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PHYSICAL CHANGES IN THE MEDITERRANEAN BASIN (with particular reference to Italy) (*)

1.0. THE GEOGRAPHICAL FRAMEWORK.

1.1. *Introduction.* – The present paper doesn't mean to be an original contribution to the study of the Mediterranean region. Rather it is intended to be an organised outline of both the main physical geographical aspects and of the man-environment relationship in this peculiar region. The outline will be useful to focus on some unique environmental aspects and to stimulate reflection and further research by geographers.

We think that this region is particularly suitable for an analysis of a large variety of aspects of human impact at a local and regional level and for an understanding of the consequences of global changes in a large natural region.

In fact the Mediterranean basin, which lodges the largest inner sea in the world, from the physical point of view can be considered as a transitional area:

- between the low and the middle latitudes;
- between tropical, subtropical and middle latitude climates;
- between semi-arid and humid conditions;
- between maritime and continental situations.

From this comes a congenital variability of its environmental conditions, which appears directly influenced by global changes.

It is useful to point to the geographical characteristics which make the Mediterranean such a unique and original part of the World. In fact it is characterised by a richness of contrasts, with arid and rainy regions, deciduous and evergreen vegetation, mountain and lowland environments, and especially by its fragile equilibrium.

(*) These researches have been undertaken within the framework of the «Human Dimensions of Global Environmental Change» Programme.

1.2. *The main characteristics of the Mediterranean basin.* – The Mediterranean basin is located inside a collision zone among the Euroasiatic plate to the north, the African plate to the south and the Arabic plate to the east: its morphostructural setting is complex and the evolution of the eastern and western sides, divided by the Sicilian-Tunisian route, is different.

The area has been interested by at least two old orogenetic cycles, beside the still active Alpine cycle. During the Mesozoic and the early Cenozoic, the Thetis sea, an intercontinental basin, evolved during long periods of prevailing distensive tectonic. The sediments formed on the bottom of this sea have been folded and uplifted during the different phases of the Alpine orogenesis. The more recent phases of this orogenesis have been marked by impressive paleogeographic events, such as a nearly complete desiccation of the inner sea, marked by the deposition of thick evaporitic sedimentary series, partly folded and uplifted by the later tectonic movements.

Eastern Mediterranean has limited communication with oceanic waters; the Turkish plate lies on the front basaltic crust, which today is present only in the Aegean sea; sediments coming from the Nile cover the majority of its bottoms.

The Western Mediterranean, which is of more recent and complex origin, is made of several basins presenting different characteristics whilst the oceanic crust is found only in the Tyrrhenian Sea and on the Balearic islands. Several rivers are tributary of this sea and the most important of these, the Rhone River, gives origin to a large submerged delta on the north.

With reference to the seismicity of the Mediterranean basin, located in a complex geo-dynamic area included among the African, European and Arabic plates, one should make a distinction in terms of intensity: the high seismicity of the eastern sector, where the greatest risk areas are located; the relatively moderate seismicity of the western side, which however, should not be neglected from the point of view of natural risks. The seismic phenomena are of medium intensity on the Balearic islands, on the African border and the Spanish coast, on Central Tyrrhenian, the central part of the Italian peninsula, the Western Alps, the Yugoslav area and between the Turkish coast and Cyprus. Phenomena of high seismicity (that is more than 7 degrees of the Mercalli scale) interest the area of Naples-Irpinia, the oriental coast of Sicily, Albania, Greece and the Aegean Sea, Western and Northern Turkey and Lebanon-Israel.

During the last century catastrophic earthquakes involved the areas of Friuli, Avezzano-Naples-Irpinia, Belice, Messina, the Algerian coast, Yugoslavia, Turkey, Greece, Lebanon, Alexandria of Egypt.

Volcanic activities are present on the Mount Vesuvio, on the Eolie islands, on the Mount Etna, in the Canal of Sicily, in the Aegean Sea, in the south-eastern part of Turkey.

Exceptionally strong waves can hit the Italian Tyrrhenian Sea and the Io-

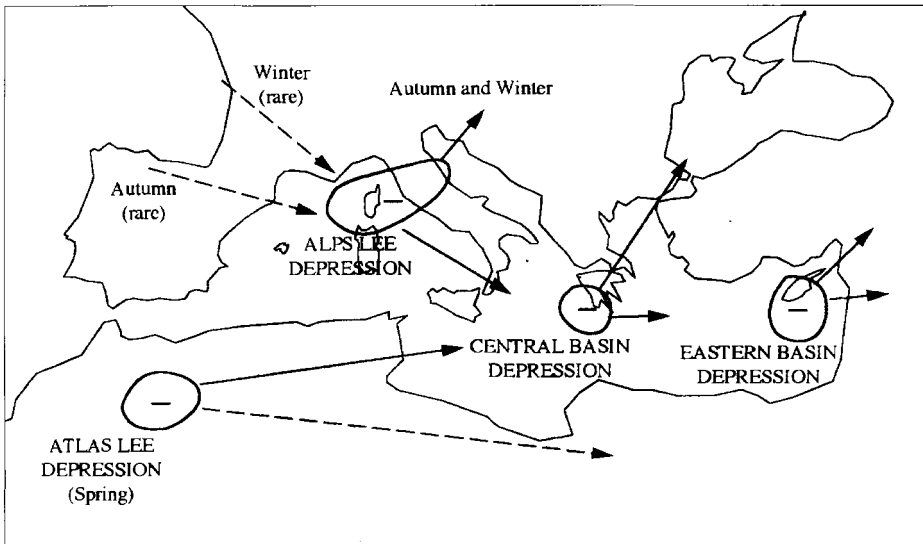


FIG. 1 – MAIN SOURCE REGIONS AND TRACKS OF CYCLONIC DEPRESSIONS (from: Wigley and Farmer, 1982, redrawn).

nic coasts, the perimeter of Sicily, the Moroccan, Algerian, Albanian, Greek, Western Turkish, Lebanese and Israeli coasts.

As far as emerged areas are concerned, almost all the Mediterranean basin is surrounded by a border of chains which causes 54% of the coastlines to be rocky or cliff-like, whereas only the remnant 46%, located mainly along the African western border and in proximity of the large delta plains (Rhone, Po), are alluvial. Alluvial coasts are presently undergoing a process of retreat caused particularly by sedimentary unbalance and intense urbanisation which involve especially the northern coasts.

The morphodynamic processes, which have sculptured the relief, are various: from the wind activity in the semi-arid areas and in the coastal belts to the glacial and periglacial processes in the high mountain environments.

With regard to the water cycle the total runoff from the inland basin toward the sea is lower than the evaporation losses so that the water deficit of the Mediterranean is replaced by the runoff from the Atlantic Ocean through the Straits of Gibraltar.

1.3. The climatic conditions. – The Mediterranean basin stretches as far as 15° in latitude and nearly 40° in longitude. The yearly average air temperatures are of more than 20°C in the south and about 13°C in the north, while the latitudinal range is not far from 15°C .

Also the annual regimes of precipitation (moreover locally affected by the orographic conditions) show a pronounced variability over time and space. The southern side has a regime characterised by winter rains and

summer droughts, while the northern side has two rainy seasons, autumn and spring, and two dry seasons, summer and winter.

The climatic conditions of the Mediterranean region are affected partly by the global atmospheric circulation (Azores and Siberia anticyclones, oscillations of the western flow and changes of the position of the connected polar front) and partly by the influences which such circulation has on the orography and the earth-sea contrasts.

These characteristics result from the predominance of the zonal over the meridian circulation, even if most of the cyclonic depressions, rather than being originated inside the Atlantic region, evolve from specific areas inside the Mediterranean basin: Atlas leeward depression, Gulf of Genoa leeward depression, Central basin depression, and Cyprus depression. In the west side of the Mediterranean basin the paths of these depressions often follow the «Mediterranean front», that is the thermal contrast between the cold continental air and the warm maritime air, while in the central and in the eastern basin the paths are going to East and North-east (fig. 1).

Briefly, the Mediterranean basin is characterised by a very high variability of climatic conditions, due to the morphological framework, and the vicinity and contrasts of continental and maritime domains.

1.4. *The human settlements and the land use.* – A total of 21 countries face the Mediterranean coasts, 11 of which are on the European side (Spain with Gibraltar, France, Monaco, Italy, Slovenia, Croatia, Bosnia-Herzegovina, Yugoslavia-Montenegro, Albania, Greece and Malta), 5 on the African side (Morocco with the Spanish Territory, Algeria, Tunisia, Libya and Egypt) and 5 on the Asian side (Turkey, Cyprus, Syria, Lebanon and Israel with the Palestinian Territories). It should be remembered that before of the political division of the former Yugoslavia (1991) there were 19 countries (excluding the Gibraltar Dominion and the Gaza Strip).

The total population living in this area of about 1,8 million of km² which correspond to the hydrographic basin tributaries of the Mediterranean Sea (with the exclusion of the Black Sea) is about 235-240 million inhabitants, with a density of more than 130 inhabit/km². Twenty coastal cities and urban conglomerations with more than 500.000 inhabitants make up at least 20% of this population.

The population settled on the coasts is larger, if we consider also other towns. Reliable estimations show that 35-40% of national populations live in the fluvial basins tributaries of Mediterranean sea. According to the U.N. Blue Plan, in 1985 the population was 132,5 millions. Recent information (1995) give a total Mediterranean population as 150,5 million, with a growth of 18% in a 10 years period at a rate of about 1,8% per year. Considering an average growth rate of 0,2% per year for the European countries and a 2,8% per year rate for the other countries, it is predictable that their respective population – today the population of the European countries is a little more than 50% of the total – will become equal before the end of the present century.

On the other hand, in the last decade (1985-1995) the urban population of the European countries has increased only a little more than 1 million of people (with an urban rate growing from 66,6 up to 67%), in the Afro-Asiatic countries the urban rate grew from 51,9 to 57,9% of the total population. It is significant that the demographic growth, in the same period and for all the Mediterranean countries, has been almost fully absorbed by the urban population.

The trends emerging from these data show an increasing demographic pressure in the Afro-Asiatic countries, as well as a growth of their urban population, concentrated in few large metropolis, and a slowdown – and in many cases a real breaking – of the urban growth in the European countries.

The coastal terrains are characterised by an alternance of urbanized areas, cultivated areas and steppes. The Mediterranean cultivations show a dominance of olive trees, vineyards, and citrus fruit groves which virtually continue from the Côte d'Azur to Gibraltar, being common on the African coast from the straits of Gibraltar to the gulf of Hammamet, interspersed with strips of meadows and pastures.

The rest of the African coast up to Alexandria is dominated by steppes with brief stretches under Mediterranean cultivation in the area of Tripoli and more sparsely in the area of Benghazi. Intensive farming (cereals, vegetables, fruit trees) are prevalent on the delta coast of the Nile River, whilst the uncultivated desert dominates over the Mediterranean coast of the Sinai.

The Mediterranean cultivation resumes, almost without a break, on the Israeli, Lebanese and Turkish coasts accompanied by vast areas of meadows, pastures and woods. Extensive farming, with a predominance of cereals, is found on the Greek coast between the Turkish border and the Khalkidhiki peninsula, whilst on the coasts of Euboea, Attiki, Peloponnisos and Ipiro Mediterranean cultivation is pre-eminent. The latter, after a strip of meadows and pastures in Southern Albania, resumes along the southern Yugoslav coast and covers the islands in the northern area; the continental coast is mainly dominated by meadows, pastures, and woods.

The protected areas along the Mediterranean coast, except those present in Italy, which will be dealt with in a separate chapter, are represented by the Rhone delta, by the tract between Malaga and Gibraltar, by the Turkish coast on the southern side of the Marmara Sea, by a tract of the north-western coast and by a region of the northern Yugoslav coast.

The tourist settlements have reached an extensive expansion on the Côte d'Azur, the Côte Vermeille and the adjacent Costa Brava, in the northern and southern parts of the Azahar Coast and on the Costa del Sol. The tourist settlements on the Balearic Islands are particularly large and intense. Only a few stretches along the western African coast are interested by tourist settlements such as the coastline between Ceuta and Tetouan, the Melilla area, and the gulfs of Tunis and Hammamet.

Several tourist settlements are found on the Lebanese coast, and more intensively on the perimeter of Cyprus; they are also present on the we-

stern Turkish coast and they are quite numerous on the Greek coast and on the Aegean islands. The Yugoslav coastline has tourist density between the Albanian border and Dubrovnik, on the Split and Zadar coasts, on the numerous nearby islands and along the coast of Istria.

The high industrial density areas are those of Marseille, Barcelona and Tunis. Steel plants are to be found in Marseille, Valencia, Tunis and Athens; metal plants are in Cartagena and Athens; shipyards at Marseille, Barcelona, Oran, Algiers, Annaba, Tunis, Susa, Alexandria, Tel Aviv, Beirut, Izmir, Istanbul, Athens; chemical plants at Marseille, Barcelona, Oran, Algiers, Skikda, Tunis, Sfax, Gabès, Marsa-el-Brega, Alexandria, Haifa, Adalia, Izmit, Istanbul, Thessaloniki. Oil terminals are in Marseille, Fos, Tarragona, Cartagena, Algeciras, Malaga, Arzew, Bejaia, La Skhirra, Gabès, Tripoli, Sidra, Marsa-el-Brega, Tobruk, Alexandria, Haifa, Sidon, Tripoli of Lebanon, Banyas, Dortyol, Mersin, Thessaloniki, Athens, Ballsh. Oil refineries are located on the coasts of Marseille, Tarragona, Cartagena, Algeciras, Arzew, Bejaia, Skikda, Bizerte, Tripoli, Sidra, Marsa-el-Brega, Alexandria, Ashdod, Haifa, Sidon, Tripoli of Lebanon, Banyas, Larnaca, Mersin, Aliaga, Izmir, Thessaloniki, Aspropyrgos, Corinth, Ballsh, Rijeka.

Coastal oil deposits are present on the mainland areas of Sfax, El Hamra, Mersin, Ballsh, and off-shore in front of the mouth of the Ebro River, the gulf of Hammamet and the gulf of Gabes; deposits of natural gas are present on the coastal stretches of Rass Maamoura, inland, and off-shore the gulf of Gabes, in the nearby of Marsa-el-Brega, in front of the Sinai coast on the Nile delta, and along the Greek western coast.

2.0. THE MEDITERRANEAN AND THE GLOBAL CHANGES.

2.1. *Significant aspects of the regional and global changes.* – Because of its particular position and closeness to the great oceanic and continental world domains (from the Atlantic to the Indian Ocean, and from Africa to Asia), as well as for its optimal dimensions, the Mediterranean basin appears very sensible to the influences of both global changes and human impact.

Significant aspects of the global and regional changes of the Mediterranean are:

- a) the increase in the sea level,
- b) reduction of the glaciated areas,
- c) increase of the climatic variability,
- d) increase of the evaporation,
- e) extension of the urban heat isles.

2.1.1. The increase in the sea level. In the last century the sea level has experienced a general rise estimated to 10-15 cm (Pirazzoli, 1993). This rise is both controlling the coastal evolution and influencing the human settlements of the low coastal belts. The forecasts of eustatic sea level rise due to «greenhouse» global warming in the 2100 are in the range of 37-

66 cm. Some coastal belts which are very near or even below the actual sea-level and are still lowering by man-induced subsidence, will become more and more at risk from storm surges (Bondesan et alii, 1995).

2.1.2. The reduction of the glaciated areas. High mountain areas represent the key environment for an understanding of the character and size of environmental and climatic changes in this century.

We can detect different intense signals of global warming in the twentieth century from the «cryosphere» of the Mediterranean region. In particular, mass wasting and evident retreat of the glaciers, the reduction of the permafrost and of the active rock glaciers in the circummediterranean chains represent significant parameters of climatic monitoring.

2.1.3. The increase of the climatic variability. Recent observations on the variability of the climatic conditions referring to the central sector of the Mediterranean basin, as occupied by the Italian peninsula, during the last century show a positive trend of temperature; the trend is more intense in May and November, especially on Sicily, while, in the same period precipitations are characterised by a negative trend, more evident in April and October, and again particularly intense in Sicily.

Otherwise, as in the Balkan peninsula, the occurrence of heavy rain periods is linked to the predominance of the meridian circulation, while the turnover of dry periods (as observed in Sardinia and in the Aegean Islands) is due to the prevalence of a zonal circulation. The average duration of dry periods in summertime, even for places not very far from the coastline (as for instance on the Mediterranean French coast), can be very different, unlike the rain periods (Pinna ed., 1991).

Another aspect of the climatic variation in the Mediterranean basin is represented by the growing frequency of very concentrated rainfall episodes (especially on the inner side of the Alps or on the Tyrrhenian side of the Apennines) (Pinna ed., 1991).

2.1.4. The increase of the evaporation. It looks certain that the recent climatic oscillations in the Mediterranean basin as well as some clear trends of their main parameters, are related, as in the rest of the World, to human impact. One of the most evident consequences is the «greenhouse effect», responsible for the rise of air temperatures, and for the evapotranspiration (both from soil and vegetation). The latter, characterised by a rise potentially oriented towards 5%, is estimated in nearly 400-600 mm per year (Jefic, Millima and Sestini, 1992).

2.1.5. The extension of the urban heat isles. A significant trend, finally, is the progressive rise of the minimum values of temperature in the large urban centres (the example of Rome, with a secular trend of 1,17 °C, is very typical), due to the urban heat island effect, rather than to global influences (Pinna ed., 1991).

2.2. *The use of natural resources and the human impact.* – It is particularly in the last two centuries that the fragile equilibrium between man and environment has been broken due to demographic expansion, the spreading and evolving of the industrial revolution with the consequent urbanisation, development of railways and modern road connections. The result of this development is the growing alteration of the natural conditions and more widespread pollution phenomena. Most of the over 500 coastal towns, having more than 10.000 inhabitants, discharge their waste waters into the seashore without any or inadequate depuration systems. On this regard, it is important to remark that the sea waters have a turnover time from 80 to 100 years, and that 75% of the industrial waste flows into the Mediterranean from the European coasts.

The use of natural resources in the Mediterranean countries reveals a broad range of activities involving nearly all biological and physical environments, with diversified approaches and a consequent different speed of evolution of the interrelation between man and environment. In particular, because of the fragility of the environment, seasonally affected by soil water deficit, land use for agriculture and grazing in the mountain areas caused an impressive erosional loss of soil.

Agriculture, even if subtracting large areas to the woods, in some places has contributed to the slope stability (for example by the building of walls and small terraces).

Furthermore, the timber utilisation has favoured a nearly continuous process of deforestation, which has changed the landscape and climate of entire regions, stimulating an accelerated soil and soft rocks erosion on the slopes. Forest and scrub firing have also increased the human impact on the Mediterranean vegetation.

The over-exploitation of surface and underground water, mainly during the dry summer periods, has reduced both the storage water and the natural surface runoff, especially in river-beds. The construction of dams and the utilisation of artificial lakes and other storage basins, both for irrigation and hydroelectric power, has only partially solved the water deficit problem. The land reclamation of several wetlands has changed the local environmental conditions, both from the climatic and from the socio-economic point of view.

Also the mining and quarrying activities, mainly the use of stone materials and marls for cement, has modified the landscapes and environmental conditions in large areas.

As a consequence of this use, fishing and hunting heritages have experienced a strong selection of the endemic species, with the disappearance of some and introduction of many alloctonous ones. The intense zootechnical and pastoral activity has confined the native fauna in very limited ambits with an irreversible disruption of the pre-existent equilibria.

In recent times a phenomenon of rural exodus caused the abandonment of extensive marginal areas and the beginning of spontaneous reforestation.

On the other hand, some areas are interested by modern and intensive forms of impact such as commercial agriculture and animal farming, with a consequent deepening of contrasts of adjacent areas.

New types of impact have developed both in urbanised and industrialised areas and in regions with intensive agriculture. In particular the chemical and physical pollution of air, water in aquifers, rivers, and sea, and the phenomenon of acid rain are threatening the value of resources, the heritage of monuments and man's health.

The evolutionary trend of the depositional coast are the result of the interconnection between natural processes and human actions. In the Roman period the shore line used to be further back than today. At the end of the Roman period, a progression of deposits started, which continued up to the end of the 19th century, probably linked with soil erosion by deforestation and soil use for agriculture and sheep grazing. At the beginning of the 20th century, however, the coast began to be eroded. This was caused as much by natural factors as it was by anthropic factors. One of these natural factors was the rising of the sea level, especially important in areas where subsidence plays a significant role (in Pisa, Venice or Ravenna), and in general along all the large Italian deltas. The exposure of various coastal stretches conditions the way they evolve; for example the Tyrrhenian and Ionic coasts, as the coasts of the large islands, are affected more intensely by the marine weather conditions; the weather variations on the islands can cause exceptional events (such as huge sea storms) which might cause considerable change on long coastal stretches.

In recent times anthropic action has, in some cases, speeded up the process of the ongoing erosion: huge hydraulic construction works along waterways, and the indiscriminate sand drawing from river beds for construction work have led to a lessening of solid detritus carried down to the sea and a consequent worsening of the already high sedimentary deficit.

Hydrological works, such as rectification of stream courses, land reclamation of flood basins, building of high levees, increasing percentage of urbanised impervious surfaces, creation of artificial lakes for the production of hydroelectric power and for irrigation, have modified the hydrological behaviour of water courses. If flood episodes are rarer than in the past, they attain a greater magnitude. The examples are numerous. We can remember the floods of Fall 1966 in North-eastern Italy and in Tuscany, the floods in Liguria and Piedmont from the 1970s to the 1990s, etc.. All these floods, which have interested also areas which historically have never been inundated, caused life losses and extensive damages.

The pollution of coastal waters linked to industrialisation has caused atmospheric variations of such magnitude to provoke a disappearance of *posidoniae*, plants which have been vital to the stability of coastal areas.

Finally the development of tourism, with the construction of new roads and infrastructures, has often caused an upsetting of the natural beach profile.

The increase of the level of anthropization has augmented the risks for the human settlements.

There are geomorphologic and hydrogeologic risks, often provoked or fostered by human intervention such as wild deforestation, irrational opening of new roads, illogical earthworks, extensive lotting which does not take into account the physical and geologic characteristic of the territory, the abandonment of land of peasants, the undiscipline of waters: all these factors provoke frequent slope troubles and landslides which involve infrastructure and populations alike.

There are risks deriving from the frequent and sometimes massive wood fires which destroy extensive patrimonies, represent a danger for the population, and deprive the territory of an important defence against water slipping and soil erosion.

Then, there are risks deriving from sea and coastal pollution due to oil terminals, oil tankers, motor-boating, urban and industrial water discharges, soil, water and air industrial pollution, air and noise pollution in high population density centers, urban waste and toxic industrial waste.

3.0. ITALY AS A CASE STUDY.

3.1. *Introduction.* – Because of its central location in the Mediterranean basin, and also for its latitudinal extension (with the Alps linking it to the Central Europe and Sicily lying in front of the African coast), the Italian region comes to symbolise a particular model, suitable to represent (also from the human-geographical point of view) past as well as present appearance and changes which characterise the Mediterranean basin.

Italy is in the expression of the intense geodynamic activity of the Mediterranean Region. Many historical earthquakes, even the 10th and 11th degree of the Mercalli scale, have been reported. Some of them have caused many thousands of casualties, morphological changes and severe damages to the settlements of large regions. As far as the volcanic activity is concerned, in the central and southern part of the peninsula, and in the surrounding sea, several living volcanic apparatus of different types are present, both emerged and submarine. Huge eruptions, like that one of Vesuvius in 79 A.D., are among the best known examples of natural catastrophes.

In Italy the large diffusion of phenomena of often marked geomorphologic and hydrogeologic troubles is essentially tied to the geologic and geomorphologic complexity and relief articulation and energy which are present almost on the whole national territory, given their young age (sharp gradient between ranges and floor of the valleys and very pronounced slopes) (fig. 2).

This last factor, in conjunction with particularly aggressive climatic conditions (intense precipitations concentrated over short periods of the year), favours the starting and constant progression of large and frequent slope processes (from superficial erosion to mass movements) with heavy repercussions on flood phenomena (esondations) in the valley and plain areas (fig. 3).

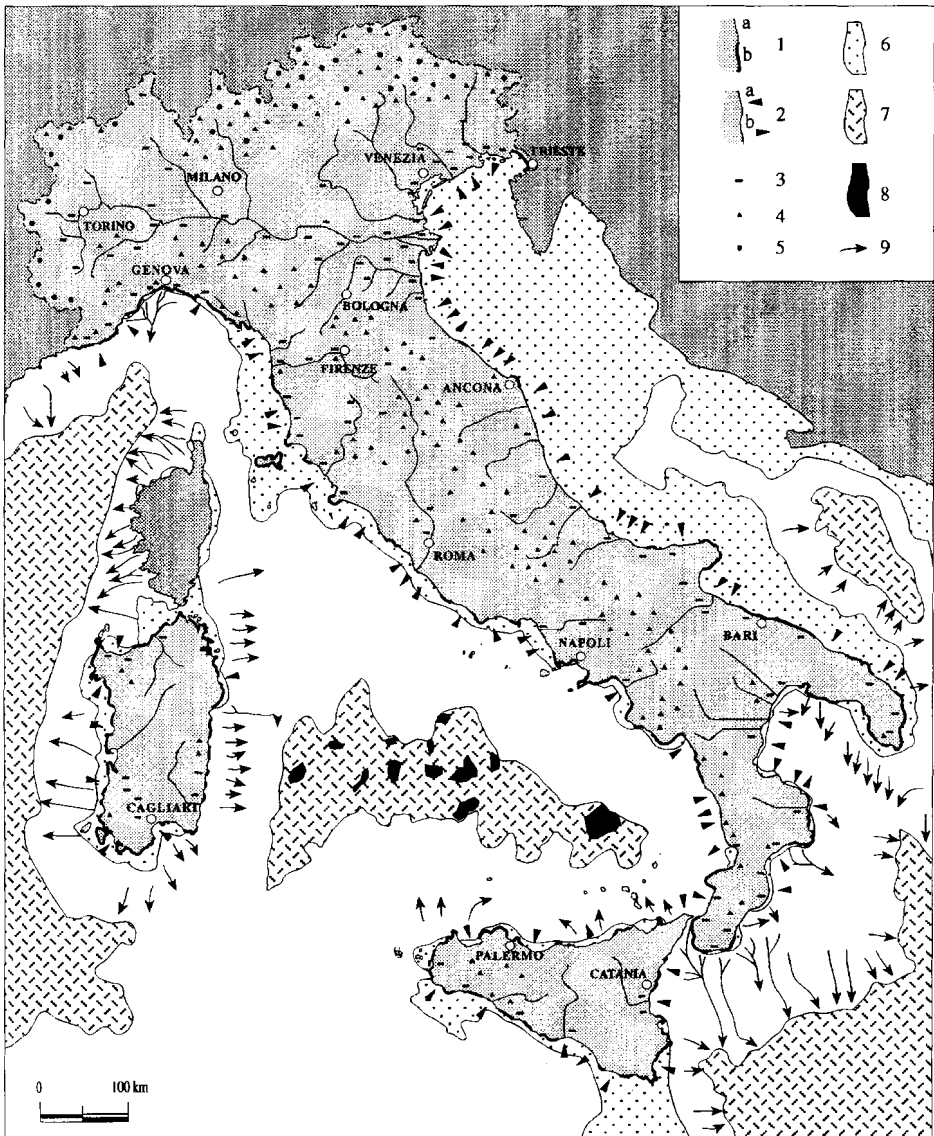


FIG. 2 – SOME PHYSICAL AND ENVIRONMENTAL ASPECTS OF ITALY:

1a) sand beaches, 1b) high coasts; 2a) retrograding beaches, 2b) prograding beaches; 3) areas with elevated inundation risk; 4) areas with frequent landslides; 5) areas with risk of avalanches; 6) continental shelf; 7) sea basins; 8) sea-mounts; 9) submarine canyons.

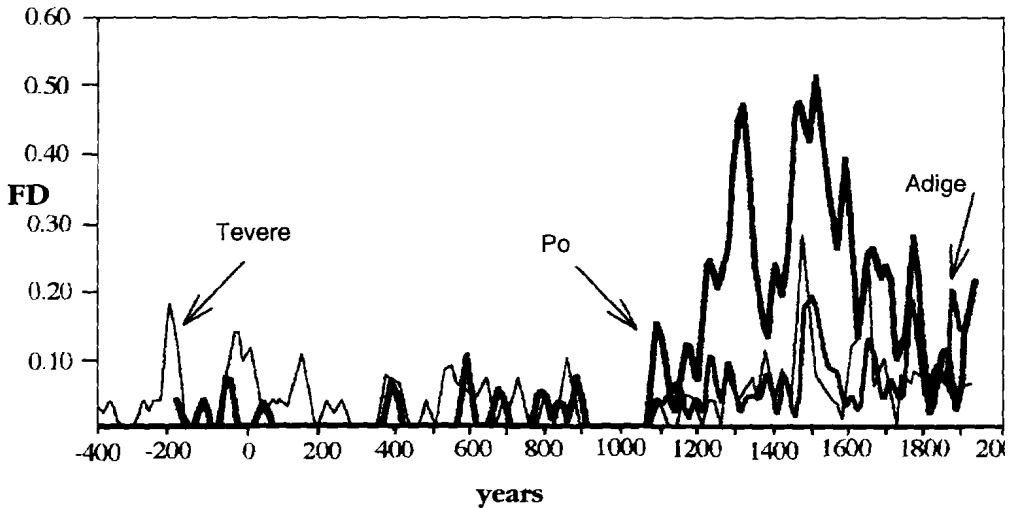


FIG. 3 - FREQUENCY DISTRIBUTION (FD) OF THE FLOODS OF TIBER RIVER, ADIGE RIVER AND PO RIVER.

The series of data are treated with the Tukey-Hanning filter ($T=50a$; $AP=5a$). It is possible to recognise some significant correlation (redrawn from Camuffo, 1992).

To these physical-geographical factors of environmental risk one should add, and increasingly so in the course of the last decades, anthropic factors such as agricultural activities (changes in type and technique of cultivation, artificial terracing, rural exodus and abandonment of the land), deforestation, development of settlements and road network (tied particularly to the development of mountain tourism). All this caused either radical transformation in the use and covering of soils, speeding up the natural processes of slope evolution, or new phenomena of geomorphologic instability.

From the point of view of human impact and settlement, Italy represents one of the main crucibles of the Mediterranean civilisations. In time, seafaring nations have mixed with shepherd and agricultural tribes of different origin. The peasant civilisations of an agricultural and partly pastoral country, as it was Italy up to the end of the 19th century, tried to use the available or usable lands for agricultural and grazing activities not only on the plains, where it was obviously easier, but also in areas of relief both in the Alps and in the Apennines. Thus, along the coastal perimeter not only the plains, generated by the streams of water flowing to the sea, were put under cultivation, but also the hill and mountain slopes facing the Italian seas (such as the Maritime Alps between Genoa and Ventimiglia, the Eastern Alps in the area of Trieste, the Apennines along the peninsula).

The loosened materials, resting on rocky substrata, of eluvial, colluvial, alluvial, landslide and eolic origin, were removed, cleansed, and transported from the places of oversupply to places of scarcity. They were placed in

terraces sustained by dry stone walls on steep slopes to be used for cultivation whilst they were cleaned and arranged with no necessity of terraces on hilly and gently steep slopes.

The emigration of young people from the countryside to the new places of work was started by the country's industrial revolution, the construction of coastal railway lines, the building of ports, the strengthening and development of ship building, military arsenals and ports. We should not forget that thousands of young people and their families migrated abroad, especially to the Americas, in search of work leaving behind their poor and scarcely profitable lands. The abandonment of the hills and mountains, however, became massive and impressive in the decades of 1950s and 1960s and in the following years. This was primarily due to the Italian economic boom caused by an enormous development of small and middle sized enterprises and partly due to the big industries of commerce, transport, ports, and foreign exchange. All this drew a large number of young people from the countryside, where unfortunately an adequate agrarian policy, able to respond to the demands of the population, has not been planned and put in place. Such a policy would have avoided their fleeing from the land and safeguarded the territory.

The abandonment of agricultural lands on the different coastal stretches of Italy caused gradual breaking up of terracing, local landslides, undiscipline of washing away and superficial waters, landslide movements of large proportion, weakening and often death of Mediterranean cultivations (such as olive groves, citrus plantations, and vineyards) with consequent geomorphologic and hydrogeologic troubles which sharply altered the peculiar characteristic of the terraced agrarian landscape, painfully carved out over years of tenacious and courageous work.

By analysing the distribution of unbalance of the national territory one can point out the high environmental risk present in Italy, which should be considered as the product of both geomorphologic hazards (for natural as well as anthropic factors) and territorial vulnerability. The regions most interested by erosion and landslide phenomena including inhabited areas are the Central and Southern Apennines (Basilicata, Molise and Calabria) followed by large stretches of the Ligurian and Tosco-Emilian Apennines, the Alpine zone, particularly on its oriental part interested also by avalanche phenomena (figg. 2 e 4).

The Italian profile, which we now present as a paradigm of the changes in the Mediterranean region, shows us some significant perspectives referring both to the coastal areas and mountains or lowlands, with an emphasis on a very typical environment, as the karst one. We will outline in order the following environments:

- a) the seas and coastal areas,
- b) the plains and the inner waters,
- c) the mountains,
- d) the karst areas.



FIG. 4 – SOME ANTHROPIC AND HUMAN IMPACT ASPECTS OF ITALY.

1) Coasts interested by tourist settlements; 2) polluted coasts; 3) polluted water courses
 4) ship factories; 5) iron and steel factories; 6) mechanical factories; 7) chemical plants; 8)
 petrochemical plants; 9) oil-terminals.

3.2. *Seas and coastal areas.* – The submarine morphology of the continental Italian platform differs greatly as far as its western basins are concerned (Ligurian Sea, Sardinian Sea, Tyrrhenian Sea, and a large part of Northern Ionian Sea): in general it is not a large platform, with the exception of the stretch in Tuscany, dotted by a number of canyons and often covered by large quantities of sediments.

The Canal of Sicily differs from this general profile; here there is an ample platform, which reaches its maximum extension on the south-western and south-eastern parts in the Adventure Bank and in the Canal of Malta.

On the contrary, the oriental basin (i.e. the Adriatic Sea) is characterised by a totally different morphology. The high and mid Adriatic develop entirely inside the continental platform, except the middle Adriatic hollow off-shore Pescara. Beyond this limit, there is a steep and canyon-run continental slide; in the high Adriatic Sea, recent sedimentary strata, which tend to disappear to the east, are particularly relevant.

3.2.1. *Coastal morphology.* The morphogenesis of the around 7,500 km of the Italian coast is conditioned by the remarkable structural and geological variability of the peninsula (fig. 2).

A recently done neotectonic zoning emphasises the fact that a large part of the Tyrrhenian basin is bordered by rising coastal strips, while, on the contrary, in the Adriatic basin it is possible to distinguish two markedly different zones: the rising southern zone and the slowly sinking northern one.

Along the coasts of the western basins it is possible to recognise topologies tied to different relationship between tectonic and nutrition, with an alternation of shallow alluvial coasts and rocky cliff-like coasts.

Similar topologies interest also the low Adriatic, the Southern Ionian, and the Canal of Sicily. On the contrary the high-mid Adriatic and the Northern Ionian are examples of a foredeep regime characterised by a cover tectonic with inverted faults interesting soils subject to erosion: the result is a gentle and predominantly hilly landscape, with ample sandy strips; such a topology is especially relevant in the North, where the Apennines foredeep is entirely filled with recent sedimentary strata.

3.2.2. *Deep changes of the Italian coastal belts due to an increase of anthropic pressures.* Today, all the coastlines of the Italian peninsula are interested by human settlements with an intensity which varies according to the region. The large concentrations of people along the coasts or in the immediate nearby are present in the areas of Rome, Naples-Salerno, Genoa, Palermo, Bari, Trieste, Venice, Catania, Cagliari. Long stretches of coast with a high population density are the coasts of Liguria, Tuscany from La Spezia to Leghorn, Latium-Campania, the Adriatic side of Apulia, the stretches between Pescara and Rimini and between Venice and Trieste, the Gulf of Cagliari.

The use of coastal soil is characterised by Mediterranean cultivations with a predominance of olive trees, vineyards, and citrus groves, with a ter-

raced disposition along the Ligurian coast and with woods and shrubs along the Central and Southern Adriatic coasts; intensive cultivations are prevalent on the northern part, with cereals, vegetables and fruit trees; woods and shrubs are common on the Gargano as well as on the Calabrian, Ionian and Tyrrhenian coasts; Mediterranean cultivations continue on the Tyrrhenian coast with almost no interruption up to the Tiber River; on the coast of Tuscany they alternate with meadows, pastures, conifer woods, and intensive cultivations.

The Sicilian coasts are almost entirely occupied by Mediterranean cultivations, the Sardinian coasts have extensive meadow and pasture areas in both the north-western and south-western sectors; elsewhere there are Mediterranean cultivations.

Today there are several protected coastal areas such as the national park of Circeo, the natural parks of S. Rossore and Maremma, the regional parks and the protected areas in the regions of Etna, Gargano, Vallegrande-Cinque Terre-Riviera Spezzina, in the promontory of Portofino in Eastern Liguria, on the Bergeggi and Gallinara islands in Western Liguria, on the mouths of the Reno and Po Rivers, in the lagoon areas in the Venetian region.

The tourist coastal settlements reached very high extension on the peninsula in particular on the coasts of Liguria, Tuscany in the nearby of Viareggio, Elba island, Gaeta-Formia, Sorrento peninsula, and on the Adriatic coasts between Pescara and Cervia and between Chioggia and Trieste. Furthermore, there are limited but very concentrated tourist areas such as those on the coasts of Leghorn-Castiglione, Castiglione della Pescaia, Anzio, Taormina, Cefalu, Lipari Islands, Salento, Sardinia between Olbia and Maddalena, and Alghero.

The highly industrialised coasts are those of Genoa, Tuscany between Leghorn and Piombino, Ravenna, Venice, Naples. Metal and steel plants are present on the coasts of Genoa, Piombino, Naples, Taranto, Venice, Cagliari, Portofino; mechanic plants are to be found on the coasts of Genoa-La Spezia, Leghorn, Naples, Palermo, Taranto, Ancona, Trieste; chemical plants are on the coast of Tuscany, Priolo Gargallo, Cagliari, Taranto, Brindisi, Ravenna, Venice and Trieste.

The major oil-tanker terminals are located on the coasts of Liguria (Genoa, Vado Ligure, La Spezia), at Leghorn, Pantano di Grano, S. Salvo, Naples, Milazzo, Palermo, Augusta, Gela, Brindisi, Bari, Ancona, Ravenna, Marghera, Trieste. The main refineries are located on the coasts of La Spezia-Leghorn, of Latium and Campania, in the area of Milazzo, in the area of Augusta, in the Salento peninsula, near Ancona, Ravenna, Marghera and Trieste.

Coastal oil-fields are on- and off-shore on the coastal stretches between Gela and Ragusa and between Pescara and Ancona; fields of natural gas are present both on- and off-shore along the Adriatic coastline between Porto Tolle and Gargano, on the Ionic Calabrian coast and on the coast of Augusta, with several platforms especially in the Adriatic Sea.

3.2.3. Water pollution of the Italian coast and the Mediterranean basin. The pollution of the Mediterranean waters is due to the silliness of the coastal, as well of inland populations who pollute the rivers flowing to it, who carelessly consider the basin as a convenient tank where to discharge enormous quantities of liquid and solid waste. They do not seem to take into account the fact that the Mediterranean is a closed sea with one of the highest population density in the world, at least on the European side.

Pollution is even worse since we deal with a peripheric basin with minimum communication with oceanic waters; a program of partial cleansing or lessening of the degree of pollution should operate through the Strait of Gibraltar, where it has been calculated that several decades would be required for superficial waters and even more for deeper waters.

Much responsibility of the pollution of marine waters lies on superficial continental waters (that is rivers and lakes) whose pollution is derived from urban residual waters, industrial waste, insecticides, pesticides, and fertilizers used in agriculture, non degradable synthetic detergents, hydrocarbons, hot industrial waters. The waters with the highest degree of pollution are to be found in highly industrialised areas: almost all prealpine lakes on the Italian side are considerably polluted (Orta, Maggiore, Como, Iseo, Garda); they are located in regions of intense industrialisation such as Piedmont, Lombardy, Venetia, which heavily pollute also the rivers Po, Reno, Adige, Piave, Tagliamento, Brenta, with visible effects at their mouths (fig. 5).

There are other coastal waters which receive the mouths of minor unpolluted streams or which do not have streams coming from inland, whose water pollution derive primarily from the concentration of people (with discharge of biologic waste and non degradable synthetic detergents) and secondly from the presence of industrial conglomerates, oil terminals, oil refineries, chemical plants (see previous pages).

It should be kept in mind that in Italy there are several oil-tank ports: Savona, Genoa, La Spezia, Leghorn, Civitavecchia, Naples, Cagliari, Milazzo, Gela, Augusta, Taranto, Ravenna, Marghera, Trieste; in the Mediterranean there are Marseille, Sète, Málaga, Pireo, Eleusi, Salonicco and the ports of the African and Asiatic coasts.

Oil derived pollution is due to the numerous oil terminals present on the Mediterranean coasts, oil-refineries located on the coastal areas, washing up made by several oil-tankers during navigation, serious accident periodically occurring to the oil-tankers (let us remember the 1985 collision, occurred in the Messina Strait, between the Patmos oil tanker and the Spanish super-tanker Castillio de Monte Aragon, which provoked a 7 km black spot on the Calabrian and Sicilian coasts; let us remember the 1991 explosion of the Haven tanker off-shore the Genoan coast, whose oil burnt for days producing high black smoked columns, spoiled the beaches of the Riviera or descended on the sea bottoms forming very large tar crusts) (fig. 6).

One should not underestimate the thermic pollution caused by dischar-



FIG. 5 – CLEANING OPERATION OF A POLLUTED BEACH (TYRRHENIAN COAST).

ge of industrial hot waters or power stations into sea, lake or river waters since the biologic water world is very sensitive to changes of temperature. We should remember that the coasts of the Italian peninsula, Sicily and Sardinia have several power stations, while other are located on the coasts of France, Spain, Greece, Western Turkey, Cyprus and Northern Africa.

A serious problem is the pollution of underneath water strata, since a large quantity of water for domestic and agricultural purposes is extracted in this way. The pollution comes from several sources: losing wells discharging organic waste and detergents underneath, urban waste going underneath when sewage systems are not properly built, pesticides, insecticides, chemical fertilizers for agriculture washed away by rain waters, harmful industrial waste, discharges of toxic materials hidden underneath.

3.2.4. Landslides and floods on coastal slopes and high coasts (human and natural risks). Reliefs along several stretches of Italian coasts determine steep maritime slopes with a predominantly high coastline, interspersed by alluvial coast in front of alluvial fluvial plains.

Of the around 7,500 km of Italian coastline, more than 50%, that is a little more than 4,000 km, is made of high rocky and often cliffed coasts characterized by withdrawal phenomena which, depending on the geologic-structural and geo-morphologic conditions, are revealed by rockfall, rockslide, rocktoppling or slumping landslides. These are particularly widespread



FIG. 6 – FIRE OF HAVEN OIL-TANKER IN THE TYRRHENIAN SEA NEAR GENOA (1991).



FIG. 7 – SHORELINE EROSION ON AN URBANISED COAST (LATIUM).

in Liguria, Campania, Calabria, Apulia, Sicily and Sardinia on the slopes most exposed to the strong sea-storms of libeccio, mistral and sirocco (fig. 7).

Also the coastal basin of the above mentioned areas are subject to frequent processes of geomorphologic instability.

The closeness of watershed ridges to the coastline, between the coastal and inner valleys – as in the emblematic case of Liguria, where the separation line between the Tyrrhenian and Po basins ranges beyond 1,000 m at a very short distance from the sea (which is often only 1-2 km away) – conditions the presence of very steep gradients (50/100%) subject to erosion phenomena.

The geomorphologic hazards of large stretches of the Italian coastal areas are tied both to natural factors, which favour or cause troubles, and to factors directly or indirectly bond to human intervention. The latter affects the slopes near the floor of the valleys, the terminal coastal plains, and along the high coasts which in turn either increase the impact or generate a further one. These anthropic factors can be summarised as follows: variations of vegetation (deforestation, changes in cultivations, fires) with consequent effects on areal and linear erosion of soils; abandonment of agricultural activities along the slopes, with their consequent degradation due to dismantling of artificial terracing, drainage works, and the regime of meteoric waters (fig. 8); development of settlements and road network along the slopes and full urbanisation of alluvial plains, with effects on the permeability of soils and on the times of decrement; rectification and narrowing of natural river beds, with an increased risk of esondation; coastal and sea-works, with repercussion on coastal dynamics and speeding up of erosion phenomena on both alluvial and high coasts (fig. 9).

The sum of all these factors causes a spreading and an increase of geomorphologic unbalance: the increase of alluvial phenomena is particularly meaningful, with a possible flooding of large areas at the bottom and at the mouth of valleys. The latter is in relation with an increase of solid materials transported by streams (overflowing of river beds and reduction of hydraulic sections) in connection with particularly intense meteoric events (for instance in regions like Calabria and Liguria, with a total precipitation of 1,000-1,500 mm, per hour and per day rains can register up to 100 and 300-400 mm respectively).

The areas presenting the highest flooding risk are the terminal parts of the alluvial plains facing the North-eastern Adriatic – the riverain areas of the Po, the Brenta, the Piave, and the Tagliamento (low plain in Veneto); stretches of the coastal plains of the regions Abruzzo (R. Pescara) and Apulia (R. Ofanto); along the Ionian Sea, stretches of the Metaponto Plain relative to the Basento and Agri rivers and the Calabrian coast (R. Simeto); the Plain of Cagliari and the plain of the R. Flumendosa in Sardinia; on the Tyrrhenian side, the terminal stretches of the Sele and Volturno in Campania, the Tiber in Latium, Ombrone and Arno in Tuscany, as well as the main streams in Eastern Liguria such as the Entella, the Bisagno, the Polcevera, the Sansobbia, and the Letimbro.



FIG. 8 – DEVASTATION OF THE DESERTED HUMAN LANDSCAPE ON THE COASTAL SLOPE OF CINQUE TERRE.



FIG. 9 – QUARRYING ACTIVITIES ON THE ELBA ISLAND COAST.

The interaction between the above mentioned hazards, both nature caused and human induced, and the intense anthropization of the coastline (territorial vulnerability) produces a high environmental risk potentially affecting a large territorial area and a good part of the population settled on the coasts.

3.3. *Plains and inner waters.* – A significant model of the Mediterranean plains is surely the Po Plain. The surface of its basin (79.000 km²) is a little more than 1/4 of the Italian territory.

Two thousand years ago the major Italian inland area, the Po plain, was still covered by a continuous deciduous forest, with a climate less continental than today. Extensive deforestation occurred mainly after the Middle Ages; today, in the Po delta, only a piece of the ancient forest remains (the Mesola Wood). The native vegetation of the Po plain can be found only in the narrow stripes of the main river banks; it is altered however by a large number of exotic species (for instance, *Robinia pseudoacacia*).

The first basic change of the Po plain landscape was a consequence of Roman colonisation, caused especially by agricultural parcelling, and in the late Middle Ages by land reclamation made by monastic orders which built many big abbeys. These were also responsible of the hydrographic network changes provoked by the excavation of many canals.

However, major changes of the hydrographic network were made under the Republic of Venice by means of the diversion of the rivers tributary of the Lagoon of Venice. Other significant changes are represented by rectifying of the course of the Po River and the regulation of many other river basins in the Italian peninsula (Adige, Piave, Arno, Tiber, etc.) (fig. 10).

The Po-Venetian Plain, which is formed also by other rivers (Adige, Brenta, Piave, Tagliamento), including its hilly borders contains more than 1/3 (about 37%) of the Italian population, whose high industrialisation and elevated standard of life involves an important water use and the production of large quantities of solid and liquid wastes. During the eighties about 1/6 of the runoff water was used by man and then introduced in the environment as polluted liquid wastes. About 80% of the industrial pollutants have been produced by alimentary, chemical, paper and textiles factories. The part per millions of nitrate, phosphate, chloride, sodium and calcium ions, as well as pesticides in the liquid wastes have dramatically increased in the last decades. After some Authors the development of algal jelly in the Northern Adriatic Sea is probably linked with the eutrophication of the waters by the polluted waters of the Po River.

3.4. *The mountain environment.* – To underline the changes occurred in the Mediterranean region during the last centuries, we should considerate mountain environment, and particularly the Alps because of their fragile equilibria.

Since protohistory, a very important aspects of the human impact on the

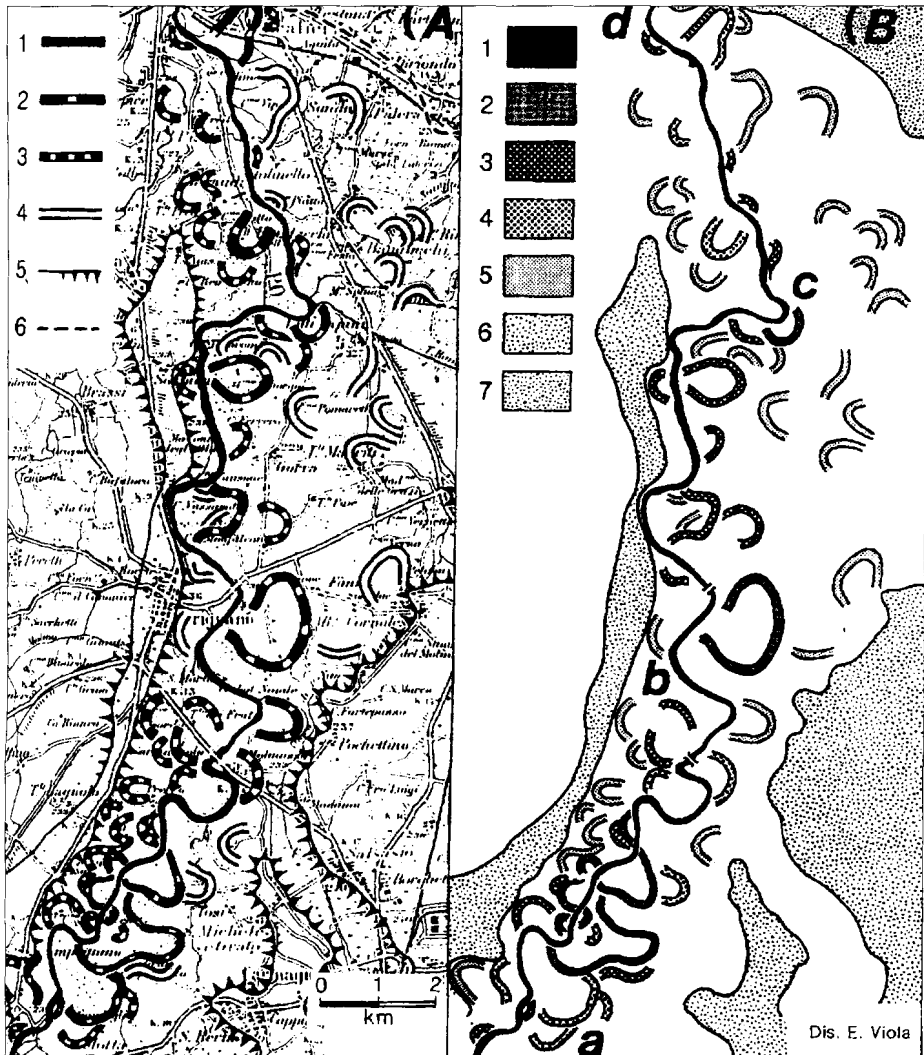


FIG. 10 – EVOLUTION OF THE PO RIVER ALLUVIAL PLAIN UPSTREAM FROM TURIN.

(A) types of water courses and (B) evolution of the river paths. In (A): 1) Active channel with irregular meandering; 2) abandoned meander bends with the original banks still preserved; 3) ditto, with concave bend still preserved; 4) ditto, without preservation of the original banks; 5) river terrace; 6) alluvial plain limits. In (B): 1) water course in 1991; 2) meander abandoned after 1949; 3) traces of paths active during the 19th century; 4) traces of 18th century active paths; 5) traces of paths active before 1700; 6) fluvial terrace of the Pleistocene; 7) high plain with edges of Pleistocene fluvial deposits. In white the Po River alluvial plain (Holocene). (From Dutto and Maraga, 1994).

The changes in the evolution style are clearly linked with the human influence.

mountain slopes has been represented by the forest clearing and soil use for agriculture and sheep grazing. These forms of soil use have caused an impressive loss of soils, with development of badlands and desertification of large areas (fig. 11).

From the point of view of environmental changes the high mountain milieu is very sensitive. The best indicators of change are:

- a) the glaciers, the permafrost, the snow-line;
- b) the changes of the altimetric limits of vegetation.

3.4.1. The glaciers, the permafrost, the snow-line. On the Italian side of the Alps the signals of a climatic change are manifest, and in accordance with observations in other sectors of the chain.

The most significant environmental changes in the high Alpine mountain region since the mid- past century can be summarised as following:

- 1) thickness and surface area reduction of the glaciers; thickness reduction, that can be estimated from the geometry of the large morainic ridges deposited during the Little Ice Age, ranges between a few tens up to a few hundreds meters, according to the size of the glaciers; the surface reduction of the Italian glaciers (mainly on the southern side of the Alps) up to now has been more than 30% (40% in the Aosta Valley);

- 2) length reduction of the glaciers mostly linked to the retreat and flattening of the fronts; the length reduction has been between a few hundred metres and some kilometres; on the whole, about 90% of the Italian glaciers are retreating (fig. 12);

- 3) fragmentation of some glacial flows and individualisation of smaller apparatus;

- 4) extinction of the smallest glaciers after the 1961; in the Lombard Alps nearly 30% of the 271 glaciers became extinct (that is 86);

- 5) increase of the till coverage on the zones of ablation; anyway the so called black glaciers are still rare (f.ex.: Miage and Brenva);

- 6) increase of the rock windows and of nunataks;

- 7) reduction of the surface of the North facing iced walls;

- 8) rise of the snow line; the snow-line raised from some tens to a few hundred metres, getting up to 3000 metres (as in the inner massifs, like Mount Rosa and Cevedale).

In the Italian peninsula, the most southern European glacier, the Calderone glacier located in the Gran Sasso massif at a latitude of 42° N, lost nearly 70% of its surface area and 90% of its volume during the twentieth century (Gellatly et alii, 1994).

In addition, the reduction of the sporadic permafrost inside the active rock glaciers has been nearly continuous (Smiraglia et alii, 1994).

Even if after the Little Ice Age, which lasted from the mid fifteenth to the mid nineteenth century, the trend in regional warming seems nearly constant, at least two little glacial progressions occurred: in the 20s and between the 60s and 80s of the present century.

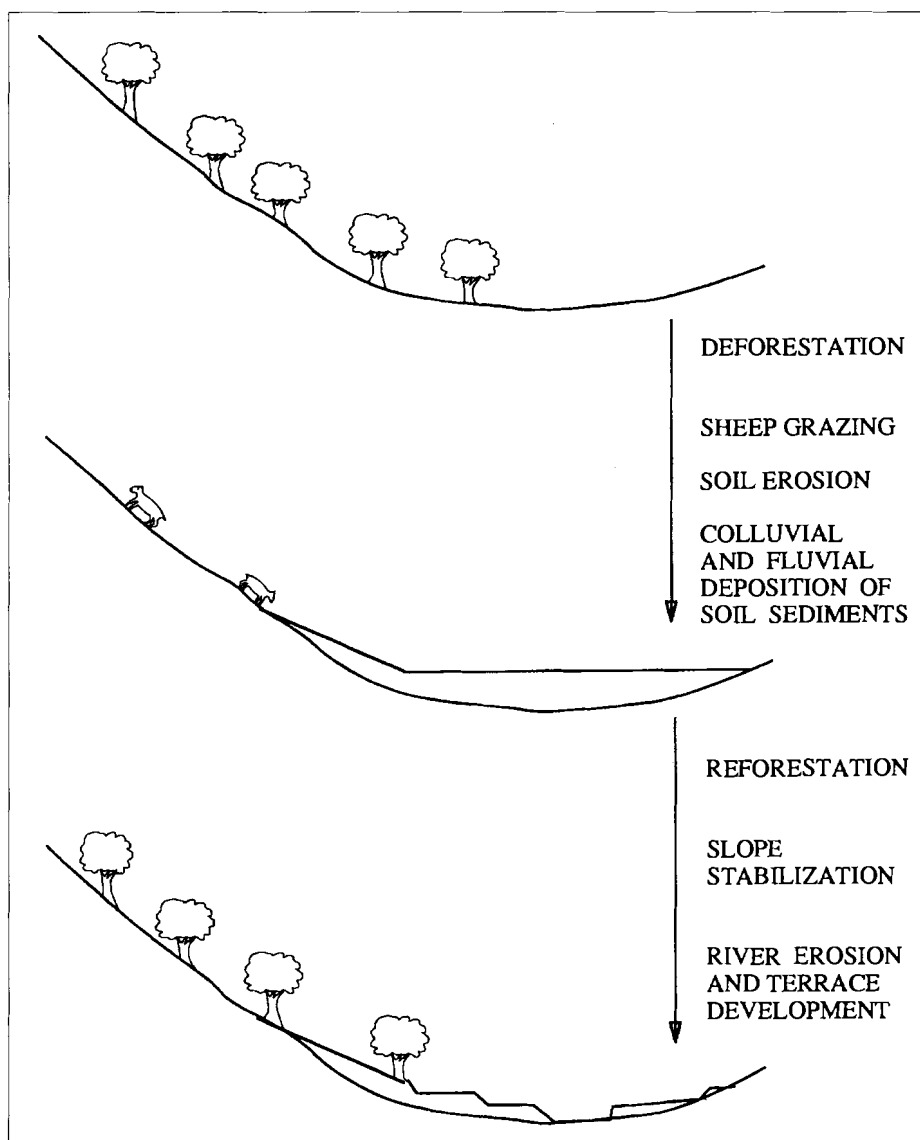


FIG. 11 – ASPECTS OF THE HUMAN IMPACT ON THE MEDITERRANEAN SLOPES.

The slopes have been forest-cleared by man and used for sheep grazing and/or agriculture. The soils have been eroded from the steeper surfaces and colluvia and alluvia have been deposited at the foot of the slopes and in the valley bottoms. Where the relief is in clay rocks, bedlands have developed on steeper slopes; on the contrary if the slopes are in hard rocks, part of the slopes have become stony deserts. In some areas, the spontaneous reforestation, linked with the ceasing of soil use, has favoured the terracing of the valley bottoms.

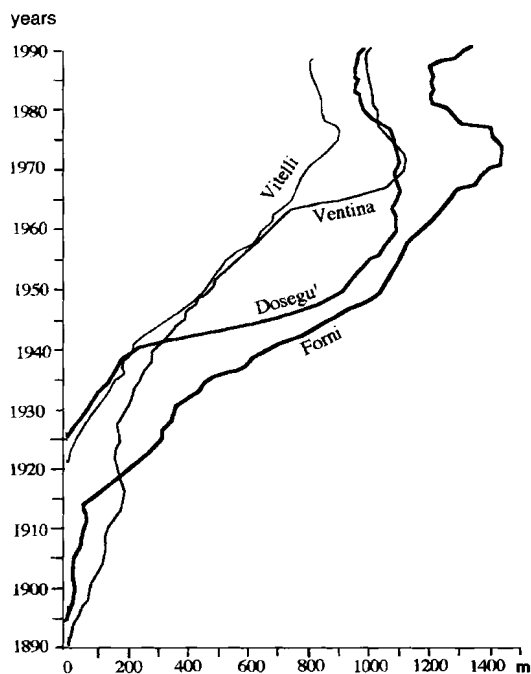


FIG. 12. CUMULATIVE GLACIER FRONT VARIATION FOR SOME VALTELLINA GLACIERS.

Along the abscissa (towards the right), negative variations are reported.
(After Pelfini and Smiraglia, 1992).

3.4.2. The timberline. The changes of the timberline (altimetric limit of tree vegetation) are linked with:

- a) variation of the phyto-climatic gradients
- b) rise of the altitude lines
- c) increase of the human pressure.

The actual flora in the Mediterranean basin is the expression of the interactions between climatic changes and activities of human communities. In particular the human activity caused deep structural changes of the original vegetation since proto-history, which consisted in the reduction of the number of species and a widespread occurrence of synanthropic and exotic species introduced both voluntarily and unintentionally.

However, it is still possible to point out the persistence of phyto-climatic gradients such as:

– a North-South gradient, deduced from the percentage of the «northern» species, with values higher than 20% in the Eastern Alps, of 10-16% in the Southern Alps, the Northern Apennine and the massifs of Gran Sasso and

Maiella, of 5-10% in the Po Plain and most of the peninsula and less than 5% in the more southern coastal belts and in the islands;

– a West-East gradient, evidenced by the decrease of western species, the highest percent of which is in Sardinia (>4%) and in the Tyrrhenian coastal belt, while the lowest is in the Adriatic coastal belt (<2%).

It is possible to compare these indexes with the percentage of exotic species that can be taken as an index of the degree of anthropic activity: the value is more than 5% in Lombardy and Po Plain, as well as in long and extensive sectors of the coastal belts and large part of Sicily (3-5%).

Moreover, the combined influence of the peculiar climatic conditions and human activities favoured the diffusion of annual species (therophytes), that are indicators of hot summers and seasonal water deficit, conditions emphasised by the forest clearing, the ploughing of the soil and by extensive farming. On the isles the therophytes represent more than 45% of the vegetation, in the mountains less than 21% (Pignatti, 1989).

An important consequence of the human impact, clearly recognisable in the landscape, has been the lowering of the upper timberline. Forest clearing in the mountain belt to enlarge the areas for summer grazing and the seasonal use of pasture has resulted in the maintenance of large secondary meadows. In the Southern Alpine valleys the forest was cleared also for the charcoal production, which was indispensable for the siderurgy industry.

In the last decades, because of the rural exodus and mountain depopulation, with a consequent reduction of both grazing activity and charcoal production, in most areas human pressure has decreased and the timberline has raised (certainly also because of the snow-line rise). For instance, in Valtellina (Lombard Alps, Bernina massif) many larch trees, only about 75 years old, surpassed the altitude of 2300 metres (fig. 13).

However, in some areas interested by tourist settlements and by intensive grazing, human pressure has deeply modified the biological characters of the environment.

In most mountain areas the income is insufficient to promote works of maintenance: the coppices are no more used and are exposed to different forms of regression; the spontaneous advance of the wood on the secondary meadows and abandoned field is following a natural dynamic, but is strongly modifying the structure of the environment and the landscape (Pirola and Credaro, 1994). This evolution interacts also with tourist activities.

The industrial and tourist settlement areas cause changes of the surrounding vegetation. This is due to the crowding of fragile environments, like the forest during the vegetative period, and the dispersion of different types of non natural wastes. The equilibria retrieval times are short both in the mountains for the low temperatures and in the Mediterranean environment for the summer water deficit.

All the Mediterranean environments are fragile for the facility of the development of fires during the summer season. Most of the fires are provoked by human activities. In some areas the shepherds use to burn the bush to

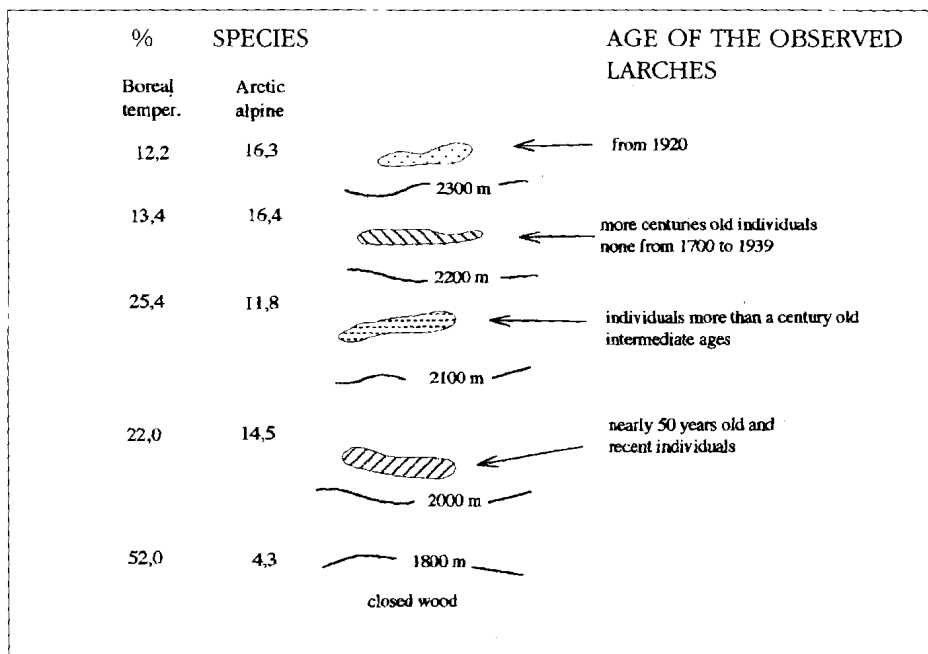


FIG. 13 – LARCHES AGE ON CENTRAL LOMBARD ALPS (VALTELLINA) AND ITS RISE OVER THE TIMBERLINE

(from Pirola and Credaro, 1994).

clear the pasture. The consequences of this custom on vegetation are well recognisable from the structure and the impoverishment of the vegetation: all the forms of «chaparral and garigue» are regressive forms, often controlled in their evolution by the thin soil and the scarce water availability, caused by the reiteration of fires since the first civilisations in the region. In the last decades many fires are primed by the activities of tourists. The last stage of the structural regression of vegetation is represented by the combination of annual species (therophytes) with a very low productivity.

3.4.3. Land use and recent human impact in mountain areas. However, the environmental changes which marked the Mediterranean basin during the last two centuries (and also the Alpine region), cannot be separated from the social and economic evolution of the European peoples and countries starting with the industrial revolution.

In fact, before the latter a sort of equilibrium was archived between the natural conditions of the Alpine environment and human activities, often by their adaptation to the former.

Because of the particular position of the Alpine system in relation to the

rest of Europe, even if at different times and in different proportions, the two sides of the Alps (the North, that is the Central European side, and the South, that is the Mediterranean one) have both been affected by the industrial revolution. The latter showed its impact mainly in the second half of the 19th century, when the large Alpine valleys, on whose plain outlet a consistent urban conglomeration was already formed, began to be crossed by the long intereuropean travel lines, and the watershed pierced by the first rail tunnels (from the Semmering, open in 1854, to Simplon, open in 1906). The increasing network of railways within the Alpine system (included the funicular- and rack-railways) is but the general result of the great economic revolution based on massive rise of production, consumption and exchange; this is the contrary of the «vie montagnarde», the mountain way of life based on a very moderated use of natural resources.

At the end of the last century and at the beginning of the present century the most interior Alpine valleys had still preserved almost unaltered their environmental conditions, even if there was growing evidence showing that the Alpine world was being affected by social and economic hard crises represented by more and more frequent episodes of mountain abandonment.

In the years subsequent the First World War, the effects of mountain depopulation – a phenomenon of European range, which began to affect the Alps in the second half of the past century – reveal all their impact. An official enquiry on the Italian mountain depopulation, made mainly by demographers and geographers in the 1930s, showed the real impact of a deeply compromised scenario. The poor conditions of human settlement were the real causes of mountain depopulation, a phenomenon that increased with the development of plains agriculture, in clear contrast with the archaic mountain economy. This contrast was also accentuated by the ways and means of the development of communication.

The decades subsequent to the Second World War were characterised by a great spreading of the Alpine valleys economic modifications. In this respect, the noteworthy development of activities linked to tourism, the exploitation of hydroelectric resources, the industrialisation on the large valleys corridors, and the spreading of the communications network were initially regarded as a revitalisation of a territory close to a demographic collapse.

As some geographers sharply remarked, such modification processes increasingly led the Alpine valleys to be the continuation of the typical plains economic management and the new industrial civilisation landscape.

It should also be underlined that the most evident modifications of the Alpine landscape are those which affect the medium and high valleys, and are caused by tourist exploitation inserted in a rural environment widely undermined by depopulation, exodus of traditional activities, and uncontrolled restarting of natural cycles.

It is very significant that the reasons leading to this new mountain occu-

pation, caused by the economic stimulus from the urbanised and industrial plains, are diametrically opposed to those which generated the humanisation of the Alpine landscape in the past centuries.

These considerations reflect the echo and preoccupation expressed by many scientists (geologists, pedologists, biologists and also geographers) on the results of these modifications upon the ecological stability of the Alpine environment, even if we don't know yet the real amount of the changes suffered by the Alpine territory. The latter suffer from a general hydrogeological instability with dramatic situations recurring after a few days of continuous rainfall.

It is not possible to foresee how far such alteration will continue and to what point this new anthropization will arrive. Through it is sure that, lacking concrete actions of safeguard and conservation, the hydrogeological instability will go on with irreversible results. We must not forget that in the past centuries in the Alpine valleys slope stability and hydrogeological control were achieved by means of a continuous and widespread human presence on the territory; to these morphological and climatic features the highlander adapted his own need that is houses and seasonal rhythms of rural activities.

3.5. *Karst geo-ecosystems.*

3.5.1. General aspects of the Karst of Italy. Karst environments represent nearly half of the mountainous area of both the Mediterranean region and Italy. Typical aspects characterising karst environments include the following:

- a strong articulation of the relief (due to many karst depressions; the karst plateaus are comparable to the low gradient but highly dissected fluvial basins);
- a prevalence of steep slopes inclined towards the centre of the closed depressions, even if the regional slope is moderate;
- a sharp interface soil-hard rocks;
- a high frequency of closed forms which act as traps for soil sediments;
- soil sediments trapped inside the fissures and the cavities of the rock.

In the Mediterranean karst, the soils belong to the so called «terra rossa» soils, polyphasic soils or paleosols containing a medium to high percent of iron sesquioxides and clay minerals. According to some Authors, these soils are the result of weathering of the insoluble residual of carbonate rocks or of covers rocks. Anyway these soils are often the product of a long term weathering of cover rocks residuals and of allochthonous materials as loess like sediments, volcanic ashes, etc.

In karst environments there is a kind of geologic aridity due to the scarcity of surface water and linked to the diffuse permeability of karstified rocks. The peculiar climatic regime of the Mediterranean karst environments emphasises this character during the summer period of soil moisture

deficiency and induce a high seasonal susceptibility to forest firing and soil erosion.

On the contrary, in correspondence of marginal springs large amounts of water are discharged, which determine oasis for vegetation and become key resources for the inhabitants of the region.

The karst geo-ecosystems of Italy are representative of typical karst environments and natural landscapes of the Mediterranean region. Due to the fragmentation of the relief induced by the recent tectonic evolution, a large number and an extreme variety of karst units are distinguishable, from very small to very large in size, from high mountain karst to coastal karst, from karst in Palaeozoic limestones to karst in Miocene, Pliocene and Pleistocene rock units. The Mediterranean karsts in evaporitic rocks are peculiar, which often determine salinization of waters and soils of nearby areas.

3.5.2. Environmental changes and human impact in the Italian karst areas. During the middle Holocene, many karst areas were covered by an extensive forest called, in its lower altitude belt, «Mediterranean forest» or «sclerophyll forest», because of the presence of hardleaved evergreen trees. Man has cleared this forest to utilise soil for grazing and agriculture and favoured in this way the erosion of the soil cover. In time, this erosion caused a nearly complete desertification of many mountain slopes.

Forest clearing, sheep and goat grazing and induced soil losses have modified both the topo-climates and the hydrological behaviour of karst geo-ecosystems (fig. 14).

Some tens of years ago, many of the karst morpho-units of Italy, especially during the dry summer season, looked like stony deserts. Now, following the land use abandonment, especially of the marginal areas, on many slopes a scrub vegetation has began to develop. The starting points for the growth of this vegetation are the small traps of soil inside fissures, grikes and small pits. Very typical from this point of view are the landscapes of Supramonte in Sardinia, where cleared stony areas alternate with bush. Most of the plateau of Classical Carso of Trieste, which was described as a stony desert during and after the first World War, is now a brushwood.

Human pressure, even if decreased in most karst units, changed its character and locally increased in some areas. In particular we find the following forms of impact:

- opening of very large quarries;
- slope terracing for modern intensive agriculture;
- large use of fertilisers and pesticides for modern intensive agriculture;
- stocking of large bio-masses of cattle, pigs, chicken in small areas; these animals are maintained mostly with industrial fodder; the waste materials are let in the environment without or with insufficient treatment plants, which causes an increase of nitrate content of the runoff waters;
- urban development of some areas, increase of the surfaces impervious to infiltration and concentration of runoff in a few points;

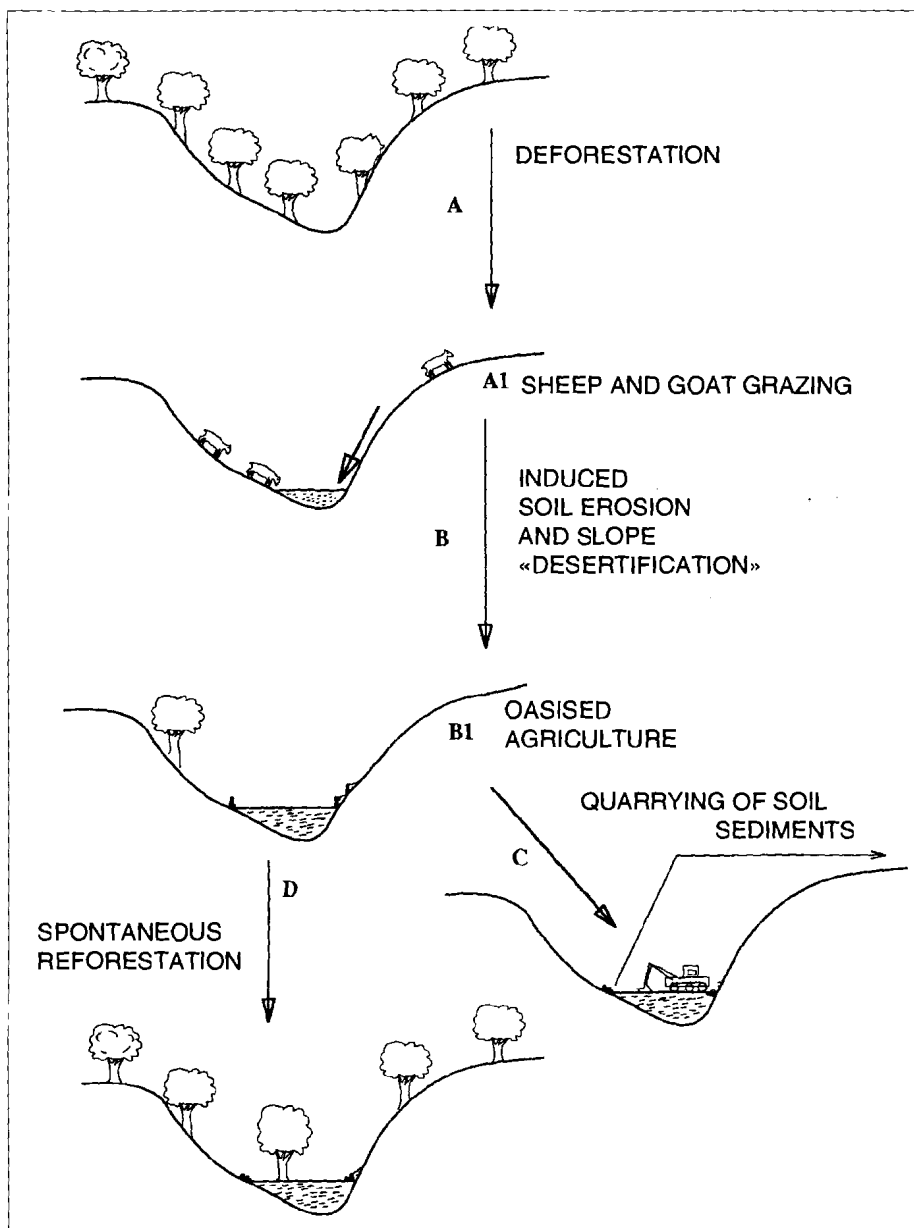


FIG. 14 – ASPECTS OF THE HUMAN IMPACT IN A KARST DOLINE.

After forest-clearing by man (A) and the soil use for sheep grazing (B), the soils have been eroded from the slopes and their sediments have been deposited on the doline bottom (B1). The doline bottom, delimited by dry walls, has been interested by an oasised agriculture (B1). The lower part of a slope has been terraced also for agricultural use (B1). In some dolines a spontaneous reforestation, linked with the abandonment of soil use, took place (D) in others the soil sediments have been quarried for the land reclamation of part of the surrounding areas (C).

- development of industrial settlements;
- creation of huge solid wastes deposits;
- building of roads, railways, tunnels and other infrastructures;
- building of dams and creation of artificial basins for hydroelectrical plants or for water storage for agriculture, etc.
- pollution by agricultural pesticides;
- introduction of new materials previously lacking in the natural environments like hydrocarbon compounds, salt for ice melting on the roads, special wastes etc.

In general it is evident that the environmental changes linked with these forms of human pressure and impact are the result of the interaction between the natural processes and the human activities. So it is really difficult to discriminate from the local changes the consequences of regional or global changes.

In the last years the monitoring by data loggers of environmental variables of karst geo-ecosystems began to give interesting information on the regimes of some variables. In particular the discharge, water temperature and conductivity regimes of the large karst springs may reflect both local aspects of human impact and local and regional climatic changes. The establishing of a monitoring network for some tens of the main karst springs in Italy and in the Mediterranean basin could give fundamental information for the understanding of the environmental dynamics.

In this way, the karst geo-ecosystems could also become very good indicators of the regional and global changes.

4.0. FINAL REMARKS.

This contribution is only a preliminary sketch of some of the aspects and elements connected with the regional and global changes.

In the future it will be fundamental both to focalize the research work on some of the key elements and to prepare syntheses which consider the possible interferences among the different environmental components and factors, utilising G.I.S. and models.

In particular, physical geographers and biogeographers should proceed in the analysis of the changes of bioindicators like timberline, change in the distribution areals of different species, etc.

Also the analysis and the monitoring of some significant physico-geographical elements, like mountain permafrost and glaciers, large karst springs, lake and sea temperature and salinity, pattern of atmospheric and sea circulation, variability of precipitations, chemical characters of soils, water, etc., could give very important indications.

Beside this, it is important to analyse in an over-regional perspective the forms, dynamic and evolution of human impact.

Geographers should promote and manage the interdisciplinary research work on this very important region.

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