in the case of the Drini, or because they were diverted (*e.g.* the Drini into the Buna).

The coastline between the mouth of the Buna and the Viluni Lagoon was characterized in the first part of the present century by an accretive tendency. It was advancing rapidly up to 1937 and more slowly till 1968 (BOÇI, 1994). Between the 1970s and 1990s accretion rates became increasingly smaller and in the last decade coastal erosion started along the southern lobe of the Buna Delta (between 1.5 and 2.0 m/year), at the island of Franc Josef and on the beaches along Viluni Lagoon, where the present coastline position is clearly further inland than that surveyed in 1918 by the Austrian Geographical Institute (BOÇI, 1994).

The decreased sediment load of the Drini, caused by its diversion into the Buna, has triggered coastal recession between Shëngjini and Tale, with greater intensity on the southern lobe of the delta. Moving southwards, the coast becomes part of the sedimentary system of the Mati, a river that has been heavily canalized. In the 1920s the river mouth had a single channel, oriented in a southwesterly direction. Between the 1930s and 1940s the channel split into two, with the southern branch becoming the main one. This caused an asymmetric development of the delta, with a general trend of positive coastline migration towards the SSW (Figure 5). The coastal area between Tale and Patok can be considered as having a positive net sediment budget, despite the fact that accretion at the mouth of the Mati slowed down since the barrage of Ulëza was constructed. The erosion of Patok Beach is a fairly recent process, began in the early 1980s, caused by changes in the hydrological regime of the Ishmi, due to engineering works started as early as the 1960s.

In the last centuries the Ishmi changed course on several occasions (BOÇI, 1994). In the 1920s it had a single mouth located in the centre of the bay, moving later in the 1930s to a double channel apparatus. Thereafter, the northern channel clogged up in the 1950s-1960s, the river mouth reached the present configuration, with small sediment and water discharge, so that the river channel is almost extinct. The southern sector of the physiographic unit has coastal cliffs cut into poorly consolidated Neogene sandstones and mudstones subject to erosion at many points.

It can be concluded that only 20 % of the coastline in this physiographic unit is accreting (Figure 1a) and that this trend has slowed down in the last decades. Littoral drift is strongly controlled by the geometry of deltas and mouths of the Drini, Buna and Mati: deltas protruding out at sea cause a divergence of littoral drifts at their sides. Although it is clear that the magnitude of these diverging sediment patterns is equivalent at either side of the Drini, in the case of the other two rivers it seems that the southward component is clearly dominant (Figure 1a). Points on convergence of littoral drift patterns are observed at Shëngjini and along the coast between the Mati and the Ishmi.

#### *From Cape Rodoni to Cape Pallës*

Within the Gulf of Lalëzi, of a total length of coastline of 32 km, 65 % consists of sandy beaches fed by the sediment load of the Erzeni. The remaining 35 % consists of rocky cliffs located at the edges of the physiographic unit. At present 47 % of the unit is eroding, particularly in three areas: near Cape Rodoni for about 8 km along the cliffs and for another kilometer along the nearby beaches, along the right lobe of the delta of the Erzeni, along the cliff of Cape Pallës for about 2 km. While published information agree on a general tendency towards coastal recession, they present different erosion rates. SHUISKY (1985) for example believes that the cliffs of Cape Rodoni are retreating at an average speed of 0.2 m/year, while BOÇI (1994) proposes 0.3-0.5 m/year.

From cartographic studies it emerges that the mouth of the Erzeni, between 1918 and 1990, has progressively rotated southwards (Figure 5). This has caused a continuous erosion of the northern lobe of the delta and an accretion of the southern one at a speed of about 50 m/year (BOÇI, 1994). For the same period BOÇI (1994) indicates a total erosion of four kilometers

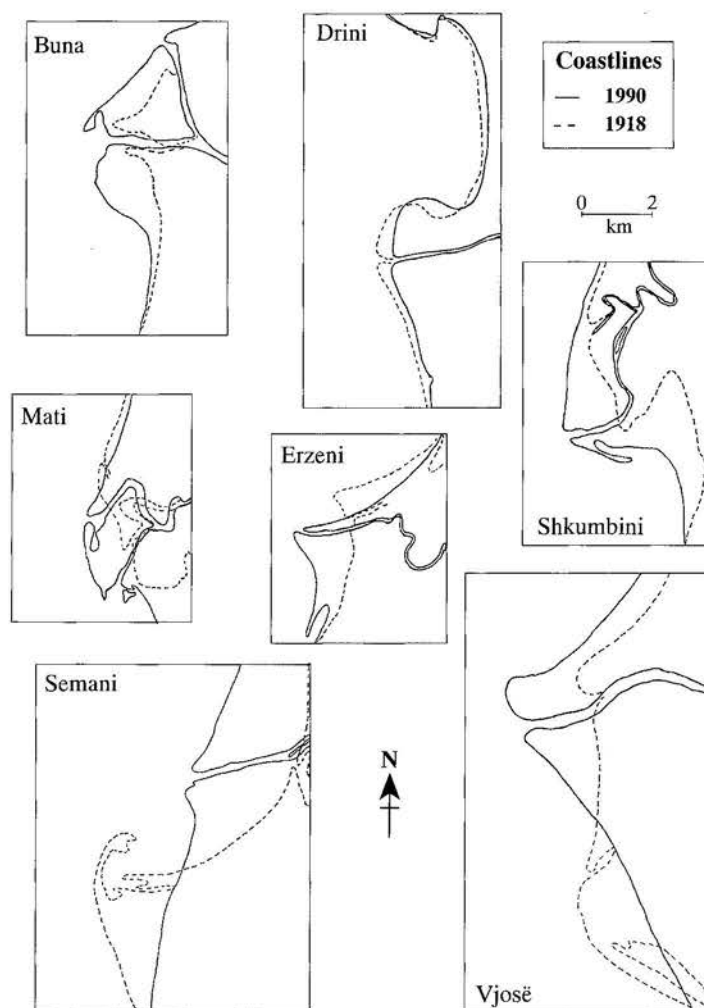


Figure 5 – Coastal change at the mouth of major Albanian rivers between 1918-1990 (1918 coastline surveyed by the Austrian Geographical Institute, 1990 coastline modified from BOÇI, 1994).

for the coast northwards of the Erzeni mouth, while PANO (1992) considers it of six kilometers with a retreat of 5 m/year. The remaining part of the coastline has accreting beaches, although accretion rates are generally quite small. Cliff retreat is likely to continue in the future with the same rates observed at present, since the main control parameter is rock erodibility but it is likely that erosion peaks will change locations, due to the migration of the mouth of the Erzeni. This last consideration assumes that no further engineering works are carried out on the river. If these will take place, river discharges will change, leading to a larger instability in the coastal zone and to an increase in erosion rates.



Examining morphologies and patterns in coastal change, it is possible to delimit dominant directions in sediment transport within the unit. The only area where there is divergence of coastal drift vectors is the mouth of the Erzeni. Longshore drift vectors also move away from the two headlands, converging towards the centre of the bay. Sediment moving longshore from Cape Rodoni southwards becomes scarce towards the northern side of the mouth of the Erzeni. On the southern side of the mouth longshore drift is scarce too, allowing the hypothesis that another pattern of transport exists from Cape Pallës towards the Erzeni mouth.

#### *From Cape Pallës to Cape Turrës*

The two headlands of Cape Turrës and Cape Pallës delimit a coastal cell 35 km long and of great economical importance for the country due to the presence of Durrës, the main port of Albania (Figure 1a). Urbanization of the coastal zone is high by Albanian standards and the population rate varies considerably during the year because of tourism in the summer. The two headlands delimit the bay as a unit from a physiographic and sedimentological point of view, acting as barriers to sediment losses and inputs from outside the bay. The coastline at the two ends of the unit is a rocky cliff coast for about 17 km, while the remaining 54 % of the bay has sandy beaches, frequently with dune ridges vegetated by pine trees.

The anomalous orientation of the bay with respect to the rest of the Albanian coastline is related to the sheltering effect created by the Pallës headland for wave motion from the NW. Sediment inputs into the bay are provided by the Darçi River and to a smaller extent by artificial channels like the Lishati or small streams like the Burzës, all flowing on soils subject to high run-off erosion rates. Other main inputs come from beach and cliff erosion. At the northern end of the unit, near the Durrës headland, there are coastal landslides in poorly consolidated Pliocene sands and mudstones. Beaches are in equilibrium only in the area between Durrës and Kavajë; moving southwards a slight coastal retreat can be observed down to Golemi, while between Golemi and Karpeni, beaches are eroding rapidly. There erosion rates average at 0.5 m/year with peaks of 1-2 m/year near the mouth of the Darçi. From a general point of view, erosion within this part of the bay increases from south to north (Figure 1a) and is exacerbated by illegal sand mining on beaches and dunes.

A recent study (SIMEONI *et al.*, 1996) found that littoral drift converges towards the port and that fine muddy sands (30-40 % mud) are present at many sites on the sea bed within the bay. These deposits are often associated with *Posidonia sp.* meadows and are scarcely mobile. The deep water channel of access to the port tends to silt up so that dredging takes place. This intervention policy should be re-evaluated in the context of the general dynamics of the bay, where sediment inputs external to the cell are non-existent and the main source is beach erosion (SIMEONI *et al.*, 1996).

#### *From Cape Turrës to the Gulf of Vlorë*

The coastline between Cape Turrës and the Gulf of Vlorë, with a total length of about 80 km, can be considered as a single physiographic unit because there are no evident natural discontinuities within it. Obviously this does not imply that the sediment discharge from the Shkumbini feeds the beaches of the Gulf of Vlorë and that areas influenced by river discharges

cannot be delimited. The choice of considering this coastal stretch as a single unit is dictated by the rapidity of coastal change on a scale of decades. Within the space of a few years, river mouths become abandoned as new ones are created, wetlands change in shape and extension, and beaches advance considerably. Such dynamic coastal changes within short time scales require a continued and detailed relocation of boundaries between local areas of influence, an approach not suitable for a description at the scale used in the present study.

The area is the typical microtidal coastline occupied by fluvial deltas (DAVIES, 1972): a wide coastal plain in the hinterland (Myzeq, the largest of Albania), large coastal wetlands along the lagoons of Karavasta and Nartë, beach ridges, sandy beaches and coastal dunes. The coastline between Spilea and Vlorë is oriented NNE-SSW and its outline reflects the presence of the old delta plains of the Shkumbini, Semani and Vjosë. The total sediment load discharged by these three rivers is high, about  $32,130 \times 10^3$  tons/year, equivalent to 49 % of the total discharged by Albanian rivers into the sea (PANO, 1992).

Many coastal transformations have taken place due to modifications caused by river delta migration, with abandonment of old channels following a decreased discharge or creation of new river mouths. The surface hydrography of the coastal plain reflects such changes as well as the generally accretive tendency of the coastline. Archeological sources report that the town of Apollonia, founded over 2500 years ago, was located 5 km away from the coast (PASKOFF, 1985), compared to about 8 km today.

From the study of historical cartographic sources, we find that at the beginning of the present century the Shkumbini became divided into two parts (Figure 5). The southern branch of the river gradually increased its discharge, forming spits that built up an area of 35 hectares, enclosing the new coastal lagoon of Kulari. Between 1970 and 1990 the northern branch of the river gradually closed, halting sediment input to the adjacent beaches, which started to erode.

The Semani also changed the position of its mouth with time, being always characterized by a number of secondary channels. The river mouth changed position six times in the last one hundred years, moving along a coastal strip of 23-25 km. Between the end of the 19<sup>th</sup> century and the 1950s the northern channels became increasingly important (Figure 5). Thereafter, until the 1960s, the delta plain advanced towards the sea and in the 1970s the coastline reached its present position. In this period of positive migration the accretion rate was in the order of 40-50 m/year. The coastline around the mouth has two sectors, sites of old river channels, which are unequivocally eroding. The first sector started to erode at the end of the 19<sup>th</sup> century, with an approximate speed of about 30 m/year. PASKOFF (1985) evaluates modern erosion rates as 15 m/year. Despite the fact that erosion slowed down, it is still a dominant factor at Semani beach, a popular coastal resort twenty years ago, nowadays almost disappeared. The second sector that is eroding is located 13 km northwards from the mouth of the Semani. Published work (PANO, 1984) relates the erosion to changes in the river mouth induced by the disastrous floods of the winters of 1962-1963. Average erosion rates calculated for the last 30 years are in the order of 35 m/year (BOÇI, 1994), with maximum peaks of about 50 m/year (PANO, 1984).



The mouth of the Vjosë river has been in constant accretion for the last 120 years, with maximum growth between 1918-57 (Figure 5). Later the delta started to be reworked by wave action. The estimated growth rate was in the order of 15 m/year for the period 1918 and 1972. Southwards of the present delta there is an area, 4 km long, where erosion has been taking place (average 15 m/year, maximum 47 m/year), dismantling about 1200 hectares of beach. The erosion is caused by the abandonment of one of the channels of the Vjosa, occurred progressively between 1937 and 1957. Erosion speeds have become smaller from the early 1970s onwards, in the order of 8 m/year.

The coast of the Gulf of Vlorë consists mostly of cliffs, generally cut into limestone with at times terrigenous intercalations. In the inner part of the gulf, inland of the small bay of Dukati, lies the Orikumi plain, filled with Quaternary marine deposits and alluvium. At this point there is a small gravel barred beach that separates the open sea from the lagoon of Pasha Limani. This beach has recently started to be eroded so that protection works have been carried out to safeguard the coastal road. The western part of the gulf, the Karaburuni Peninsula, is oriented NW-SE and presents active rocky cliffs cut into limestones. In some small bays (Shen Janit and Ragozhës) there are small gravel beaches at the toe of active cliffs.

Within the physiographic unit some areas of partition of longshore transport can be identified, mainly at the mouths of the Semani and Vjosë. Areas of convergence are instead located along the barrier of Karavasta Lagoon, at the mouth of the Semani and some kilometers northwards of the mouth of the Vjosë.

#### *The Ionian Coast*

About one-third of the Albanian coastline stretches along the Ionian Sea with a low degree of occupation by man. It is scarcely populated, since the only human activities are related to agriculture and cattle grazing: total inhabitants are in the order of 60,000 people. The sea bed has a narrow continental shelf, on average 2.5 km wide, with the -5 m contour located at less than 30 m offshore and the -20 m at 200 m offshore. Erosion of cliffs is prevalent along the coastline with formation of pocket beaches or narrow gravel beaches at the base of slopes like at Lukova and Spile near Himarë. The coast inside the Gulf of Butrinti has a different landscape, since the deposits of the Bistrica and Pavllës rivers have created a coastal plain at Vurgu. The headlands of St. Teodoro and Argila Point delimit a small bay where the town of Dhërmi is located. The surrounding cliffs consist of poorly consolidated breccias that erode feeding a long and wide beach in the centre of the bay, where there is the outfall of a small stream. The sea bed is quite steep with nearshore slopes in excess of 10 %. A weak longshore transport is directed northwards.

Further to the south lies the small bay of Spilesë that is delimited by two headlands; on the northern one is the town of Himarë. The bay has a beach consisting of limestone gravel and pebbles, which is 20 m wide and divided in two parts by a small rock outcrop. An interesting aspect of this bay is the presence of two freshwater springs of karstic origin which outflow close to the beach. The nearshore sea bed is steep, but there are no signs of coastal instability. Ten kilometers southwards from Himarë lies the wide bay of



Palermos, with high rocky cliffs cut into limestones and narrow pebble beaches. The two headlands at the bay's borders protect it from wave action during storms and the sea bed is steep attaining considerable water depths (20 m) close to shore. All these features, together with the size of the bay, identify it as an ideal site for recreational boating activities.

The Gulf of Gravës is located to the south of Mount Palermos, with a large coastal plain in the hinterland, where the town of Borsh is located. The area is of some agricultural importance because of plantations of olive and orange trees. The coastal plain was originated by the alluvium of a local stream that also created a small pebble beach, 30 m wide. The foreshore is wide, with a gentle slope (6-7%), indicating relative stability of this coastal segment.

The coast of the Albanian Epiroean stretches from Saranda to Cape Stili, with a N-S orientation. The Bay of Saranda is located here with a cliff coastline. Although the dominant wind direction is from the south, the largest waves are created by winds blowing from the NW. Sedimentary inputs into the bay are generated by erosion of the cliffs and to a smaller extent by input from the Cuka artificial channel, created to divert the Bistritsa and Kalasa rivers. The coastline is overall in equilibrium.

The Gulf of Butrinti marks the southernmost part of the Albanian coastline, extending down to the Greek border and is quite different from the rest of the Ionian coast. The northern section of the gulf has rocky cliffs and shallow coastal waters, where a large spit is developed occluding part of the bay's entrance. The central part of the bay is a depression of tectonic origin where a lagoon has developed. The lagoon is bordered by calcareous hills, with the exception of its southern part where the Pavllës River is located. It is connected to the sea by a channel 1-2 km long and 7-8 m deep. The channel tends to silt up and periodic dredging takes place (personal communication, Ing. Z. Ypi, Durrës Port Authority). In the southern part of the bay the Pavllës River has a high sediment load that feeds a coastal stretch 12-15 km long, in evident accretion (PANO, 1992). One may consider that there is an area of convergence in littoral drift patterns in the centre of the bay, near the Butrinti Channel, because of the asymmetry in the channel's entrance, the spit's morphology and the shallow sand and mud banks in the northern part of the bay.

### COASTAL MANAGEMENT ISSUES

We have pointed out how the sediment load of Albanian rivers decreased in recent years, triggering erosion phenomena along the coastline. It is clearly necessary to minimize sediment losses within coastal cells. Information provided by the Durrës Port Authority (personal communication, Ing. Z. Ypi, Durrës Port Authority) indicates that the loss of sediment dredged from the entrance of the port of Durrës can be evaluated as 100,000 m<sup>3</sup>/year (200,000 tons). The sediment is currently discharged in an area outside the cell, northwards from the port at a water depth of 15-18 m, thus below the normal wave base, which excludes it from the coastal sediment budget (SIMEONI *et al.*, 1996). It is necessary to characterize in detail the sedimentology of this material and evaluate the possibility of recycling it, for example for beach replenishment schemes.

Coastal areas of ecological importance are abundant along the coast of Albania, such as the lagoons and marshes at the mouths of the Drini and Mati rivers (Shëngjini, Lezha and Kunes), the lagoons of Patok and Karavasta, the natural parks of Divjaka, Nartë and Butrinti (HAXHIU and TEKKE, 1993). Threats to the integrity of these natural environments come from changes in river discharge and pollution of the Shkumbini, Semani and Mati. In addition, in the case of Karavasta the impact on local fish farming activities should also be considered. This lagoon is connected to the open sea by three small channels, 0.3-1.2 km long and 0.7-1.6 m deep, with global water discharges in the order of 26.5 m<sup>3</sup>/s (PANO and HYSI, 1982). Longshore drift towards the centre of the Karavasta barrier (CIAVOLA and SIMEONI, 1995) creates a spit departing from the northern end of the Semani and sediment deposition nearshore. Since these processes tend to occlude the lagoon's channels, dredging takes place on the main channel (the northernmost one) to improve circulation and allow access for small fishing boats. In this case the dredged sand is discharged updrift directly on the shoreface, thus rendering ineffective the dredging and impoverishing the beach downdrift (CIAVOLA *et al.*, 1995; CIAVOLA and SIMEONI, 1995).

### CONCLUDING REMARKS

From the study of coastal processes along the Albanian coastline it emerges that the main need is not the construction of coastal defences but the control of human activities. This is particularly important in the case of a developing country like Albania, since wrong coastal management policies can have detrimental effects on the economy. Indiscriminate development of the coastal zone could for example lead to lower land values; construction of badly designed structures could trigger erosion, demanding further engineering works. The way to avoid such negative impacts is to introduce environmental indicators within economic budgets, finally considering ecological constraints at a macroeconomic level.

Future coastal management plans for the Adriatic coast should account for changes in river discharges and the implications on past and future coastal change. This means that at the base of a correct shoreline management there is the concept of the coastal zone as an area extending inland, thus at sites overlapping with river catchment management. Future investigation should look at large scale coastal behaviour to eliminate causes of instability and not simply focalise at a local level to minimize negative side effects. Great attention should be given when planning new urban centres, to attenuate damages to the environment and identify priorities of intervention.

In a similar fashion, coastal management issues for the Ionian coast are complex and in need of multidisciplinary studies rather than immediate interventions. Future pressure will come from an increased demand for recreational landings that should be planned carefully to avoid unauthorized establishments. Environmental planning activities should receive high priority, for example the disposal of liquid and solid urban wastes, exploitation of groundwater and quarrying for aggregates. Finally, construction of coastal resorts should respect local architecture and culture.

Economic development of the Albanian coastal zone will induce a migration of the population towards the sea. On one hand, population den-



sity in coastal areas will increase; on the other hand areas inland will be abandoned. The increase in the number of people living in the coastal zone will produce a larger demand for dwellings, hence an increase in urbanization with related environmental impacts. It is therefore clear that the success of future economic development is really a function of a correct environmental policy, being able to balance development needs with the respect of natural habitats and landscapes.

It will be necessary to conduct multidisciplinary investigations at a large scale, to provide a baseline for the environmental impact assessments of development projects. Furthermore, monitoring of environmental change should be given much greater importance and be carried out in a systematic way on several parts of the coastline.

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