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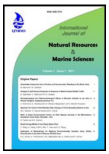
*I*nternational *J*ournal of *N*atural *R*esources and *M*arine *S*ciences

2011, 1 (2), 125-145



Mapping Units in Degradation/Conservation-Oriented Studies

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Received: 19 October 2010 / Accepted: 26 May 2011 / Published Online: 15 August 2011

Abstract The term degradation is used to specify the status of the environment. It is often associated with 'improper use'. 'Use' also implies environmental aspects other than physical ones and implies that the more intensive the use, the more susceptible the environment is to degradation, particularly if proper care for the environment is lacking. The question is, and has always been, how to map something which, apart from the physical aspects of landscape, is also influenced by socio-cultural and economic issues? The common approach in mapping degradation is based on indicators and the intention of this paper is to present three case studies: the Tabernas-Sorbas area in Spain; Iran (at the country level) and the Pico de Tancitaro area in Mexico. The geopedological map is combined with the land use-based map to produce the basis for the extraction of a considerable number of indicators.

Key words: *GLASOD, Iran, Mapping units, Mapping degradation/desertification, Pico de Tancitaro (Mexico), Tabernas-Sorbas (Spain)*

[DOR: 20.1001.1.23222700.2011.0.2.7.8]

1 INTRODUCTION

The term 'degradation' is used to specify the status of the environment, as a whole or one of its constituents, in terms of quality. Degradation of the environment, degradation of vegetation cover, of soil and/or of land are commonly used terms. They refer to the process (es) by which environmental quality and/or quantity is reduced. In contrast, conservation implies all activities which lead to the maintenance or enhancement of the productive capacity of the land in areas affected by, or prone to, degradation. Although degradation (e.g. erosion, soil salinization) can occur naturally, the term is commonly associated with 'improper use'. In some cases, mainly in older publications, degradation is used interchangeably with erosion (UNESCO, 1992).

The literature suggests that over the course of time, researchers have paid more attention to human-induced types of degradation (UNEP/GlASOD, 1990), simply because natural degradation was seen as impossible to reverse. However, what is important is how users of an environment act as their actions can be environmentally destructive or trigger land degradation. Hence, it is not inaccurate to associate the word 'degradation' with 'improper use'. Once the 'use' is established, environmental aspects, other than physical ones become relevant. Man uses the environment in different ways (for agriculture, construction, recreation, etc.) and expects a harvest (output). Glasod revealed not only the scale of the problem in the public arena (WOCAT, 2007), but also, through introducing three historic

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periods ('a': past up to 250 years ago, 'b': 50–250 years ago, and 'c': post Second World War), demonstrated that the life time of an environment very much depends on how sympathetically harvesting or extraction is done. The more intensive the use, the more susceptible the environment is to degradation, particularly if there is a lack of environmental care.

As a well organized project funded by the Global Environmental Facility (GEF) LADA (Land Degradation Assessment in Drylands) this research aimed to identify 'hot spots' (problem areas) and 'bright spots' (conservation successes), the latter being taken care of by the WOCAT (World Overview of Conservation Approaches and Technologies) project. A challenge for the WOCAT project is 'to produce a map which is a mirror image of GLASOD and a compliment to the LADA project (FAO, 2002): in other words a global assessment of conservation and sustainable land management practices.'

The question is, and has always been: how to map something which, apart from the physical aspects of landscape, is also considerably influenced by socio-cultural and economic issues. The common approach in mapping degradation is based on the use of indicators and the intention of this paper is to present case studies, where the geopedological map is combined with the land use-based map to produce the basis for the extraction of a considerable number of indicators.

2 MATERIALS AND METHODS

The method applied here is backed by the geopedologic approach to soil surveying (Zinck, 1988) and the landscape integral survey method (Zonneveld, 1995). The former is a systematic and hierarchical classification system that integrates geological (lithology), geomorphological, and pedological components of the landscape. The different levels, at the regional scale (Table 1), include 'landscape' (e.g. mountain, piedmont, valley), 'relief-type' (e.g. hill, glacis, terrace), 'lithology' (e.g. rock type, alluvium, colluviums) and 'landform' (e.g. crest, footslope, tread). Any of the above mentioned four columns (as a tabulated legend) may be further specified by phrases, for instance, 'very high rugged mountain', 'forested hill', 'severely eroded glacis', etc. The pedologic properties, depending on the scale of the study, will follow the above mentioned columns. Although a geopedological map offers more attributes than conventionally prepared soil maps, it is still not an appropriate base-map for degradation/conservation oriented studies. Other attributes, mainly management based, are required particularly when degradation is human-induced (accelerated erosion, compaction, salinization, etc).

To satisfy the mapping unit requirements, a modified version of the landscape integral survey method (Zonneveld, 1995) has been adopted. This approach suggests the term 'land unit', which results from incorporating other land attributes such as land use/cover and hydrology into the geopedological units. Although 'land use' already, to a certain extent, covers some socio-cultural and economic aspects of the landscape, where degradation occurs, additional data, depending on the scale of the survey, can still be added.

Following the same principles, but on a larger scale, a soil degradation map of Iran was prepared. A modified version of the method,—GIS-based (Index overlay model)-- was successfully applied to a multi-criteria evaluation oriented study within the framework of a geopark (Garrido et al., 2004) to assess the suitability of a planned Mexican geopark, helping decision makers decide where to place the park.

With the geopark case study, the intention was to demonstrate a modified version for degradation oriented studies at a medium scale using a 3-step procedure (Fig. 1), backed by

[DOR: 20.1001.1.23222700.2011.0.2.7.8]

fieldwork undertaken in Southern Spain.

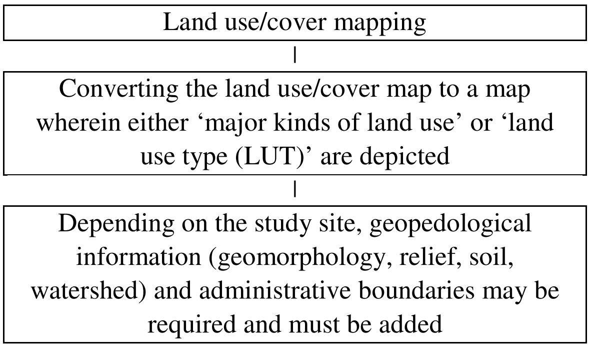

Fig. 1 Methodological flow-chart.

3 DESCRIPTION OF THE STUDY AREAS:

3.1 Tabernas-Sorbas, Spain

The Tabernas-Sorbas basin is located in Almeria Province, SE Spain (Fig. 2) and covers a total area of 84 km^2. Tabernas, a part of which falls in the study area, is accessible from the city of Almeria by following the Carretera national 340 road for about 45 km. Sorbas village is about 10 km to the east of the study area.

Climate, vegetation, land use: Annual precipitation is 218 mm, varying from 115 mm to 431 mm. More than 95% of the total rainfall is lost by evaporation. The mean annual temperature is about 18°C with an average minimum of 4.1°C in the coldest month and an average maximum of 34.7°C in the hottest month. It is a typical thermo-Mediterranean semi-arid climate and is the only true desert in Europe.

The Tabernas-Sorbas area is sparsely covered by small shrubs and typical perennial Mediterranean grasses such as *Stipa tenacissima* and *Anthylis citisoides* along the slopes. Halophytic plants such as *Salicornia* sp. and *Salsola* sp. grow mostly on saline soils along the narrow valleys. Usually eucalyptus trees and cactus grow in the valleys. Agricultural practice is very difficult in the area because of the harsh climatic conditions. The harsh conditions have urged the inhabitants to be creative in order to survive in this area. This can be seen in Fig. 3a–c).

Fig. 2 Location map of the Tabernas-Sorbas basin, SE Spain.

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3.2 Pico de Tancitaro, Michoacan, Central Mexico

The study area, a volcanic landscape, with a temperate climate and significant biological and hydrological value, is situated between the latitudes 19° 18' 26" and 19° 33' 36" N, and longitudes 102° 11' 19" and 102° 26' 13" W, covering an area of about 720 km^2 (Fig. 4).

Key social issues include a changing land use pattern over the past 30 years, the presence of a natural protected park that has never been fully legalized and the preponderance of indigenous communities with their traditional cropping and forestry practices.

Fig. 3 A few views of the Tabernas-Sorbas landscape (Upper left: Bench and graded terraces, Upper right: Masonary terraces and Lower Water conservation; '*ghanat* water stored in ponds').

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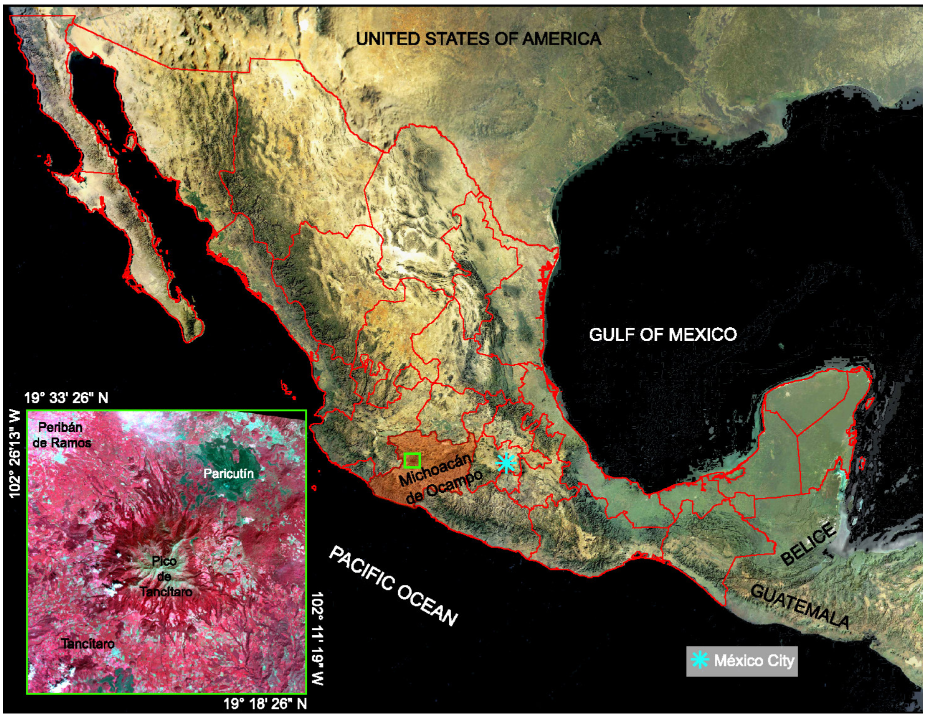

Fig. 4 Location of the study area (*Pico de Tancitaro*).

3.3 Iran

Iran is an interesting site that demonstrates how the assessment of degradation at the country level can be done, considering the variations in biophysical, socio-economic, technical, and institutional aspects (Farshad, 1997).

Biophysically, Iran, for a great part, is situated in one of the agriculturally unfavorable parts of the earth's surface (i.e. too cold, too dry, too hot, and/or too high in altitude) where it is very difficult, if not impossible, to increase agricultural production without external capital inputs. Socio-economically, high levels of poverty tend to encourage practices that increase production in the short term but undermine sustainability over the longer term.

As in other arid regions, water scarcity has physical and social consequences connected with irrigation-related practices and their impacts, including soil degradation (compaction, salinization, and water-logging), water quality deterioration, vegetation depletion through overgrazing and/or drought, and land use competition resulting from urbanization.

During the last decades, the agricultural sector in Iran has been subjected to drastic changes. While many traditional social norms are preserved, new technology dictates changes that farmers may not accept. The semi-arid agricultural areas of Iran are especially vulnerable because of the dry climate, salt-affected and/or excessively calcareous soils, low soil organic carbon content, shortage of surface water, and overexploitation of groundwater leading to a drastic lowering of the water table depth, population growth and inappropriate changes in land tenure (Farshad and Zinck, 1995; Farshad and Zinck, 1998).

4 RESULTS

4.1 Spain

The first step: land use/cover mapping

Considering that managerial activities play an important role in man-made degradation, the land use/cover map is the first map to be prepared. This can either be done digitally or visually. The color composite (of Landsat bands prepared in ILWIS) shows how green the area can be (Fig. 5). A digital classification (supervised and/or unsupervised) is done in a GIS environment, for example in ILWIS or in ERDAS (Fig. 6). Visual interpretation of Landsat data (hard copy) can also be a replacement on the condition that information is extracted from several combinations of bands (Figs. 8 and 9).

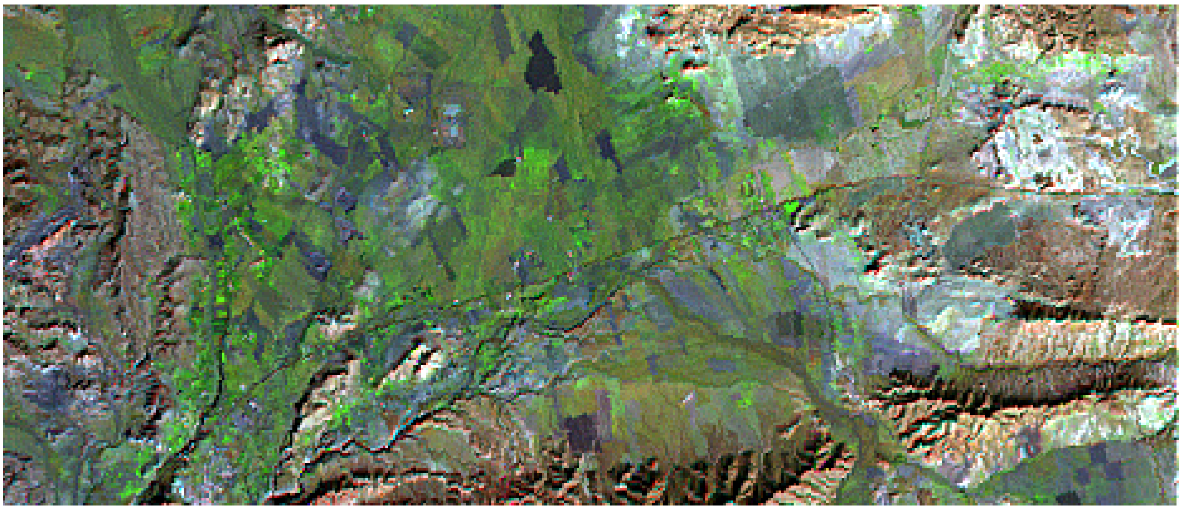

Fig. 5 A color composite map (Landsat 543).

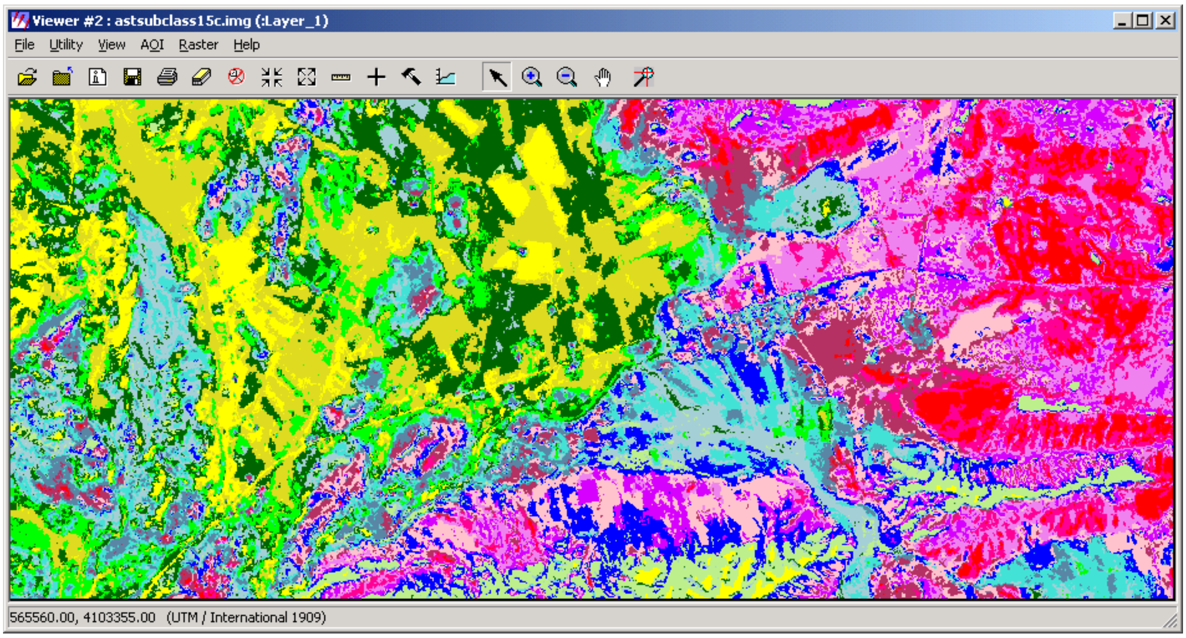

Fig. 6 Digitally prepared land use/cover map (unsupervised classification on ASTER bands 432, in ERDAS).

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Visual interpretation of the above color composite gives the following maps (Fig. 7a, b; in Fig. 7b all rocky mountains are pooled together, regardless of lithology):

To do this, some photographic elements, such as color-tone, texture, pattern, parceling, size, and shape are used. Using the classification items (for instance as used by WOCAT), the polygons are described and eventually entered into a database.

Some map unit examples are: map unit 1 = Ge (extensive grazing land), map unit 2 Oo (Other: badland), Map unit 3 = Oo (Other: badland), Map unit 4 = Ge (extensive grazing land), Map unit 6 = Mf (agroforestry), Map unit 16 = Ca (annual cropping) etc. (WOCAT, 2007).

The generalization (the yellow line in Fig. 7b which means that all subdivisions are pooled together in one polygon) carried out here might not be correct in other situations.

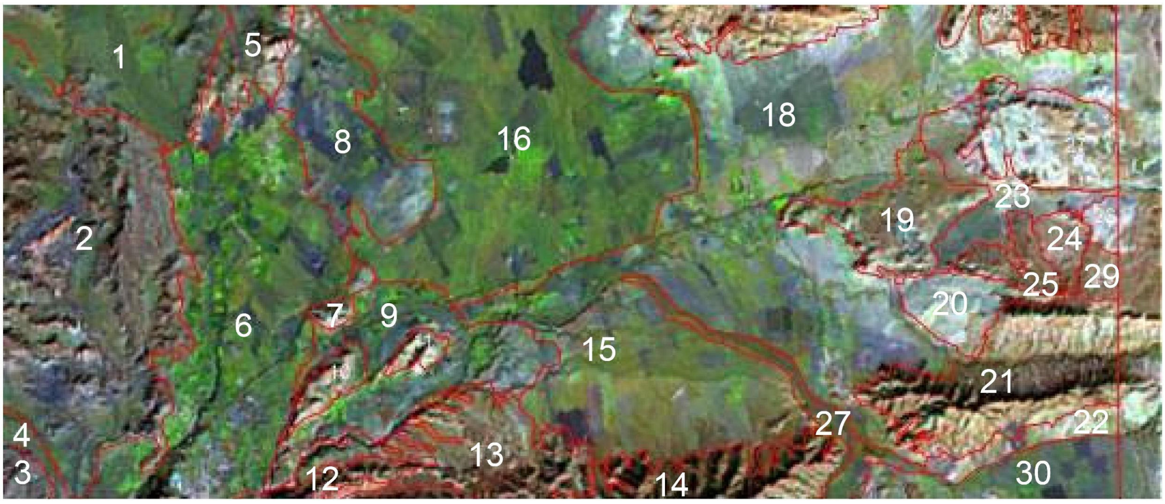

Fig. 7a Visual interpretation of the color composite (Landsat 543).

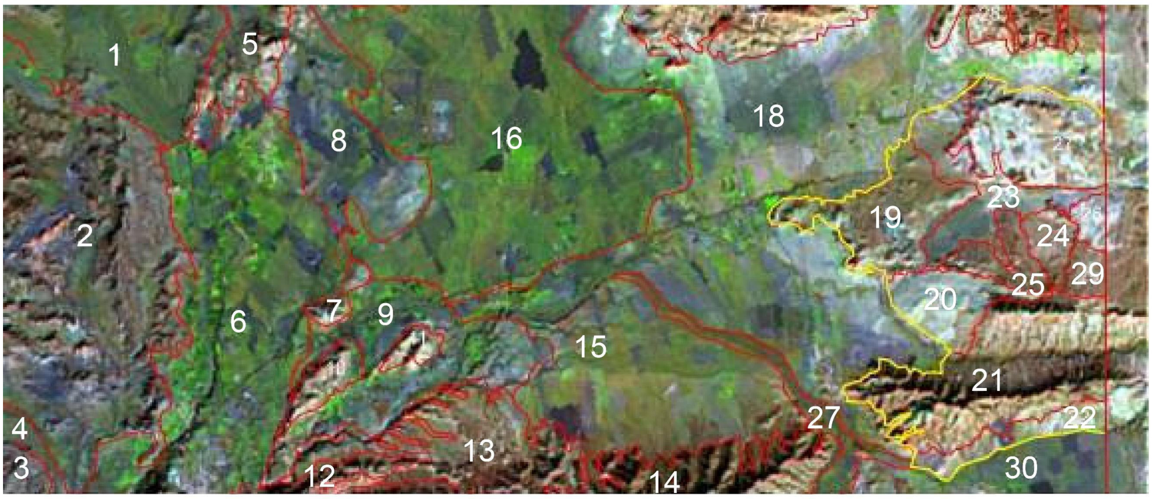

Fig. 7b Another version of visual interpretation of the color composite (Landsat 543).

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Making use of different band combination and of different sensors

ASTER, Landsat^{TM}, etc. can help improve the quality of the map (Fig. 7): The following figures (Figs. 8 and 9) illustrate how misleading it can be if the interpretation is done on only one set of data (band combination or sensor; season also plays a role).

This exercise is the simplest way to create a land use/cover map, but it demands utmost caution. If the purpose is to simply have 'a base map' one can stop at this step, but more information is required to obtain the land use system (LUS) map.

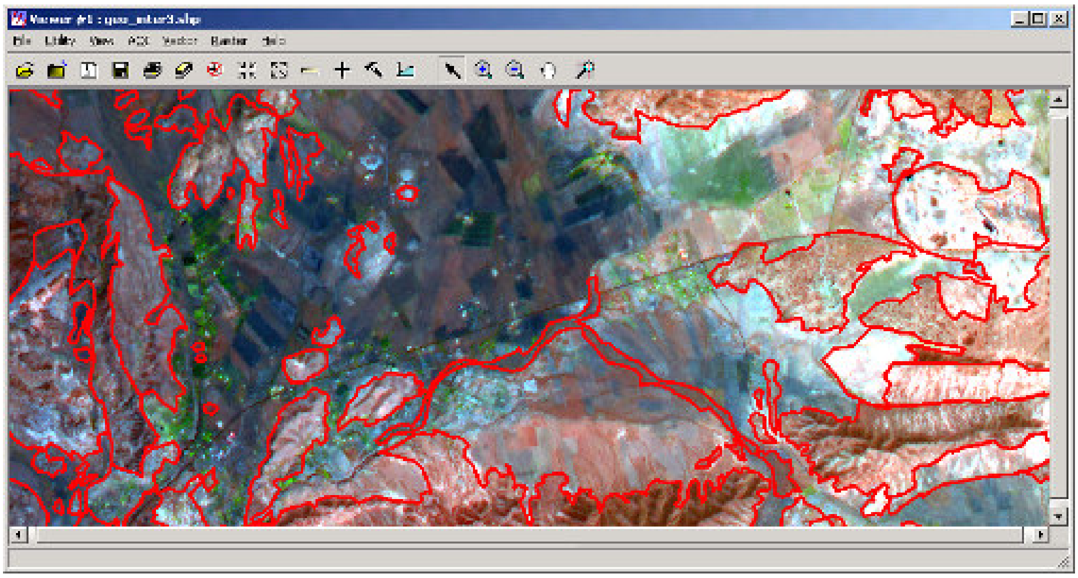


Fig. 8 FCC of ASTER bands 432 (visually interpreted for lithology).

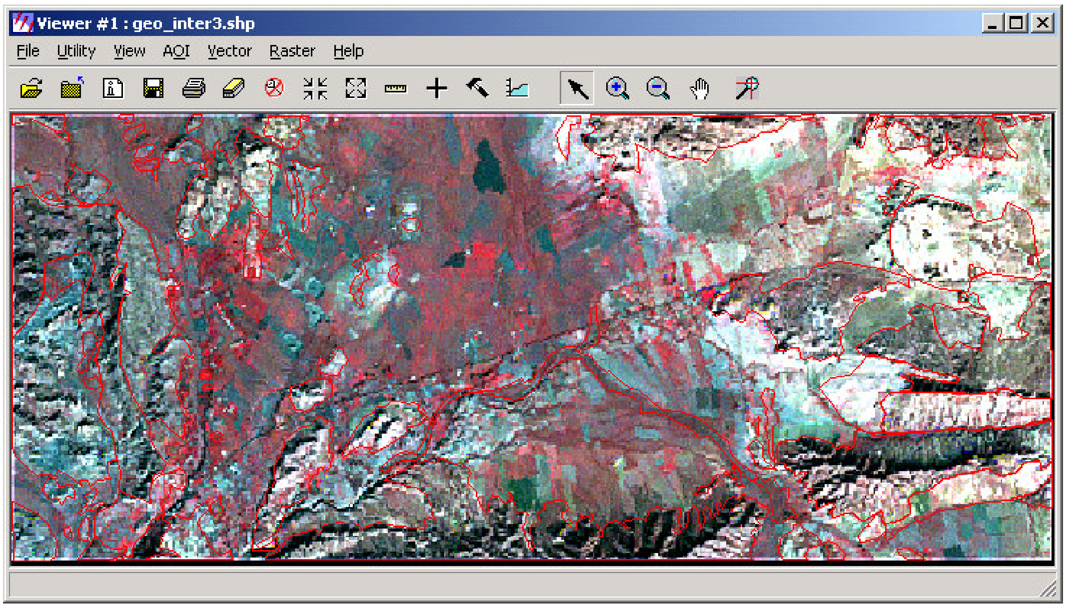


Fig. 9 FCC of Landsat bands 432 (visually interpreted).

The second step: converting the land use map to Land Utilization Type (LUT) map

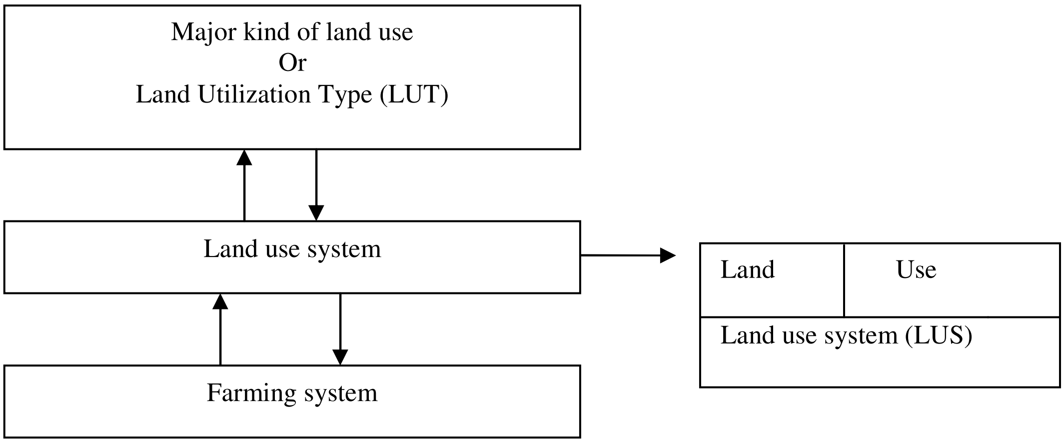
In order to convert the land use/cover map to a land use type (LUT) map, some fieldwork (interviewing farmers) is required, where further details on management (irrigation, dry farming, etc.) are collected. This information includes all types of activities from sowing and/or planting through to harvesting. For example, some of the questions asked of local people (interviewed) could be: is your grazing land extensively or intensively managed? Is it natural, semi-natural or grassland? Is it pure or mixed with trees? etc.

The third step: Land Use System (LUS) map

To create the LUS map (Figs. 10 and 11) is the most complex step, because, depending on the nature of the study site, information on relief (Fig. 12), physiography (geomorphology, soil, etc.), watershed, administrative boundaries etc. may need to be added. The information and data added here are to be used when defining the unit in terms of indicators.

LU1	LU2	LU3		LU4	LU5
LUT1	LUT1	LUT1	LUT2	LUT2	LUT3
LUS1	LUS2	LUS3	LUS4	LUS5	LUS6
Farming system					

Fig. 10 A hierarchical system: farming system, land use systems, and land units.



Land Use System (LUS)	
Land mapping unit (LU)	Major kind of land use Or depending on scale: Land Utilization Type (LUT)
Described: using 'Land characteristics (LC)', such as pH, texture (%clay, silt, sand), EC, slope gradient/ form, etc.; crystallized in 'indicators'.	Described: using management-based indicators, such as accessibility to roads/to market/to water source, tillage-based, tenure-related etc.

Fig. 11 'Land Unit= LU' (dominantly physical-based) and the 'Use' (mainly the soft side; socio-economic-cultural based).

Use of DEM:

As cropland on sloping areas may require different management than that on flat areas, use of DEM helps show the differences (Fig. 12).

Use of geology data:

The study area is considered as a basin within the mountain ranges: Sierra de los Filabres in the north and Sierra Alhamilla in the south respectively (Figs. 13 and 14).

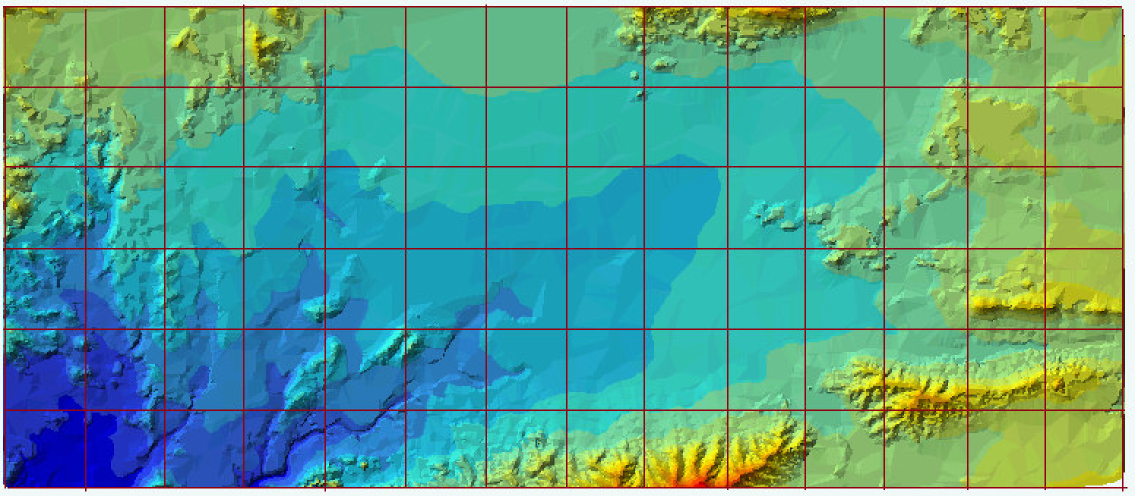


Fig. 12 Digital Elevation Model (DEM).

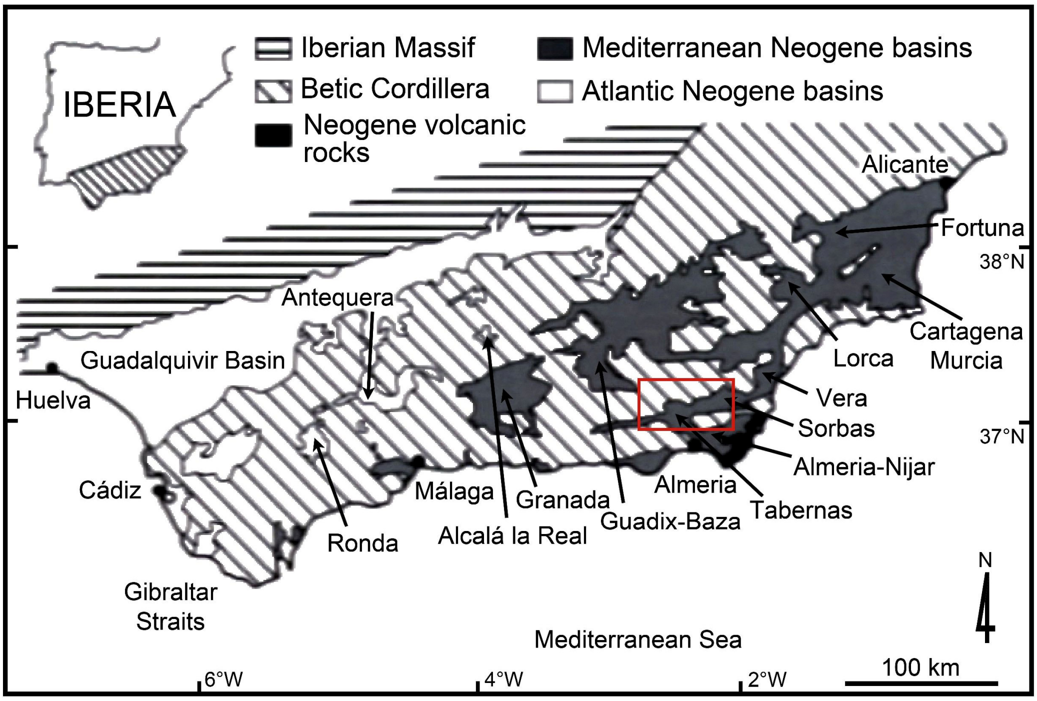


Fig. 13 The Neogene basin in southern Spain.

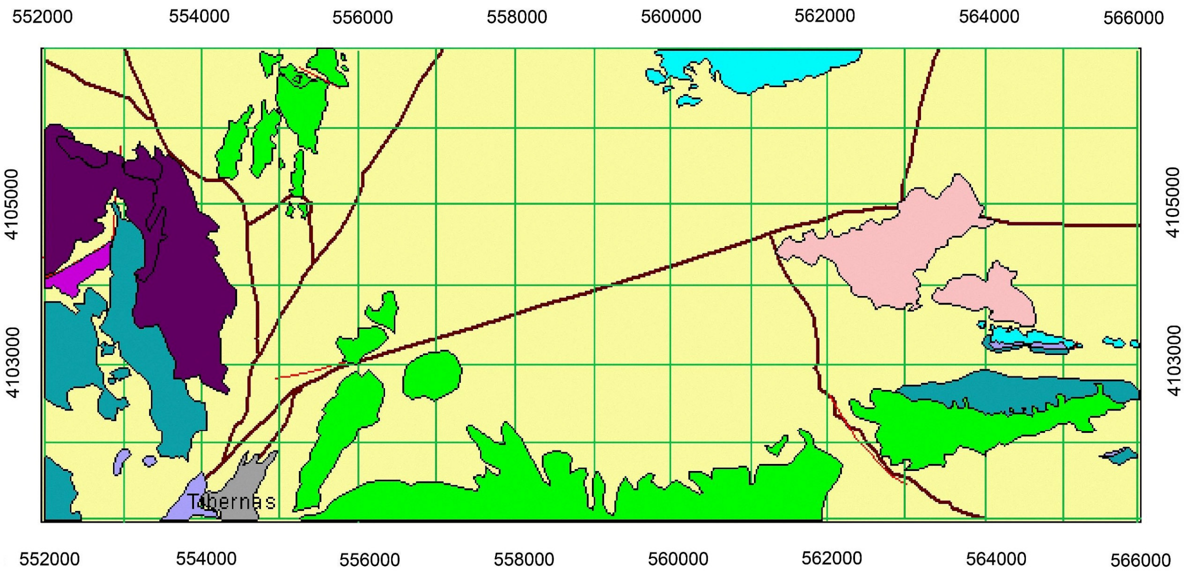


Fig. 14 Geology map of the study area (source: Wang Jun & Damian Ndubuisi Njoku, 2003).

The figure shows various lithologies, which is important to take into account when making a generalization.

Making use of Geomorphology

Making use of geomorphology very much depends on its role in the study. Geomorphology of the Tabernas-Sorbas is controlled by NE-SW and EW running mountains bordering the Tabernas basin. In the north of the study area is the Sierra de los Filabrides, and in the south is the Sierra de Alhamilla. The wind direction records, of the 'Solar Plant' near the town of Tabernas, indicate a dominantly E-W direction, suggesting the strong influence of the two mountain ridges, with the highest elevation being about 600 m in the central part, in Neogene-Quaternary Sedimentary rocks. Mountains, hill-lands, piedmonts, valleys, and alluvial/colluvial fan are the main terrain units clearly visible in the geopedological map and the legend (Fig. 15 and Table 1). The dissected denudational mountain chains and depositional landforms in the valleys, with wide canyons and numerous stream channels, are typical geomorphological features of the area.

Making use of soils

The amount of soil data needed to assess degradation/desertification may vary from site to site. Its extent however can be decided upon, taking into consideration the list of indicators (e.g. fertility, salinity, effective soil depth, drainage condition status, etc.).

The following sub-section gives a brief account of soil type, lithological constituents of the soils, and in a few cases, land use/land cover at relief-type level, for the Tabernas-Sorbas case study (Table 1).

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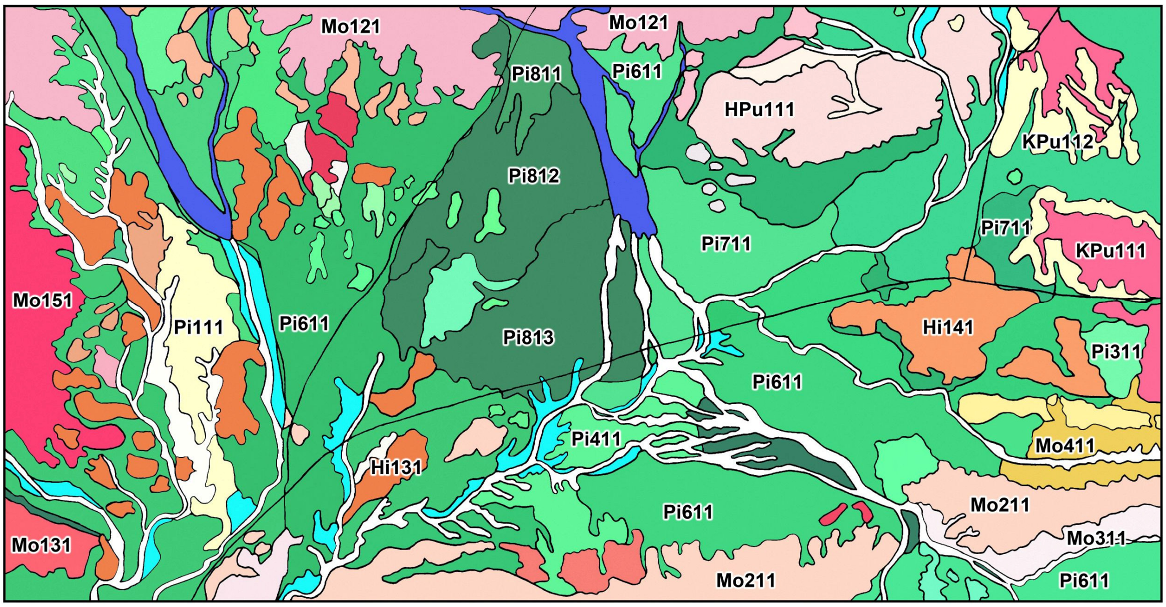

Fig. 15 Geopedologic map of Tabernas-Sorbas area, Almeria, Spain (source: R. Barahona, J. Baruti, and A. Garrido, 2003).

Table 1 A part of the map Legend, Geopedologic Map of the west and central part of Tabernas-Sorbas Basin, Spain.

Landscape	Relief type	Lithology	Landform	Symbol	Dominant taxa
Mountain	Hill	Conglomerate and sandstone	Slope facet complex	Mo111	Association Lithic Torriorthents, Lithic Haplocambids, Typic Haploargids.
		Micaschist, Quartzsite	Slope facet complex	Mo121	Association Lithic Torriorthents, Typic Torriorthents.
		Conglomerate, Marl and sandstone	Slope facet complex	Mo131	Association Lithic Torriorthents, Typic Torriorthents.
		Conglomerates and marl	Slope facet complex	Mo141	Consociation Typic Torriorthents.
		Micaschist, Quartzsite, Conglomerate and sandstone	Slope facet complex	Mo151	Association of Lithic Torriorthents, Typic Torriorthents
	Ridge	Conglomerate and sandstone	Slope facet complex	Mo211	Consociation Typic Torriorthents.
		Sandstone and marl	Slope facet complex	Mo221	Consociation Typic Torriorthents.
	Debris slope	Colluvio-Alluvium	Apical distal complex	Mo311	Consociation Typic Torriorthents.

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Table 1 (Continue)

	High Dissected Debris Slope	Colluvio-Alluvium	Slope facet complex	Mo411	Association of Typic Haplocalcids, Typic Haploargids.
Highly dissected rocky Plateau	Cuesta	Limestone, sandstone, marl.	Dissected Tread	HPu111	Association of Typic Haplocalcids and Typic Torriorthents.
		Alluvium-colluvium	Scarp-Talus-Complex	HPu121	Consociation Typic and Lithic Haploargids.
	Hill	Limestone, sandstone, marl.		HPu211	Association of Typic Haplocalcids and Typic Torriorthents.
Karst Plateau	Mesa	White Limestone	Tread	KPu111	Association of Lithic and Typic Petrocalcids
		White Limestone	Scarp	KPu112	Association of Typic and Lithic Torriorthents

To economize on length, only examples of land use/cover in a few land units are given here:

Hills (Mo1)

The slope gradient ranges between 25 and 60%. Nature conservation, which is mainly privately owned hunting land, is the major land use in the hills. Grasses and sparsely distributed shrubs are the main land cover types.

Valley terraces (Va1)

Valley terraces are mainly used for semi-mechanized agricultural purposes, in which fruit trees, olives and cereals are being grown. The use of valley terraces for agricultural purposes is largely attributed to the presence of relatively good soil in terms of nutrients and soil moisture availability.

Valley flood plain (Va2)

Flood plains are primarily used for agricultural production, especially cereals and olives.

4.2 Iran

This exercise (Fig. 16 and Table 2), carried out at the national level, shows an attempt to map human-induced soil degradation, within the framework of the GLASOD project (Oldeman *et al.* 1990). The symbols, placed in the mapping units (e.g. Wt f/g 213), indicate ‘loss of topsoil effected by water erosion (Wt), caused by deforestation (f) and overgrazing (g), with a medium rate (2), affecting about 5% of the land and a severe rate meaning that all topsoil and part of the subsoil is removed, or with moderately deep gullies less than 20 m apart’.

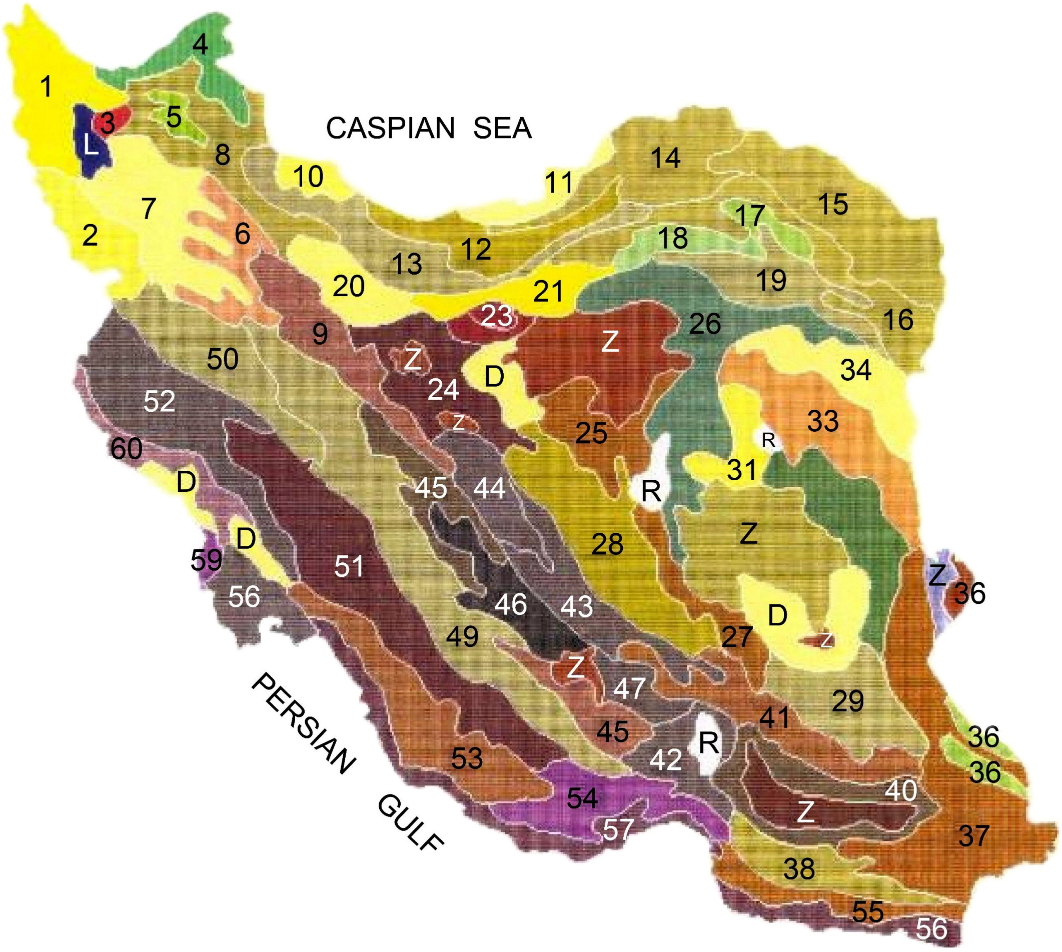

Fig. 16 GLASOD map of Iran.

Table 2 The legend for the map shown in Fig. 16.

LEGEND :			SOLL	DEGRADATION		MAP	OF	IRAN	(GLASOD APPROACH)		
1.	Wt	f/g	213	25.	Ed	e	224		Pa	f/i	123
2.	Wt	f/g	222		Cs	e	215	48.	Cs	f/e	215
3.	Cs	i/o	224		Wt	e	114		Ed	f/e	224
4.	Wt	g/i	213	26.	Cs	e	313	49.	Wt	f/e	113
5.	Wt	f	112		Ed	e	215		Pa	i/w	114
6.	Wt	f/g	113	27.	Ed	e	124	50.	Wt	f/g	114
7.	Wt	g/i	223		Wt	e	114		Co	o	222
	Pa	i	114		Cs	e	113	51.	Wt	f/w	122
8.	Wt	g/i	224		Pa	i/w	113	52.	Wt	f/g	123
	Pa	i	124	28.	Cs	e	214		Co	o	222
9.	Wt	g/e	213		Ed	e	224	53.	Wt	f/e	114
	Cs	g/e	111		Pa	i/w	224	54.	Wt	f/e	113
	Pa	i	122	29.	Ed	e	115		Et	f/e	122
10.	Wt	f/i	123		Pa	f/e	215		Cs	f/e	212
11.	Cs	i	224	31.	Wt	f/e	214	55.	Wt	f/e	113
12.	Wt	f	112	34.	Cs	g/e	114		Ed	f/e	112

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Table 2 (Continue)

13.	Wt	g/i	224		Wt	g/e	113	56.	Cs	f/e	225
	Pa	o	112	36.	Cs	g/e	114		Ed	f/e	224
14.	Wt	g/i	224		Wt	g/e	113		Pw	e	112
	Pa	i	112	37.	Et	e/g	225	57.	Cs	f/e	225
15.	Wt	g/e	123		Wd	e/g	225		Ed	f/e	224
	Pa	i	112		Cs	e/g	114		Co	o/w	223
16.	Wt	f/g	113		Pa	e/g	113		Pw	e	112
17.	Wt	g/i	224	38.	Et	e/g	225	58.	Cs	f/i	326
	Pa	i	114		Wd	e/g	225		Ed	f/g	224
18.	Wt	f/g	123	40.	Ed	e/g	224		Co	w	223
	Et	f/g	113		Cs	e/g	113		Pw	e	112
	Pa	i	113	41.	Et	e/g	224	59.	Cs	f/i	224
19.	Wt	f/e	214		Wt	e/g	114		Co	w	233
	Cs	i	213		Cs	e/g	113	60.	Cs	f/g	214
	Pa	i	113	42.	Cs	e/g	113		Co	w	233
20.	Wt	w/i	124		Et	e/g	114				
	Pa	w	124	43.	Cs	e	214				
	Co	w	223		Ed	e	224				
21.	Cs	g/e	214	44.	Wt	f/e	114				
	Wt	g/e	112		Cs	f/e	113				
	Ed	g/e	112	45.	Wt	f/e	124				
	Pa	i	113		Cs	f/e	223				
23.	Cs	g/e	222		Pa	i/o	223				
	Ed	e	224	46.	Cs	f/e	215				
	Pa	e/i	225		Ed	f/e	224				
24.	Et	e/g	225		Pa	f/i	123				
	Cs	e/g	224	47.	Cs	f/e	215				
	Pa	w/i	225		Ed	f/e	224				

Symbols indicate:

- Degrad. type
(lst 2 letters)
- Causat. factors;
(1 or 2 letters)
- Degree;
(lst figure)
- Rate;
(2nd figure)
-Extent;
(3rd figure)

4.3 Mexico

Site-selection, planning and management of protected areas for nature conservation have traditionally been approached from an eco-biological perspective. However, in recent years a new but related concept – *geoconservation* – has been introduced, which highlights the management and conservation of rocks, landforms and soils, taking into account their intrinsic, ecological and heritage value. Within this context, new terms, such as *geological heritage*, *geodiversity*, *geomorphological sites*, *geotourism* and *geopark* have been introduced. Geodiversity, for instance, states that there is no real separation between the ecological cycles and the geological processes. Genuine nature conservation would, therefore, be achievable if these two are combined and totally taken into account when planning and practicing nature conservation (Brilhá, 2002).

The 'Geopark' program launched by UNESCO in 1997 embodies a new paradigm in nature conservation, as it attempts to safeguard the *geological heritage* of the Earth, especially unique resources for geosciences education and popularization. Nevertheless, the *geopark* (as it is described in this paper) includes far more than geology.

The concept circumscribes pedological, geomorphological, biological, hydrological, economic, social and cultural aspects too (Garrido *et al.*, 2004). This means that any landscape characterized by any combination of these elements would potentially be a nominee for a *geopark*.

[DOR: 20.1001.1.23222700.2011.0.2.7.8]

Adapting the FAO framework for land evaluation to formulate a land use system (LUS) and land use requirements (LUR) led to the use of the term geocriteria (in place of the term 'requirement') and geoindicator (instead of land characteristic). These sets are crucial to evaluate and systematically describe the most important characteristics and properties of the intended geoparks (Fig. 17 and Table 3).

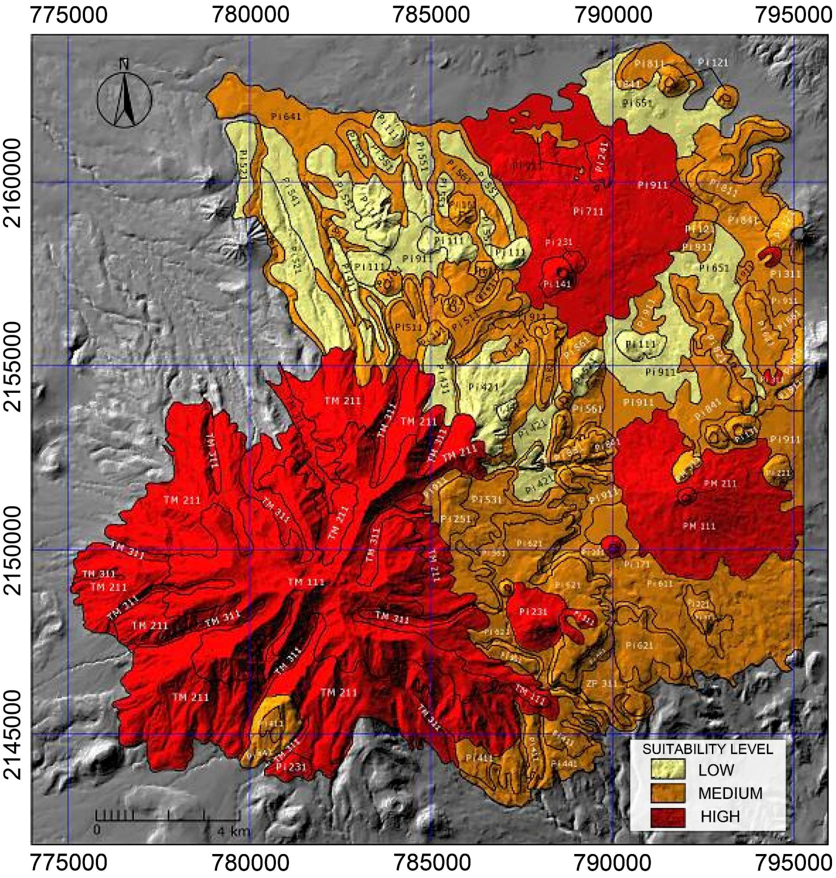

Fig. 17 Suitability map, showing the proposed area for the geopark.

Table 3 The legend for the map shown in Fig. 17.

Degree of suitability	Land Unit (code)	Landscape	Relief type/molding
HIGH	Pi 141	Overall Piedmont	Volcanic Cones
	Pi 171		
	Pi 231		Volcanic Domes
	Pi 241		
	Pi 311		Horseshoe Volcanoes
	Pi 711		'Paricutín' Lava Flow Terraces
	PM 111	'Cerro Prieto' Volcanic Mountain	Ridges/incision complex
	PM 211		Cones

Table 3 (Continue)

	TM 111	'Tancítaro' Volcanic Mountain	Ridges (High)
	TM 211		Ridges (Low)
	TM 311		Vales
MEDIUM	Pi 121	Overall Piedmont	Volcanic Cones
	Pi 131		
	Pi 161		
	Pi 211		Volcanic Domes
	Pi 221		
	Pi 231		
	Pi 251		
	Pi 411		Highest Flow Terrace
	Pi 441		
	Pi 511		Mid-level Flow Terrace
	Pi 531		
	Pi 561		
	Pi 611		Lowest Flow Terrace
	Pi 621		
	Pi 641		
	Pi 661		
	Pi 811		Mesa
	Pi 821		
	Pi 831		
	Pi 841		
	Pi 911		Accumulational/Erosional Terraces
	PM 311	'Cerro Prieto' Volcanic Mountain	Domes
LOW	Pi 111	Overall Piedmont	Volcanic Cones
	Pi 421		Highest Flow Terrace
	Pi 431		
	Pi 521		Mid-level Flow Terrace
	Pi 541		
	Pi 551		
	Pi 651		Lowest Flow Terrace

5 MAIN PROBLEMS/PROCESSES AND SELECTED INDICATORS

The complexity and range of data required in assessing and quantifying degradation/ desertification calls for a comprehensive but simple approach. A glance at a number of problems in various regions worldwide helps justify the commonly applied approach, namely the use of 'indicators'.

The following problems are often referred to as the main problems/processes, in many projects, such as GLASOD, GLADAD, DIS4ME (DIS4ME: Desertification Indicators System for Mediterranean Europe), DESIRE project. These are, amongst others: soil erosion by water, extensive gullying, soil erosion by

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wind, overgrazing, poor vegetation growth, vegetation change, water stress, salinization, increasing pressure due to urbanization nearby, competition for scarce water resources, flash floods and drought.

‘The indicators are the integrators of several processes and effects which interactively act in a synergistic way and lead to formation of desert like conditions’. Based on the following broad categories: physical, biological/agricultural and those with a socio-economic-cultural nature, a number of ‘key indictors’ can be identified including soil, water, vegetation, animal, land and water use, settlement pattern change, human biological parameters and social process parameters. In each of these ‘key indicators’ (or ‘criteria’), attributes (called ‘indicators’, by Farshad and Zinck (2000), that are either quantitatively or qualitatively determined, can be identified.

Geopedologically derived indicators in the assessment of degradation/desertification are the product of the integration of some of the geomorphologic, pedologic and hydrologic aspects of the land.

Based on the studies carried out by a few groups of ITC students, a number of geopedologically derived indicators can be deduced and developed, with the aid of pedotransfer functions. Some of the required data are: soil effective depth, soil moisture, erosion (rill, gully), salt excess, pH, humus contents, water holding capacity, susceptibility to erosion, surface stoniness cover, presence or absence of surface crust, slope and the position in the landscape, drainage condition status, fire (soil color), and compaction status (soil structure, bulk density). See also DIS4ME (online), and the FAO publication for describing land degradation indicators.

The integration of available soil information with other data layers such as slope, land cover, and rainfall in a GIS environment helps, for instance, to determine the rate of water erosion within the identified geopedological map units.

6 DISCUSSION

An obvious issue to take into account is that of the ‘farming system’, consisting of one or more ‘land use systems (LUS)’ as shown in the charts (Fig. 11), where the role of ‘land unit’ is clearly visible.

Considering the fact that landform (topography/slope + forming processes), lithology, and soil distribution form the basis of the ‘land unit’ (the land unit map (Fig. 18) may be preferred to the map in Fig. 7; depending on the objective and the scale of survey). The above land units’ aspects (lithology, geomorphology, soil etc.) determine considerably the description of the land units in terms of indicators. The role of the land units’ aspects in controlling land use type (crop + managerial aspects) is obvious, especially in areas where extensive agriculture is practiced.

The use of desertification indicators has now received wider attention in an attempt to minimize these complexities. However, it should be noted that no single indicator could be indicative of desertification, but a combination of changes in indicators are needed.

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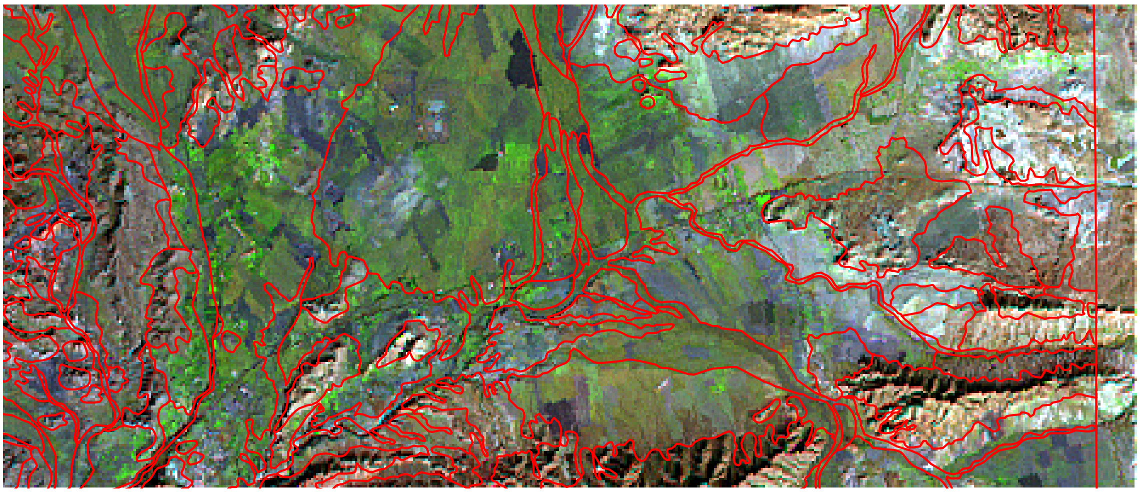

Fig. 18 Detailed land unit map for the Tabernas-Sorba area, Almeria, Spain.

A number of approaches have been used depending on the needs and the purpose of the project. In the GLASOD approach, the assessment is mainly based on determining the degree and extent of particular degradation type/process, which is later combined to give the severity level. In this approach, the causative factors and time scale under which the degradation has taken place are also included.

7 CONCLUSION

It can clearly be concluded that with derivable information from Landsat data and geopedological maps, in association with a database, even when it is in a simple spread-sheet format and combined with the analytical capabilities of GIS, a number of indicators can be determined to provide an input into the overall assessment of degradation/ desertification in a given area.

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واحدهای نقشه‌برداری در مطالعات مبتنی بر تخریب/حفاظت

عباس فرشاد

ITC، هلند

چکیده اصطلاح تخریب برای تعیین وضعیت محیط زیست مورد استفاده قرار می‌گیرد و اغلب با "استفاده نادرست" همراه است. "استفاده" همچنین دلالت بر جنبه‌های زیست محیطی غیر از انواع فیزیکی داشته و نشان می‌دهد که استفاده بیشتر از محیط زیست موجب حساسیت بیشتر آن به تخریب خواهد شد به خصوص اگر مراقبت‌های مناسب برای محیط زیست وجود نداشته باشد. سوالی که همواره وجود داشته این است که چگونه چیزی را که جدا از جنبه‌های فیزیکی چشم انداز، تحت تأثیر مسائل اجتماعی- فرهنگی و اقتصادی می‌باشد به صورت نقشه درآورد؟ در نقشه تخریب رویکرد رایج بر مبنای شاخص‌ها استوار بوده و هدف از این مقاله ارائه سه مطالعات موردی در منطقه Tabernas-Sorbas در اسپانیا؛ ایران (در سطح کشور) و منطقه Pico de Tancitaro در مکزیک است. نقشه زمین-خاکشناسی با نقشه کاربری اراضی ترکیب شده تا به تعیین مبنایی برای استخراج تعداد قابل توجهی شاخص بیانجامد.

کلمات کلیدی: ایران، نقشه تخریب/بیابان‌زایی، واحدهای نقشه‌برداری، GLASCOD، Pico de Tancitaro (مکزیک)، Tabernas-Sorbas (اسپانیا)

[DOR: 20.1001.1.23222700.2011.0.2.7.8]