Advantages and disadvantages of land use changes for the preservation of soil resources. Review of soil conservation practices and the need for related research

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Advantages and disadvantages of land use changes for the preservation of soil resources. Review of soil conservation practices and the need for related research

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SUMMARY - The intensive and frequent land use changes in the Mediterranean countries have numerous and negative environmental impacts. In order to asses land degradation, several models and cartographies have been prepared: Glasod, Corine, Italian Ministery of Environment and UNEP. The future EC policies for agriculture and related soil conservation aspects must be oriented by these documents as well as by the state of art of the main soil conservation practices. Needs for future research are concerned with the following fields: 1) Economical analyses of soil conservation practices; 2) Remote sensing for detecting land degradation; 3) Natural resources survey based on land and land use units; 4) Constitution of bench mark soils; and 5) Correlation of similar land use in different countries.

Key words: Land use changes, land degradation, soil erosion, environmental impact assessment, landscape protection.

RESUME - Les changements intensifs et fréquents de l'utilisation du sol dans les pays méditerranéens causent de nombreux impacts négatifs sur l'environnement. Afin d'évaluer la dégradation du sol, plusieurs modèles et cartographies ont été préparés : Glasod, Corine, Ministère Italien de l'Environnement et UNEP. Les futures politiques de la CE pour l'agriculture et les aspects en relation avec la conservation du sol, doivent être orientées suivant ces documents, ainsi que les connaissances actuelles des principales pratiques de conservation du sol. La recherche future a besoin d'études dans les domaines suivants : 1) Analyse économique des pratiques de conservation du sol ; 2) Télédétection pour détecter la dégradation du sol ; 3) Etude des ressources naturelles basées sur le sol et sur les unités d'utilisation du sol ; 4) Etablissement de sols types ; et 5) Corrélation entre les utilisations du sol semblables dans différents pays.

***Mots-clés**: Changements d'utilisation du sol, dégradation du sol, erosion du sol, evaluation de l'impact sur l'environnement, protection du paysage.*

Introduction

As pointed out by OECD (1991) there are two main features deeply affecting the modern agriculture and its consequent changes:

i. The trend towards increasing vertical integration of the food sector.

ii. The growing imbalance between agricultural production and the demand for outputs.

Following the vertical integration the farmers have only a limited degree of choice since they depend almost on the external market which is well-known to be subject to frequent changes. The second feature outlines the tendency for agricultural production to overcome the real consumers demand. Since both of these trends can be expected to continue in the 1990's, they provide the background for new changes in land use which not only will affect agriculture but also the environment and the landscape ecology. It is clearly important to analyze these changes and their environmental effects, for re-orientating land planning and regional agricultural policy.

Land use changes in the Mediterranean countries positive and/or negative consequences in relation to the soil resource

Agricultural land use changes

During the 60's and 70's the focus on increasing soil productivity has led to intensification of agriculture which has been followed by numerous environmental impacts and namely:

i. Increased soil degradation, especially erosion.

ii. Increased transfer of residual substances from farmland to surface water and groundwater.

iii. Increased presence of extraneous matter in foodstuffs.

iv. Disappearance of certain types of rural landscape and habitat.

From 1970 up to 1988 the consequences of the new agricultural policies have intensively marked the land use in the OECD countries. Table 1 shows that the agricultural areas have increased in the world, they have decreased in USA, Japan and Europe, with few exceptions (France, Holland, Greece, Norway and Switzerland). According to FAO (1985), the area of cultivated land in European Mediterranean countries has fallen by 6,633,000 ha in the period 1965-85 (equal to 9 per cent of total agricultural land). A summary prepared by Giordano (1992) on the agricultural land use changes which occurred in the EC Mediterranean countries, deals with the following 3 points:

a) Farming has become both more intensive and more highly mechanised, particulary in more favourable agricultural areas. As a consequence, monoculture systems have tended to spread into hill areas where traditionally crop rotations and crop sequences were carried out. They also tend to concentrate on the plains, with a consequent reduction on the hills and mountains of pastures; grass crops, manure uses and fertilizers. Even in the lowlands -contrary to what might be thought- contraction of forage crops has also occurred, due to the increasing use of food-concentrates by livestock breeders, according to Giau (1988). In addition, there has been a progressive depopulation of the countryside, especially in more remote areas, as the decline of share-cropping has seen the emergence of forms of land management characterised by larger farms and fewer farmhands.

b) At the same time, far-reaching developments in agricultural practices and technology have occurred. Farm mechanisation and intensification have led to a number of significant changes in field management, including:

Table 1. Land use changes[1] in the period 1970-1988 (OECD, 1991).

	Land area	Arable and crop land			Wooded areas		
	Area 1988	Area 1988		Change '70-80	Area 1988		Change '70-80
	10^3 km^2	10^3 km^2	(%)	(%)	10^3 km^2	(%)	(%)
Canada	9,215	460	5	9.7	4,500	49	1.6
USA	9,167	1,899	21	-0.6	2,946	32	-3.4
Japan	377	47	12	-15.0	253	67	0.1
Australia	7,618	470	6	16.3	1,060	14	13.1
New Zealand	268	5	2	-12.3	73	27	1.3
Austria	83	15	18	-10.4	39	47	4.5
Belgium	33	8	24	-12.9	7	21	1.7
Denmark	42	26	61	-3.6	5	12	4.4
Finland	305	24	8	-8.5	234	77	-0.1
France	550	195	36	6.2	152	28	8.2
W.Germany	244	75	31	-1.4	74	30	2.7
Greece	131	39	30	0.5	26	20	0.4
Ireland	69	10	14	-15.7	3	5	38.4
Italy	294	121	41	-0.7	68	23	9.5
Netherlands	34	9	27	5.9	3	9	0.7
Norway	307	9	3	5.9	83	27	5.6
Portugal	92	36	39	-5.8	31	34	10.9
Spain	499	204	41	-3.7	157	31	8.9
Sweden	403	29	7	-3.9	280	70	1.4
Switzerland	40	4	10	7.0	11	26	7.2
Turkey	770	277	36	1.4	202	26	0.1
UK	242	70	29	-3.1	24	10	25.5
Yugoslavia	255	78	30	-5.4	94	37	5.3
OECD	30,881	4,032	13	2.0	10,229	33	1.4
World	130,693	14,754	11	4.3	40,490	31	-3.4

1 The following definitions (FAO classification) have been used:

- Arable land refers to land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens (including cultivation under glass), and land temporarily fallow or lying idle.

- Permanent crop land refers to land cultivated with crops that occupy the land for long periods and need not to be replanted after each harvest, such as cocoa, coffee and rubber; it includes land under shrubs, fruit trees, nut trees and vines, but excludes land under trees grown for wood or timber.

- Wooded areas refer to land under coniferous, non-coniferous and mixed forest as well as other wooded land according to FAO specifications.

- The removal of hedgerows, ditches, dry stone walls and tree line.
- The creation of larger fields.
- Field-levelling.
- Increased frequency of tillage.
- Cultivation of steeper slopes (often involving up-and-down ploughing).
- Increased irrigated areas (Table 2).

c) Traditional terrace systems have also been abandoned on steep slopes, while top-benching is frequently practised in hilly and mountainous regions, thus completely altering both the landscape and local hydrology. The decline of pastoralism, and reduction in livestock numbers, are likewise affecting soil conditions by reducing the returns of manure to fields, and by substituting forage crops and permanent pastures with annual crops, which provide less complete soil cover and less effective protection against erosion. Together, these changes are undoubtedly affecting soil fertility, and/or be encouraging soil degradation in many areas of the Mediterranean region.

The above illustrated changes in agricultural land use have a number of impacts on the environment (Table 3).

Table 2. Trends in irrigated areas (OECD, 1991).

	Agricultural land				Irrigated areas			
	10^3 km^2			% Change	10^3 km^2			% Change
	1970	1980	1988	1970-1988	1970	1980	1988	1970-1988
Canada	645	730	785	22	4.2	5.8	8.2	95
USA	4,350	4,282	4,314	-1	159.0	205.8	181.0	14
Japan	58	55	53	-8	34.2	30.6	28.9	-15
France	320	318	313	-2	7.5	10.9	13.7	83
Germany (a)	131	122	119	-9	2.8	3.2	3.3	15
Italy	194	176	171	-12	25.6	28.7	30.8	20
Netherlands	22	20	20	-9	3.8	4.8	5.5	43
Spain	328	312	306	-7	23.8	30.3	33.2	40
UK	189	185	185	-2	0.9	1.4	1.6	76
North America	4,995	5,012	5,099	2	163.2	211.6	189.2	16
OECD Pacific	5,064	4,973	4,916	-3	50.0	47.4	50.1	0
OECD Europe	1,958	1,903	1,853	-5	98.0	122.1	135.3	38
OECD	12,016	11,887	11,872	-1	311.3	381.1	374.7	20
World	45,903	46,649	46,874	2	1,674.0	2,104.4	2,286.7	37

(a) Includes Western Germany only

Table 3. Agricultural practices and impacts on the soil (FAO-UNESCO, 1980).

Agricultural practices	Impact on soil	Impact on other physical resources
Land management	Soil degradation	Loss of biodiversity Loss of habitats Land degradation
Irrigation and drainage	Salinization Waterlogging	
Tillage	Reduced soil porosity Structural degradation	
Mechanisation	Physical soil degradation	
Fertiliser application		
Nitrogen		Nitrate leaching
Phosphate	Accumulation of heavy metals Effects on soil microfauna	Direct discharges leading to eutrophication Residues in drainage water
Manure slurry	Accumulation of phosphates Excessive copper (pig slurry)	
Sewage sludge	Accumulation of heavy metals	
Pesticide application	Effect on soil microflora	Residues in drainage water
Intensive livestock farming	Accumulation of phosphates	Offensive odours Aesthetic impacts Direct discharges leading to eutrophication

Effect on soil

Water and wind erosion

They are often accelerated by inappropriate ploughing and tillage practices which interact with natural pedogenesis and induce soil erosion. As mentioned by OECD (1991) the maximum rate of erosion compatible with maintenance of soil productivity is approximately 10 tons per hectare in temperate climate.

Soil compaction

Soil structure can be damaged by use of heavy farm machinery which compact the soil and reduce its permeability.

Fertilizers

Intensive fertilization may bring the soil towards undesirable side-effects such as accumulation in the soil of heavy metals and phosphates.

Pesticides

Pesticide residues can pass from soil to crops and then on to food chain.

Effects on water

The intensive use of nitrogen fertilizers, over and above recommended rates, can cause large quantities of nitrates to leach into groundwater. The amount of leaching is influenced by several factors:

i. Quantity of fertilizers applied.

ii. Type of fertilizer.

iii. Type of soil.

iv. Type of crop.

v. Time of year at which the fertilizer was applied.

vi. The livestock breeding concentrated in small areas results in a large amount of animal manure which can transport considerable quantities of phosphates and nitrates in different ways:

- Leaching into the ground water.
- Run-off.
- Flooding on the land.
- Both over-fertilization and manure are responsible for the water eutrophication with its excessive growth of algae.

Effects on flora and fauna

Programmes of land reclamation and development. They may drastically change the natural and semi-natural habitats especially in humid areas. Nevertheless it should be observed that some plant and animal communities are in danger of disappearance if specific agricultural practices were changed.

Fertilizers and pesticides; the effects of pesticides are determined by:

i. Their properties (toxicity, biodegradability and potential for bio-accumulation).

ii. Quantity used.

iii. Method and frequency of application.

iv. Area of application.

Effects on amenity and life quality

Inevitably a number of agricultural practices (e.g. livestock production) may affect the life quality and many agrarian infrastructures can reduce the visual amenity.

The effects of agriculture and forestry on the landscape of Mediterranean regions have been pronounced, as underlined by Giordano (1992). Many typical Mediterranean landscapes -such as the terraced slopes, fields planted with trees (*Morus spp. and Salix spp.*) and the moist woodlands near river mouths- have largely disappeared, due mainly to the change in farming practices and socio-economic conditions. Other landscapes, such as the *dehesa* of the Extremadura in Spain and the forests of the karstic environments of Sardinia in Italy (Aru, 1986), are in danger of total destruction. Due to the constant preoccupation with increased production, people have long ignored the need to protect the farming and forest landscape. The result has been a diminished and impoverished aesthetic environment. Recently, however, awareness of these impacts has begun to grow; people are beginning to accept that 'the landscapes are part of their cultural heritage and as such represent a profound need both for the individual and for society' (Noirfalise, 1989).

Forest land use changes

In the same period, Table 1 shows that the forest areas have decreased at global level but increase in the OECD countries, with the single exception of U.S.A.. A very significant increase is recorded in the OECD countries and especially in Ireland and United Kingdom with an increase of 38% and 25% respectively. Using the FAO (1985) statistics, the forest area has increased during the period 1965-1985, by 6,460,000 ha (equal to 14 per cent of wooded surface area). Forestry has become more intensive and large areas of monospecies plantations have been established (e.g. in Portugal). With the increase of wooded surfaces there is also the important decrease of wood utilization as shown on Table 4. In the Mediterranean environment fire is one of the most dramatic changes that may occur in the forests. Forest fires have immediate, very serious consequences: burnt wood loses some or all of its commercial value, the scenic value and recreational possibilities of the forest are greatly reduced and serious erosion risks may appear if violent storms occur soon after a fire and if the soil is susceptible to be eroded.

Protected areas and land use changes

New kinds of land use changes must also be found in the protected areas (Table 5), where special conservation laws may suggest or impose given land use types. As a general rule in the protected areas land use types characterized by permanent grass or forest covers are encouraged.

Urbanism and land use changes

During the last 30 years the expansion of urban areas has led to a considerable consumption of agricultural land. Table 6 illustrates the situation for the short period 1961-1971 but the trend has not changed as can be seen on Table 7 which analyzes the Italian situation from 1955 to 1981.

Methods (models and cartography) for the assessment of the induced soil degradation

Regarding the problem of the land use changes in relation to the consequent land degradation much research has been carried out at different levels. The practical interest of such research is concerned with the possibility of finding a rational solution which would allow high land productivity and minimize at the same time the negative effects. In the next sub-paragraph a tentative summary of the principle works concerned with land degradation will be presented.

Table 4. Intensity of use of forest resources (harvest/annual growth)(OECD, 1991).

	Growing stock	Annual increment	Annual harvest			Intensity of use		
	m^3/ha	m^3/ha	million m^3			Total harvest/annual growth		
	1980-85	1980-85	1950s	1970	1980-85	1950s	1970s	1980-85
Canada	74.00	1.70	71.10	121.40	151.30	-	-	0.470
USA	109.30	3.60	304.60	397.40	442.70	0.600	0.570	0.580
Japan	105.80	3.00	73.20	50.50	40.60	-	-	0.530
Australia	64.40	1.00	-	-	16.30	-	-	0.390
New Zealand	150.90	14.70	2.80	8.60	10.20	-	-	0.870
Austria	274.00	6.20	11.20	15.10	15.20	1.370	0.810	0.780
Belgium	148.00	7.50	2.70	3.20	2.80	1.180	1.230	0.620
Denmark	141.00	7.70	2.20	2.50	2.10	0.860	1.090	0.750
Finland	86.00	3.20	48.90	54.70	53.60	0.920	0.960	0.820
France	120.00	4.00	35.50	34.70	39.50	1.090	0.750	0.620
W.Germany	224.00	5.70	35.30	33.70	40.90	1.410	0.990	0.960
Greece	73.00	1.80	4.00	35.00	2.90	1.030	0.880	0.710
Ireland	102.00	7.30	0.20	0.40	0.90	0.670	0.220	0.320
Italy	154.00	3.10	15.40	11.90	9.00	1.040	0.850	0.750
Netherlands	103.00	4.20	0.80	1.20	1.20	1.200	0.980	0.950
Norway	83.00	2.60	11.90	10.20	11.30	0.830	0.650	0.630
Portugal	90.00	4.40	5.40	7.50	10.80	1.000	0.920	0.940
Spain	68.00	4.30	14.20	16.80	13.30	-	0.660	0.460
Sweden	101.00	3.00	43.50	56.60	57.60	0.760	1.050	0.700
Switzerland	364.00	5.60	4.20	4.80	4.80	0.880	0.910	0.910
Turkey	58.00	2.90	7.20	19.90	19.60	-	1.040	1.020
UK	108.00	5.60	4.30	4.20	5.20	1.390	0.870	0.440
Yugoslavia	138.00	3.50	35.20	23.80	21.20	2.380	1.060	0.720
OECD	93.20	2.60	703.30	914.30	952.10	-	-	0.520

Table 5. Protected areas, in 10^3 km^2 (OECD, 1991).

	1970	1980	1985	1989	% of land area 1989
Canada	148.2	214.6	229.5	718.6	7.8
USA	234.5	473.9	649.5	790.4	8.6
Japan	19.7	21.3	22.0	24.0	6.4
Australia	108.6	250.7	354.1	364.8	4.8
New Zealand	25.5	26.2	27.9	28.3	10.6
Austria	2.6	2.6	3.0	15.9	19.3
Belgium	0.0	0.0	0.1	0.8	2.6
Denmark	0.1	0.1	1.3	2.8	6.7
Finland	4.8	4.8	8.0	8.1	2.6
France	4.7	12.8	16.5	45.0	8.2
W. Germany	1.3	2.9	5.3	27.6	11.3
Ireland	0.1	0.1	0.2	0.2	0.4
Italy	3.0	4.1	5.2	12.7	4.3
Netherlands	0.9	1.1	1.6	1.5	4.4
Norway	2.1	37.9	47.2	47.6	15.5
Portugal	0.7	2.5	3.8	6.2	6.7
Spain	9.2	16.8	17.0	25.6	5.1
Sweden	5.0	10.6	15.9	17.1	4.2
Switzerland	0.2	0.2	1.2	1.2	3.0
Turkey	0.5	2.3	2.9	2.5	0.3
UK	13.0	13.2	15.5	25.7	10.6
OECD	586.3	1,107.7	1,437.4	2,180.5	7.1
World	1,597.1	3,566.2	4,237.7	5,290.8	4.0

Land degradation can very often be evaluated (qualitatively or quantitatively) in terms of soil erosion which is a process accompanying the degradation during its evolution, and sometimes represents its final stage. That explains why many documents dealing with land degradation are actually expressed as soil degradation.

World map of the status of human-induced soil degradation (GLASOD project, ISRIC-UNEP, 1990)

The starting point of the project is the ascertainment that soil degradation is a very widespread problem but its geographical distribution and total affected areas are only very roughly known.

The methodology is conceived so as to give sufficient details on the various aspects of soil degradation. Four different colours were selected to represent the four main types of soil degradation (water erosion, wind erosion, chemical deterioration and physical deterioration). The colour of a mapping unit is determined by the dominant degradation type occurring in the unit. When two types of soil degradation have the same weight of importance the map shows coloured strips. In these cases a colour mosaic was shown on the map.

A major point of deliberation was the way in which the seriousness of a certain soil degradation type could best be represented on the map. The status of soil degradation is indicated by its degree, relative extent in a mapping unit, and recent-past rate. The seriousness of a type of soil degradation was expressed by a combination of the degree and relative extent. Since there are four possible degrees and the relative extent is given in five categories, a total of 20 combinations are possible. As it would be impossible to give an individual cartographic representation for these 20 combinations, they are grouped into 4 groups. On the map, each group is represented by different colour shades: light shades refer to low degradation severity, dark shades to very high severity.

Inside each cartographic unit a special symbol will provide information on the following items:

- soil degradation type	-W	water erosion
	Wt	loss of topsoil
	Wd	terrain deformation
	-E	wind erosion
	Et	loss of topsoil
	Ed	terrain deformation
	Eo	overblowing
	-C	chemical deterioration
	Cn	loss of nutrient and/or organic matter
	Cs	salinization
	Ca	acidification
	Cp	pollution
	-P	physical deterioration
	Pc	compaction, sealing and crusting
	Pw	waterlogging
	Ps	subsidence of organic soils
- no human-induced soil degradation	S	stable terrain
	SN	stable terrain under natural conditions
	SA	stable terrain with permanent agriculture
	SH	terrain stabilized by human intervention
- non-used wastelands	D	active dunes
	Z	salt flats
	R	rock outcrops
	A	deserts
	I	ice caps
	M	arid mountain regions
- causative factors	f	deforestation and removal of natural vegetation
	g	overgrazing
	a	agricultural activities
	e	overexploitation of vegetation for consumptive use
	i	(bio)industrial activities
- recent-past rate	two symbols indicate if the rate is medium or rapid	
- off-site effect	only one form of off-site effect is reported (uncontrolled flooding)	

As a conclusion of the legend description of this relevant soil degradation document it can be observed that items are strictly related to land use changes operated by man over time. Man's behaviour has not always been in conflict with the sustainability of the natural resources. Let us consider for example the eastern part of Ireland where the historical intensive agricultural land management did not exert a negative effect on soil degradation. As a matter of fact the GLASOD symbol SA (stable with permanent agriculture) highlights the described situation.

Table 6. Land use changes in the period 1961-1971 (Best, 1981).

	Urban land		Arable and crop land		Wooded areas	
	1000 ha	%	1000 ha	%	1000 ha	%
Belgium	24	0.8	-145	-4.8	13	0.4
Denmark	27	0.6	-198	-4.6	18	0.4
France	254	0.5	-2,106	-4.0	3,203	6.1
W. Germany	359	1.5	-640	-2.6	69	0.3
Ireland	11	0.2	266	3.8	98	1.4
Italy	289	1.0	-1,183	-4.0	343	1.1
Luxembourg	2	0.8	-4	-1.6	-1	-0.4
Holland	43	1.3	-135	-4.0	27	0.8
UK	192	0.8	-927	-3.8	183	0.7
CEE	1,201	0.8	-5,072	-3.4	3,953	2.7
USA	2,589	0.3	-25,081	-2.7	16,991	1.8
Canada	772	0.1	-673	-0.1	-7,616	-0.8

Table 7. Urban land use changes in Italy (Merlo, 1984).

Year	Urban land area	
	ha	%
1955	727,000	2.5
1965	1,131,000	3.8
1975	1,655,000	3.6
1981	1,744,000	5.9

Soil erosion and important land resources evaluation of the European Community (E.C. CORINE programme)

Problems of land resources are acute in the Mediterranean region. Good quality land is scarce, and often threatened by development; soil erosion is encouraged not only by physical conditions but also by agricultural intensification.

Faced with these problems, the European Commission has been carrying out a project to assess and map soil erosion risk and land quality, as a basis for policy formulation, within the context of the CORINE Programme (Giordano *et al.*, 1991). This clearly requires the collection and analysis of a wide range of data, and the development of sophisticated models. On the other hand practical constraints have also had to be taken into consideration. Both time and resources were limited. The area to be covered -some 1.2 million km^2- was large and varied. Data availability represented a serious problem. The method used, and results obtained, also had to be compatible with the CORINE information system as a whole. For these reasons the approaches used had to be relatively simple. The scale of mapping similarly had to be fairly broad (1:1 million). And there was no opportunity to carry out fundamental research. The results, consequently, can be regarded as no more than a "first approximation". The method which was developed is shown in Fig. 1 and 2.

Starting with the first we may note that the methodology considers two different indices of soil erosion risk:

- Potential soil erosion risk, which is taken to represent the inherent susceptibility of the land to erosion, and is thus derived from the basic physical factors of soil climate and topography; and
- actual soil erosion risk, which refers to the risk of erosion under current land use and vegetational conditions, and which is determined by adjusting the potential soil erosion risk to take into account the protection afforded by the present land cover.

Fig. 2 refers to the land quality which is taken in the CORINE project to express the general capacity of the land to produce biomass and support agricultural crops and other vegetation. As such, it is seen as a function of three primary factors: soil conditions, climate and topography. These define what may be regarded as the potential land quality. In practice however, land quality is often significantly upgraded as a result of human endeavour, for example, through some land use changes like irrigation, terracing or artificial drainage. For this reason, the assessment method used in the CORINE project allows the potential land quality index to be adjusted on the basis of land improvements, to define what is referred to as a actual land quality. As far as the soil erosion risk is concerned a summary of the results is presented in Table 8. It is worthy of note to consider that the actual soil erosion risk being largely influenced by the land uses expressed by soil cover is susceptible to become better or worse according to the occurred land use changes.

Evaluation of soil erosion in Italy in relation to land management practices (Italian Ministry of Environment)

The concepts of "danger of erosion" has recently changed. Instead of measuring only the amount of eroded soil, we consider the maximum quantity of soil that can be eroded without any significant decrease in biomass productivity. So the main interest in soil erosion and land degradation is today oriented to the land management systems as well. As a matter of fact we know that a good tillage is the prerequisite for a sound agriculture able to maintain its natural productive capacity. The importance of agricultural systems in affecting soil erosion is well known since the beginning of this century. This is demonstrated by the first experimental parcels for testing soil erosion as a sequence of different land management (Woodruff, 1990).

Taking into consideration all these facts the Italian Ministry of Environment has set up a project for evaluating and classifying land management types in relation to their impacts on soil erosion in some Italian pilot areas. For full details see Giordano (1991). Referring to the methodology a matrix has been established combining 42 environmental types with 36 land management types. The specific local situations of the five pilot areas have been introduced in the matrix after field check. This simple methodology allows us to notice if the soil erosion risk is determined by natural factors rather than by land management or if it is the opposite. As a consequence the following two questions may be answered in a tentative way:

- What land management type is the most suitable in a given environment in order to reduce the soil erosion risk?

- In what environment may a given land management type be applied without increasing the erosion risk?

Cartographic documents on soil erosion in the Mediterranean basin

The analysis and correlation of the existing soil erosion maps in the Mediterranean basin is found in Giordano and Marchisio (1991) in the framework of UNEP programme "Soil erosion in the coastal Mediterranean zone". Here we wish to take the opportunity to consider the land cover and the related land use changes as the most important parameter for providing the map users with information on actual soil erosion risk.

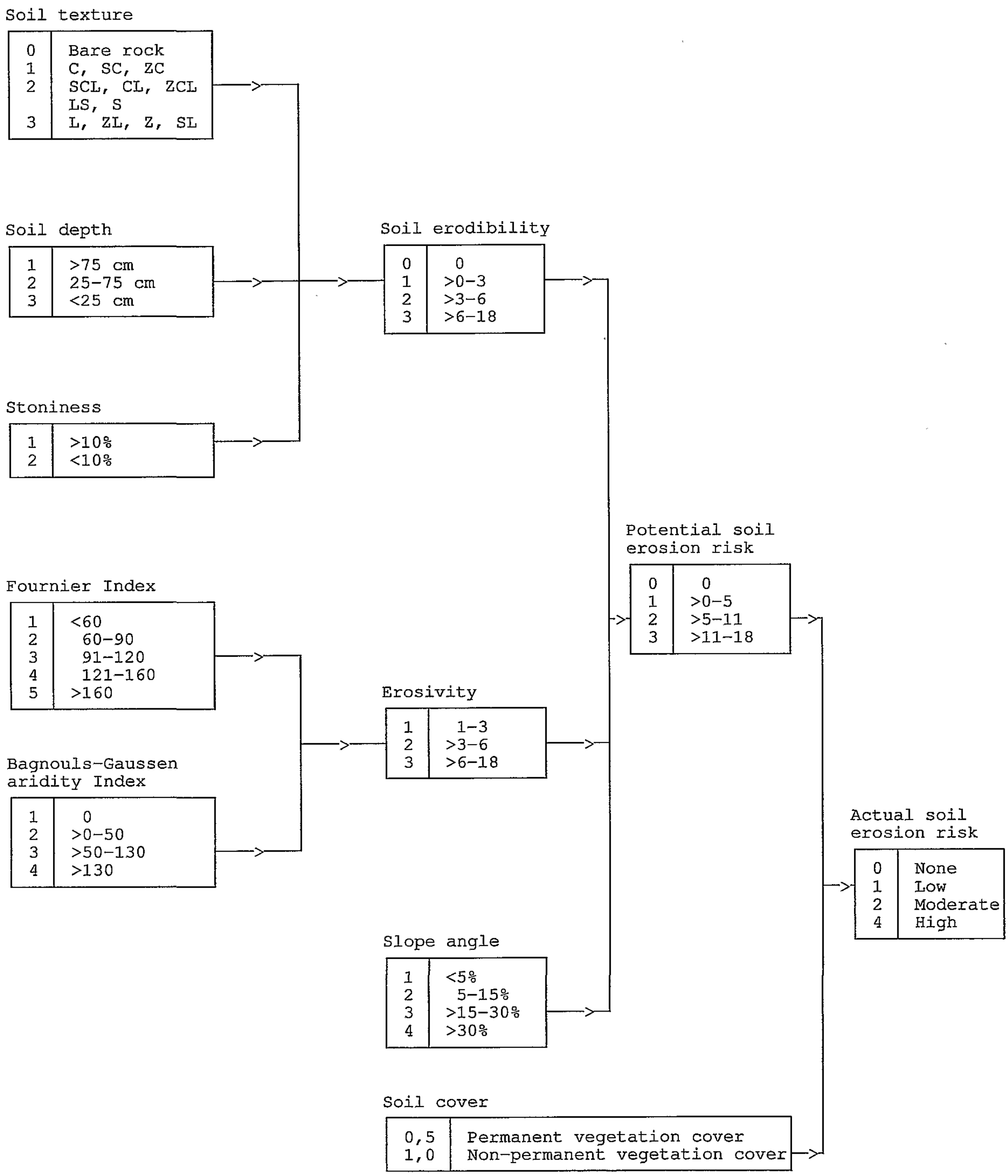


Fig. 1. Soil erosion assessment methodology (Giordano *et al.*, 1991).

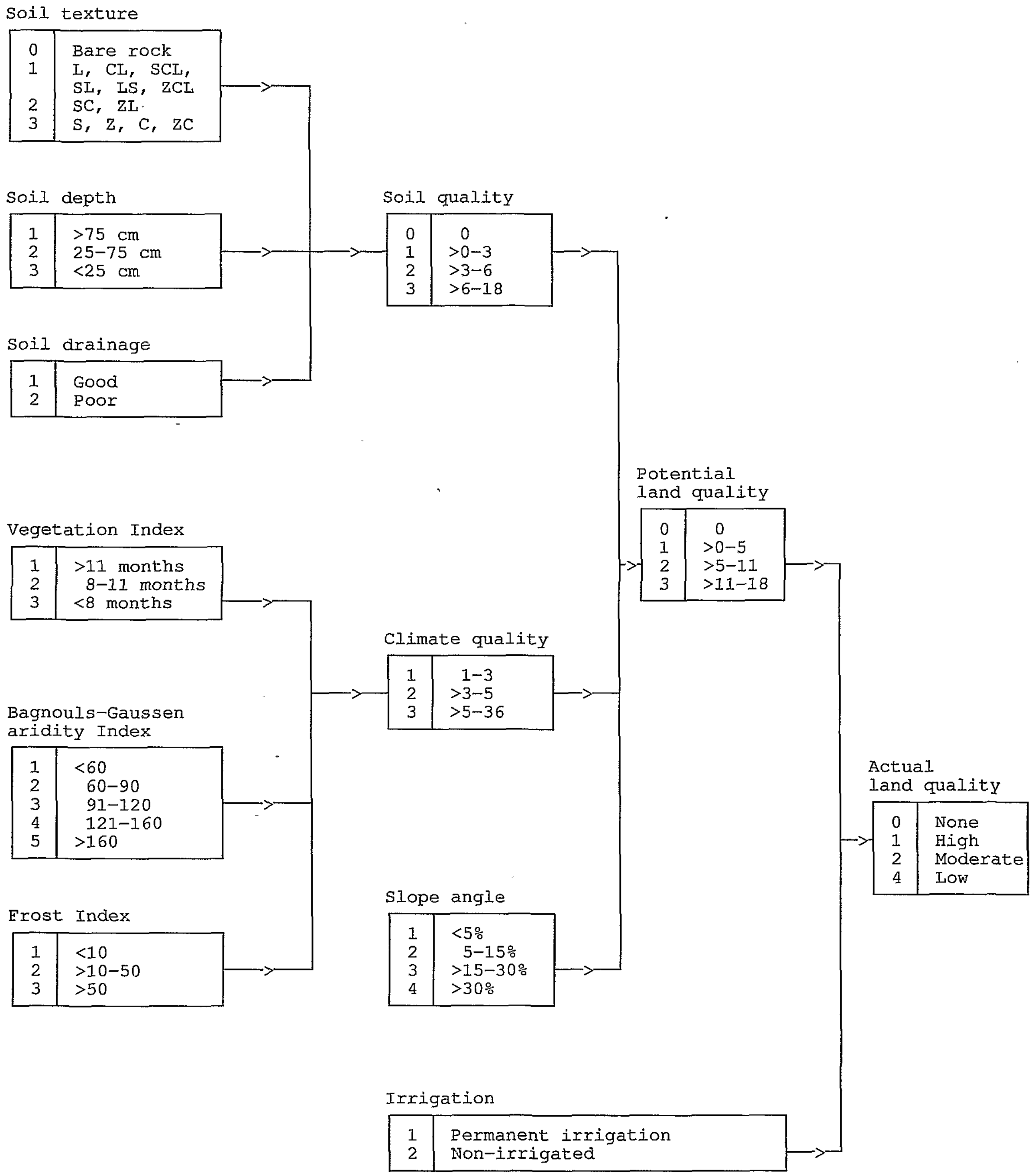


Fig. 2. Land quality methodology (Giordano *et al.*, 1991).

EC policy for agriculture and related soil conservation aspects

The Council of the European Communities recognises the importance of adopting a global and coherent approach to the problem of land degradation. Directives and regulations on the introduction and maintenance of agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside are now under way. However, the soil system is much more complex than either the air system or the water system; it is therefore more difficult to design the measures to protect soil quality.

Up to now a comprehensive EC directive to curb aspects of soil degradation as a whole does not exist. Several directives regulate the admitted levels of pollution and the amount of toxic substances found in the foods, but nothing has been said about soil degradation and disappearance of cultural and typical rural landscapes. From this point of view the EC directive "set-aside" seems to be open to multiple consequences. On the one hand it fights against soil erosion but on the other does not care about conservation of the rural landscape and of the land management designed to secure future production, described as *landesque capital* by Blaikie and Brookfield (1987): stone walls, terraces, irrigation, drainage and reclamation systems.

With reference to the forestry sector (Giordano, 1991) we have to admit that an explicit common forestry policy in the European Community does not yet exist. Instead, forest policies remain the responsibility of national authorities, and as such tend to vary from one country to another. In the majority of Mediterranean countries, however, two contradictory aims can be said to be typical. On the one hand policy is designed to maintain ecological amenity and leisure qualities, while on the other hand, policy endeavour to maximise commercial forest production.

These two objectives tend to be independently and separately pursued. Nature conservation and leisure requirements, for example, tend to be restricted to forests of low productive potential, often those situated on steep slopes and poor soils. Here, rational replacement exploitation is carried out, regeneration being allowed to occur primarily by natural processes, through varying in detail according to local circumstances. Commercial production, on the other hand, is pursued primarily through the establishment of fastgrowing plantations. These are maintained by intensive management techniques, analogous to those used in modern farming. They tend to be concentrated in fertile lowlands, which are amenable to mechanical cultivation, fertiliser application, weeding and spraying.

Table 8. Soil erosion risk in the Mediterranean region (Commission of the European Community, 1992).

	Potential erosion risk				Actual erosion risk			
	High		Moderate		High		Moderate	
	km^2	%	km^2	%	km^2	%	km^2	%
Portugal	61,211	69	21,740	25	26,788	31	48,195	55
Spain	202,335	42	205,754	43	145,090	30	220,944	46
France	16,577	12	38,398	28	1,724	1	22,629	16
Italy	82,891	30	85,414	31	30,370	11	94,453	34
Greece	57,584	47	27,095	22	24,830	20	47,575	38
Total	420,578	38	378,365	34	228,802	21	433,796	39

Review of the main soil conservation practices in the Mediterranean environment

Considering the USA current soil conservation practices (Hornik and Parr, 1987) we have to recognize that in the Mediterranean basin there are more ways to prepare the land for cultivation. The reason of such a diversity is to be attributed to at least two main considerations:

- In the Mediterranean basin many different methods of land conservation had been experimented since thousands of years.

- The countries of the Mediterranean basin have for long time known a high human pressure which induced the farmers to cultivate the land in difficult environmental situations.

As a consequence they had to perform agriculture often having prepared the land with specific interventions. We refer to that kind of land reclamation and preparation as *sistemazioni idraulico-agrarie* in Italy. Some of these old *sistemazioni* are described in Fig. 3; at present they can not always be proposed for the high cost of execution and maintenance. To a certain extent these *sistemazioni* can be considered as "agro-forestry systems" with a specific role of the trees planted in the fields. For preparing the land following the contour lines, it is necessary to have large surfaces at one's disposal. This is, of course, a limiting factor in the Mediterranean environment, characterized by small size farms. Where the land tenure allows such a type of land management, some modifications occur as compared to the simpler American model.

Taking into consideration the Italian contour line systems some features make them different from those of the USA. In the Fig. 4 the drainage network superimposed to the contour lines shows what is called in Italian *sistemazione a girappoggio*. Another way to manage the contour line system to better fit the local situation is the so called *sistemazioni with connected terraces* (Fig. 5). This one is relatively quite modern way of preparing the field since it allows the agricultural machinery to pass easily from one elevation level to another.

Terraces are the most typical Mediterranean works for preparing the land for agriculture. As it can be seen in Fig. 6 and 7 terraces demand considerable investments and skill and at present very seldom are they economically justified, even if they represent the best way to manage agriculture on steep slopes. Due to the intensive spread of agriculture mechanisation, steep soils that once were only cultivated with terraces are today ploughed up and down, since any other manner of planning is dangerous for the human security. In order to avoid or to reduce severe soil erosion, ditches are excavated obliquely to the slopes (Fig. 8). This type of land preparation is cheap but leads to a high degree of soil erodibility. Nevertheless it must be admitted that in certain cases of heavy clayey soils with high danger of mass movements, the up and down ploughing is an effective way to remove the water from the soil quickly. In conclusion it must be said that soil conservation practices are especially effective when considered in their environment, i.e. natural constraints, economical expectations and cultural heritage.

The best soil conservation practice will be that allowing the optimization of this complex system and the attainment of an ecological equilibrium and better life quality.

Needs for future research

The following researches seem to be particularly important:

a) Economical analysis of soil conservation practices.

Operations of soil conservation are seldom put into action since they have not a short term economical validity.

In a comprehensive environmental framework the economy must be analyzed in long term.

b) Remote sensing.

The monitoring of the changes in land use is the basic tool to show where the changes occur.

Remote sensing is also essential for point c).

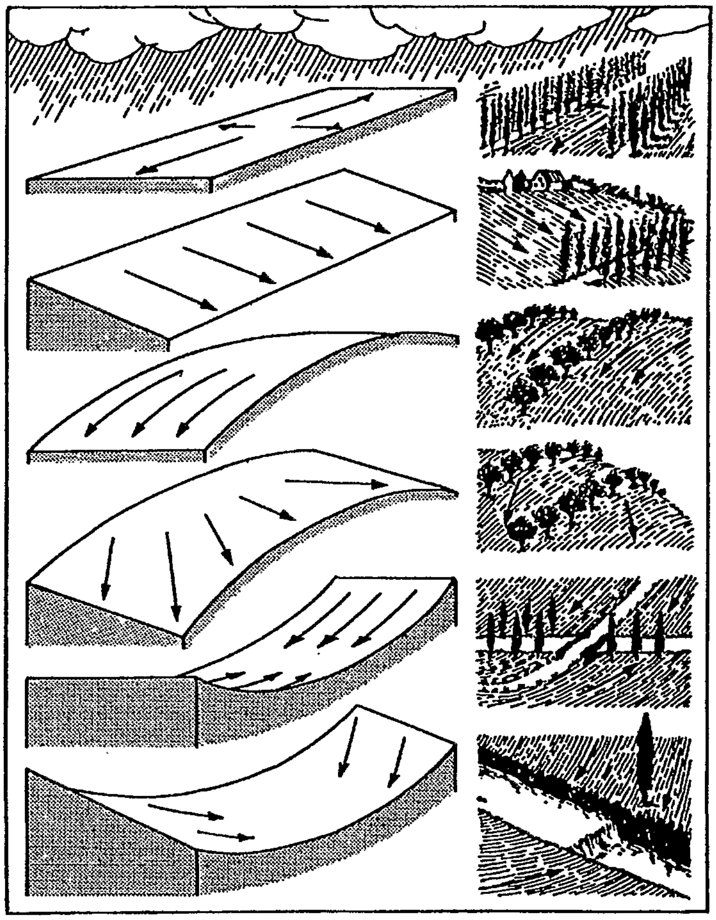


Fig. 3. Exemples of *sistemazioni idraulico-agrarie* to hilly environments (Aquater, 1989).

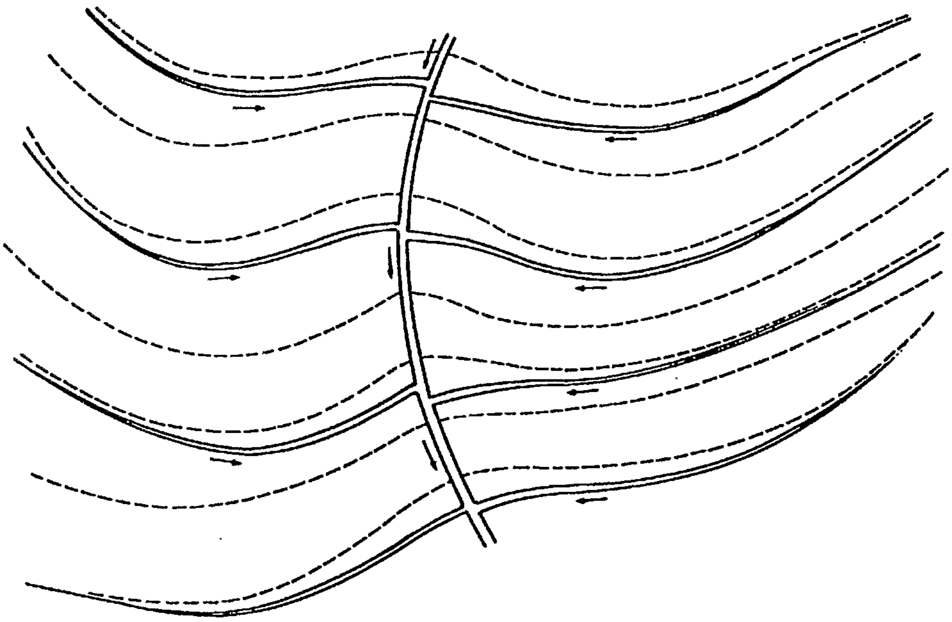


Fig. 4. Land preparation called *a girappoggio*: it consists of planghing works performed according to contour lines and of a creation of a drainage network (Aquater, 1989).

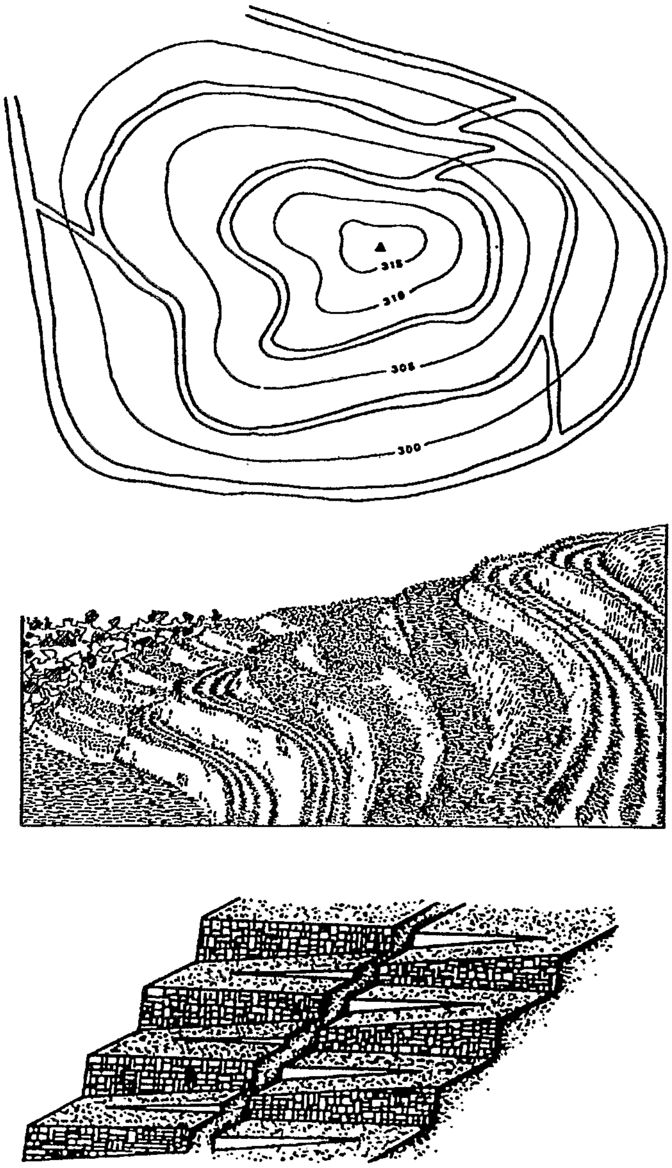


Fig. 5. *Sistemazione* characterized by connected terraces (Giardini, 1984; Aquater, 1989).

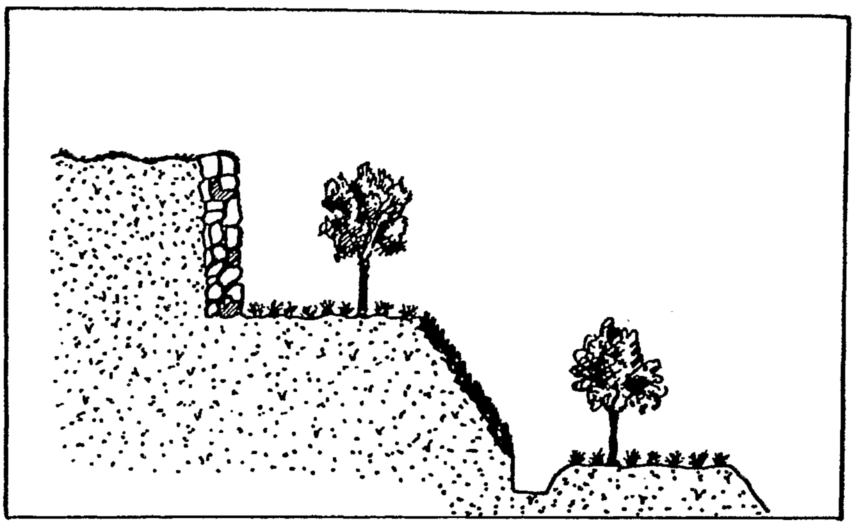
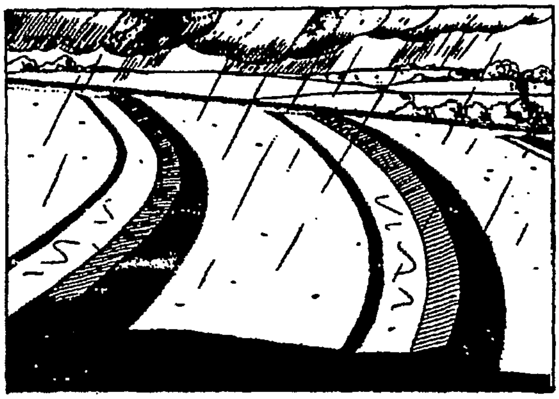


Fig. 6. Scheme of a terrace used in the Mediterranean agriculture (Aquater, 1989).

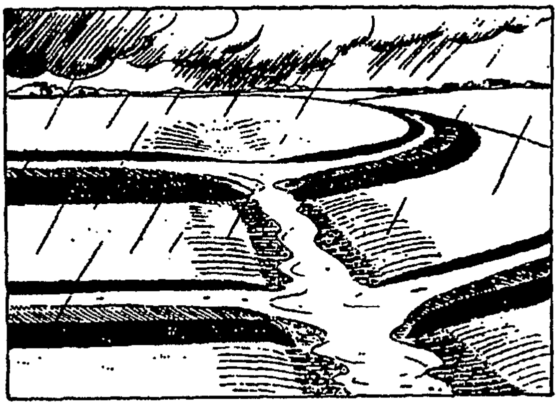
a)



Level terraces

(specially good for dry climates without soil erosion problems)

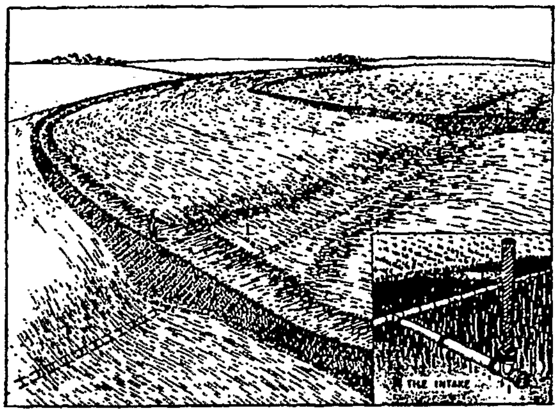
b)



Gradient terraces with grassed waterway

(convenient for dry and sub-humid climates with soil erosion problems)

c)



Gradient terraces with tile intake

(as "b" but with more advanced agricultural practices)

Fig. 7. Main types of terraces suitable for crolling soil erosion (Grill and Duvoux, 1991).

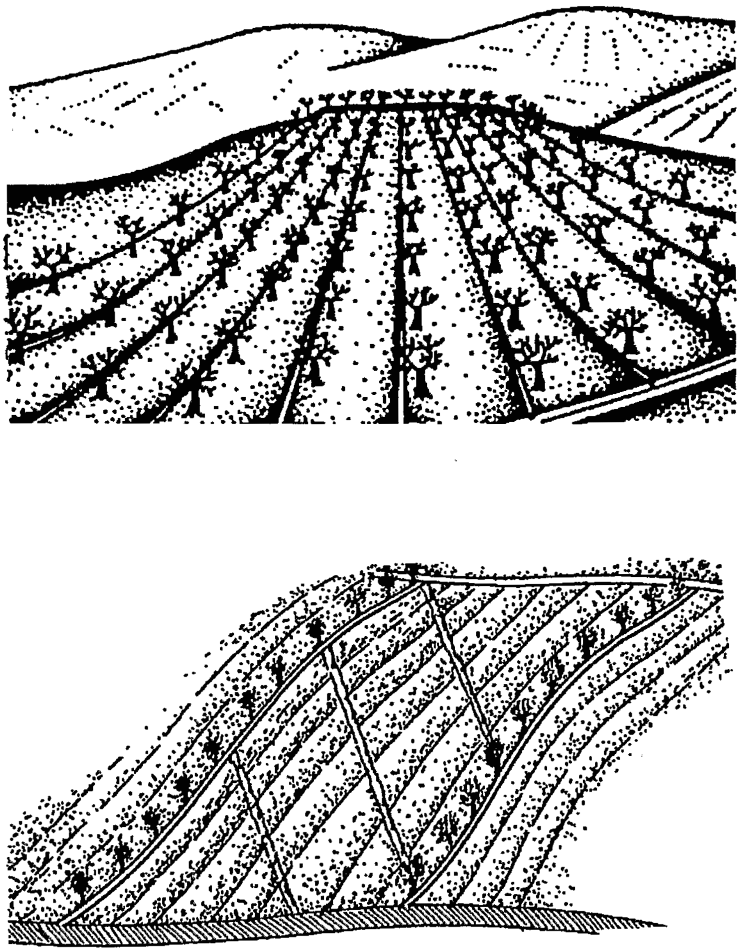


Fig. 8. *Sistemazione a rittochino* (up and down with ditches)(Giardini, 1984; Aquater, 1989).

c) Land units and land uses survey.

A sustainable agriculture must select land use types in accordance with the land units, considered as ecosystems.

d) Investigation on the set aside areas.

The practices of the set aside has important consequences on the environment and the landscape.

Advantages and disadvantages must be known in advance.

e) Constitution of bench-mark soils.

Starting from the soil as a natural body a certain number of sites has to be considered with all the concerned relevant aspects. Among them actual and past land use as well as socio-economy and human history are of primary importance.

f) Correlation of similar land use in different countries.

A better understanding of the land use changes may derive from the comparative analysis of analogous situations in different countries.

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