IMPROVING COASTAL LAND DEGRADATION MONITORING IN LEBANON AND SYRIA

LIFE TCY/00/INT/00069/MED

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- "Reconnaissance Survey"
- "Detailed Analysis"
- "Strategy and Recommendations"
- "Interactive Participatory Programme (IPP)"
- "Geographic Information System (GIS)".

The report integrates all project components into a comprehensive document.

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EXECUTIVE SUMMARY

1. This Report is the major document resulting from the EC-funded Life Program, of the project “Improving Coastal Land Degradation Monitoring in Lebanon and Syria” N°: LIFE TCY/00/INT/00069/MED. The project focuses on assessing coastal land degradation in Lebanon and Syria (eastern Mediterranean – though this Report covers only the Lebanese case). It is concerned with improving the monitoring of degradation processes, especially through encouraging public participation, and upgrading national capacities using tools of remote sensing and GIS for better environmental management and planning of coastal zones. The project partners are the CTM-ERS/RAC UNEP/MAP (Environment Remote Sensing Regional Activity Centre), PAP/RAC UNEP/MAP (Priority Actions Programme Regional Activity Centre), GORS (Syrian General Organisation for Remote Sensing), NCSR/NCRS (National Council for Scientific Research/National Centre for Remote Sensing).

2. The project serves several purposes through working on the coastal zone and two pilot areas chosen within the coastal zone. That includes specific characterisation, thematic maps, public participation, determining environmental impacts and indicators thereof. The participatory work includes seminars, workshops and on-site interviews. The project gives an action plan for participation, as well as a draft management plan for the pilot areas.

3. A major component of the project is the Diagnostic Analysis which is a general evaluation of the total area of study where available data are collected and screened, a Reconnaissance Survey Map of 1:100000 is produced from satellite imagery, followed by a socio-economic study for the participatory component. The training provided for this component allowed producing the integrated public participation action plan, as well as the general predictive soil erosion map on 1:100,000 scale.

4. Following the diagnostic analysis of the study area covering the coastal stretch, recommendations for management of the whole area focus on application of certain measures, i.e. preventive, mitigation and restoration of affected areas. This should consider both the technical and the policies/institutional sides. For this reason several natural and human factors are considered, e.g. morphology, soils, land use, etc., and recommendations given for different areas with particular characteristics.

5. The project requires choosing two pilot areas to do detailed analysis on them. The two pilot areas chosen in Lebanon are the Damour and Zahrani watersheds, the former is in central Lebanon, while the latter is in the south, with areas of 333 km^2 and 140 km^2, respectively. They were chosen according to a rating grid using several criteria including location and size with respect to the total study area, natural characteristics, vegetation cover, soil cover, erosion processes and human interference. Obviously, the two watersheds have lots of differences which make the assessment of their degradation processes more meaningful and educational for the purpose of the project.

6. Another major project component is the Detailed Analysis for which the Damour and Zahrani watersheds were chosen (N°5 above). This starts with the predictive soil map (result of diagnostic analysis) checking it in the field according to indicative criteria on stability, erosion, land use, agropractice, land value, and trend of changing patterns, which allows later to produce maps showing details relating to specific land degradation processes in the two watersheds. This further allows, especially in view of field work, to identify and prioritise areas for intervention, or hot spots. The pilot areas in Damour and Zahrani show unstable and stable intervention areas, fifteen types in total, which are described and evaluated for application of remedial measures. For the detailed analysis, relevant socio-economic factors of the coastal zone are given since human interference and landuse are major parameters in land degradation.

7. Of course, facing land degradation requires understanding their processes, classifying them and mitigating their effects. This section reveals the currently applied remedial measures, how they apply in the pilot areas as obtained through field observation and farmers interviews, and what the possible preventive, protective and curative measures are. Since the topic is interdisciplinary in nature, the concern at this stage is not restricted only to soil (as one environmental element) but covers agriculture, forest, water, as well as social and development needs. This allows interplay of the above measures to cover the actual sites, practices, monitoring and policies. The section also describes assessment procedures for remedial measures, i.e. the rating values of preventive, protective, or curative measures, and hence gives recommendations on the remedial measures in view of the two pilot areas.

8. The procedural steps of the project build up incrementally from one level to the next in a logical framework to reach the top, i.e. the management. This is what section 8 dwells on where all the previous background is used to show in a nutshell the problems, their priorities, their remedial measures, and link that to institutional-administrative issues. This is done in an attempt to draft a management plan which is given for the two pilot areas. An outline of management planning activities is given revealing the objectives, the phases, the activities and indicators of achievement, or sustainability of the plan. An important aspect of the plan is involvement of the community and value of its feedback. It is the combination of field conditions, social attitudes and institutional arrangements that will decide the recommended management of remedial measures desired.

9. One further preparatory step to the management plan is to realise what the pre-requisites for its implementation are, which this section focuses on. Clearly, the management plan, in view of the technical know-how needed, calls for the necessity of training and capacity building for the different stakeholders. The section reflects their different types, i.e. ministries, NGOs, municipalities, other agencies, researchers and the private sector, as well as strategies plus knowledge base needed, and the most relevant legislature-organisational framework for an effective operation. The different stakeholders require different training, therefore recommendations are given notably on strengthening co-operation, technical upgrading, regulations, rehabilitation and economic incentives. This is followed by recommendations for participatory modalities, notably in view of the integrated public participation that constitutes a significant orientation of the project.

   The section further discusses and tabulates the tools of observation reflecting the extent of degradation, i.e. the indicators. These are shown for the soil factor, as well as for climate, land, vegetation and water. Their units, features and monitor are given, during degradation, for the implementation and post implementation program. But this action program needs to be approved by the concerned stakeholders, which the section abides on through showing verification of approval of the remedial measures. They are linked again to major concerns on environment, socio-economic development and regulatory aspects whose functional issues are given, and indicative parameters used to evaluate their effectiveness. In the same section the need is shown to secure approval of the procedures of remedial measures, to identify the authorities concerned, secure the funding, and define indicators to check that objectives are being met.

   Finally, there remains the last step of program implementation, namely, securing the funds for the management plan. Since the plan involves several stakeholders, and since most of the expertise would be local, it is proposed that local funding be obtained through collaboration of the stakeholders. International help is shown to be fairly available when logically justified by the national need.

1. INTRODUCTION

The National Centre for Remote Sensing of the National Council for Scientific Research, the Lebanese Partner in the project “CoLD: Improving Coastal Land Degradation Monitoring in Lebanon & Syria”, an EC-Life project N° (LIFE TCY/00/INT/00069/MED), is involved in the project as part of its applied research interests, especially focusing on facing environmental deterioration and the need for securing sustainable development plus conservation of natural resources.

NCRS has been established in 1995 and become fully operational in 1997. This came as the culmination of a focused effort to catch up with recent advances in applied information and environmental technology. The Centre has proved to be an important tool for decision makers as it is supporting various activities that are essential to several ministries. The research team at the Centre has to its credit numerous studies dealing with important sectors including natural resources, i.e. water, soil, forestry, environmental degradation processes, contribution to land use planning, cadastral and geographic databases, plus natural hazards. Furthermore, the Centre secures highly needed monitoring data in various sectors, and produces different thematic maps and applications of remote sensing and GIS.

This Report focuses on the 2 Pilot Areas (Damour river watershed and Zahrani watershed in coastal Lebanon) chosen to produce in-depth findings, results and recommendations based on the previous activities of the project, namely: 1. the Reconnaissance Survey which provided the Land Unit Map and the Predictive Erosion Risk Map on the coastal area of study (from shoreline to 800 m elevation inland); 2. the Public Participation Program which formulated an action plan with guidelines for procedures.

The Report starts with a briefing on the “CoLD” Project (Chapter 2). Then a summary of the results of the preliminary Diagnostic Survey is given including general recommendations for management of the whole study area (Chapter 3). In the following, the 2 pilot areas are described in detail (Chapter 4), followed by the detailed analysis results for these pilot areas (Chapter 5) with a description of the mapping methodology, the erosion map, the socio-economic factors and prioritisation of future intervention areas. The detailed analysis was based on a descriptive mapping approach recommended in the UNEP/MAP/PAP “Guidelines for erosion and desertification control management with particular reference to Mediterranean coastal areas, 2000”. In compliance with the methodological procedure recommended in the Guidelines, recommendations for remedial measures have been developed (Chapter 6) and consolidated in the form of draft management plans for the selected pilot areas (Chapter 7), both part of the Strategy/ Recommendations activity of the project. This is complemented by the description of the prerequisites for implementation of the management plans such as capacity building, participation modalities and monitoring indicators, ending up in recommendations for funding. At the end of the report, the resulting conclusions are given (Chapter 9). A Bibliography and several Annexes complement the report.

2. PROJECT BACKGROUND INFORMATION

The coastal area of Lebanon is undergoing both natural and human stresses which tend to affect its resources and the community's quality of living. It is highly mountainous with slopes, geology and torrential precipitation that induce instability. In addition, 70% of the country's population and over two thirds of the country economic activities are located in the coastal areas. This high population density has led to noticeable environmental degradation including soil erosion.

Therefore the "CoLD" project is important to Lebanon as it deals with coastal land degradation, notably focusing on assessing and encouraging participatory approaches in improving monitoring of that degradation.

The objectives of CoLD are to improve Lebanese and Syrian national capacities of relying on advanced tools for environmental management and planning of coastal zones, according to the principles of sustainable development. Other objectives are the improvement of the environmental knowledge in Syria and Lebanon (Reconnaissance Survey and Detailed Analysis) especially on: area characterisation, thematic maps (overall erosion risk map, detailed erosion map), properly populated GIS (field data storage, processing and analysing, assessment and monitoring of degradation causes, and determination of priority areas.

Also, CoLD will produce an outline of national coastal areas degradation control/management plans (Strategy and Recommendations) through: Draft Management Plan for pilot areas, monitoring indicators, procedures for determination of potential environmental impacts, Draft Strategy Document, and final recommendations

The project also involves national capacity building through a Public Participation Programme (PPP) that covers: adoption of the action plan for the PPP, country-level reports, seminars to stakeholders, evaluation Workshops, thematic maps at 1:100,000 and 1: 50,000 scales, guidelines and recommendations, reports on project activities, including training modules, implementation of a Geographic Information System, and video, web-site, CD ROM, brochures for dissemination of project results.

More information on the CoLD project can be obtained from the project web-site: www.coldproject.net

3. SUMMARY OF DIAGNOSTIC ANALYSIS RESULTS AND RESULTING GENERAL RECOMMENDATIONS FOR MANAGEMENT OF ENTIRE STUDY AREA

3.1 INTRODUCTION

General recommendations for the preparation of management plans for areas affected by degradation cannot disregard the guiding principles of sustainable development, in terms of management and conservation of the resources base, and of orientation of technological and institutional progress so to ensure a continuous satisfaction of human needs for present and future generations. The application of the principles of sustainable development makes it possible to preserve natural and genetic resources, while promoting a development which is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

The application of sustainable development principles to fragile ecosystems such as arid and semiarid zones, very common in Mediterranean areas, must cope with the issues of land degradation and desertification.

This is why it is essential to combat desertification through the application of at least three main measures:

- preventive measures, in order to prevent the occurrence of degradation phenomena in lands which are not yet degraded, or which are only slightly degraded;
- mitigation measures, in order to rehabilitate the productivity of moderately-degraded lands;
- restoration measures, for soil recovery and land reclamation in seriously degraded areas.

A sound knowledge of causes of land degradation and of desertification processes is needed in order to select, for each management area, the most appropriate actions for natural resources conservation.

In this connection, the benefits of thematic mapping at reconnaissance scale - such as erosion risk mapping - should be considered mainly in terms of possibilities of selecting areas for priority interventions, where it is possible to carry out more detailed studies and field inquires aimed at determining the type and intensity of active erosion processes.

Generally speaking, areas characterised by slightly or not yet degraded land, or moderately degraded one, are often the most widespread and should be devoted special attention and priority.

Actions to restore seriously-degraded land should be limited to specific cases in which land degradation is clearly identified and recovery measures are deemed suitable, effective and sustainable.

In the field of rural sustainable development, policies should aim at operating so that agricultural and rural sectors could meet the basic nutritional needs of present and future generations and supply rural people with long-term employment, decent living and working conditions, while preserving the productive capacity of natural resources.

Therefore, the main objectives to be taken into account in the development of land management plans should be:

- on the technical side, the application of preventive, mitigation and restoration measures to relevant areas;
- on the political side, the development of policies aimed at promoting sustainable development and at reducing the impact of human pressure on land resources.

If these objectives can be considered universal, their practical application requires their translation into strategies and concrete actions, both at national and international levels.

At a national level, land management and planning policies should be implemented so to develop global outlines that embody vulnerability and risk as essential components of planning decisions.

At an international level, the scientific community could play an important role in keeping on studying desertification processes and in improving techniques to combat these processes.

The reconnaissance survey carried out over the coastal area of Lebanon and Syria was aimed at facing the need of a comprehensive, uniform data set at a small scale for the whole coastal area of the country. Even though it was performed following slightly different approaches, it allowed to classify each homogeneous unit of the study-areas relying on its overall erosion risk.

Obviously, the scale used for such a study does not allow a detailed analysis of causes of land degradation with relevant preventive or corrective measures, although it provides the opportunity to assess priority areas for more detailed studies and to get an overview of the main causes of land degradation processes in this area.

The torrential rains which are responsible for severe water erosion processes act over an environment where certain morphological characteristics (mainly slope) and land use/land cover patterns - as described by the reconnaissance survey - represent the two key factors to assess land degradation and to be taken into account for devising land management programmes.

Among other factors which play an equally important role, some soil features - such as soil texture – can be mentioned as affecting in turn water infiltration rate and, as a consequence, the infiltration/runoff ratio.

For scale reasons, considerations about recommendations coming from factors like the latter are remitted to the Detailed Analysis.

3.2 MORPHOLOGY

The morphological asset of a Country - Lebanon in the specific case - plays a key role in characterising erosion-prone areas and in defining management plans aimed at facing similar phenomena. In particular, two main factors have to be considered, namely, the slope gradient and the slope length.

The slope gradient is undoubtedly the most important factor in assessing erosion risk: the slope value weights half or more the total erosion risk value of morphological units classified as highly, very highly or extremely highly susceptible to erosion.

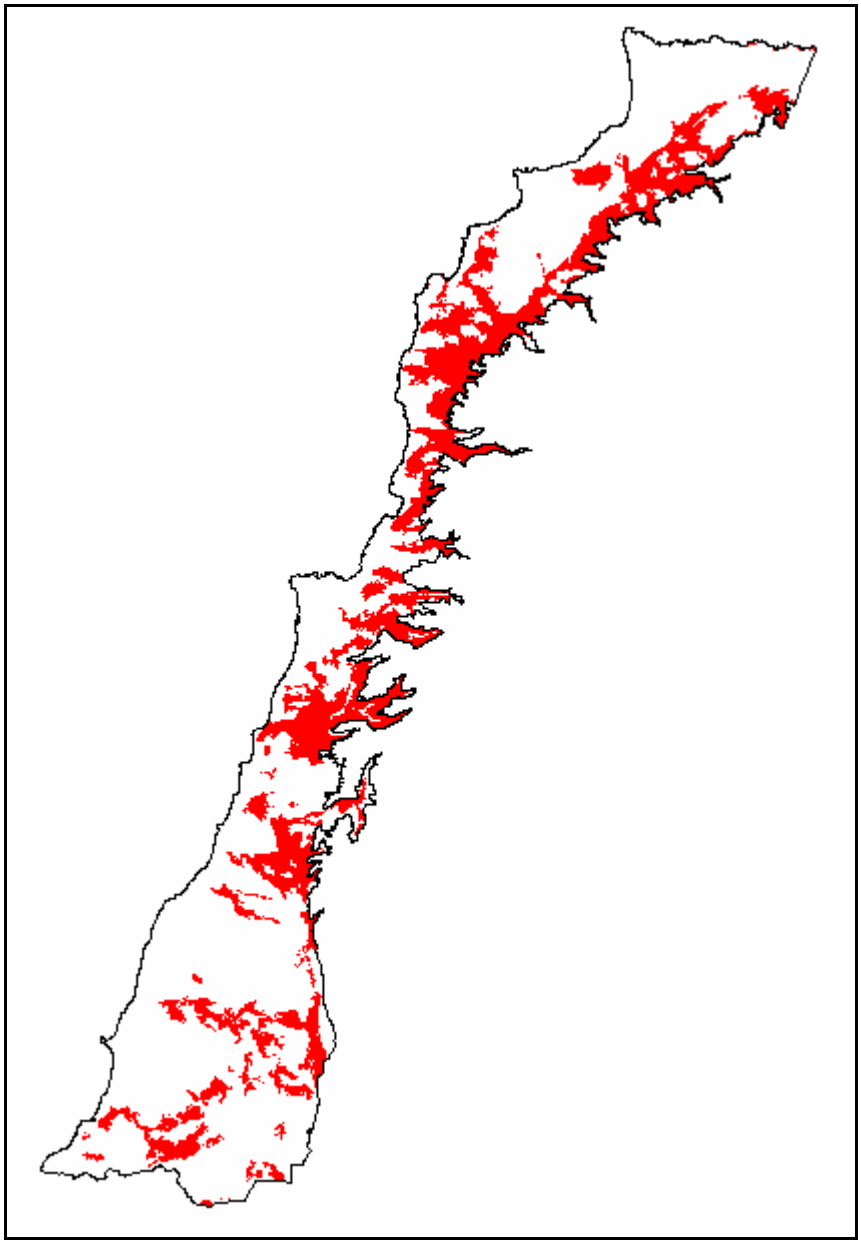
Such units represent about 36% of the Lebanese territory.

Map 3.1 displays the extent and the spread of these morphological units. In red, it shows the land units selected according to both of the following criteria:

- land units with more dissected morphologies and steepest slopes;
- land units classified as falling into the three highest erosion risk classes.

The slope length becomes a critical factor - though only locally - in the land system of Lower Coastal Plain, where it plays quite an important role on more gentle slopes in which the presence of long slopes with quite uniform slope gradient contributes to the increase in runoff speed and in the erosive power of water.

In such situations, the effect of this factor is highly dependent upon the type of land use/land cover and, for agricultural areas, upon agricultural practices for water control (see § 3.3).



Map 3.1: Areas with steep slopes falling in higher erosion risk classes (classes 4, 5, and 6) are shown in red

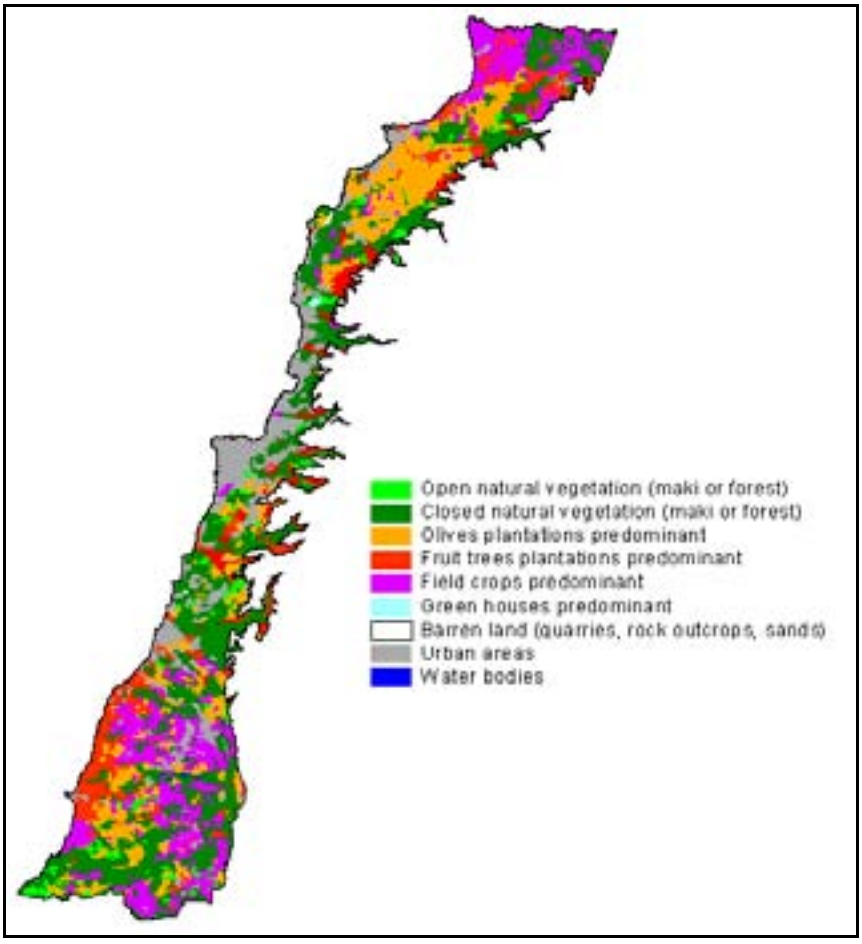
3.3 LAND USE/LAND COVER PATTERNS

According to evidence coming from field survey, from the previously existing thematic maps and from satellite data interpretation, it can be stated that the coastal areas of Lebanon and Syria show, besides a quite high variety of morphological characteristics, some dominant patterns of land use types characterised by specific erosion risk classes. Map 3.2 shows the land use/land cover map of Lebanon (the relevant legend has been simplified with respect to the original data set, for a better small scale thematic representation).

About 17% of the Lebanese study area is marked by olive plantations. They are characterised by a plant spacing which usually leaves more than a half of the soil surface unprotected from erosive action of raindrops. Most of those plantations are located on hilly areas, with morphologies varying from gently undulating to steep slopes and calcareous soils particularly rich in gravel and stones.

Olive plantations are very often irregularly mixed with natural vegetation formations such as open maki, open shrubs and, locally, smaller reforested surfaces. These natural formations have various degrees of degradation and show percentages of vegetation cover ranging from 10% to 70%. The pattern drawn by the mix of this land cover with olive plantations is, in most cases, below the minimum mapping unit size and therefore it is not mappable at the reconnaissance scale.

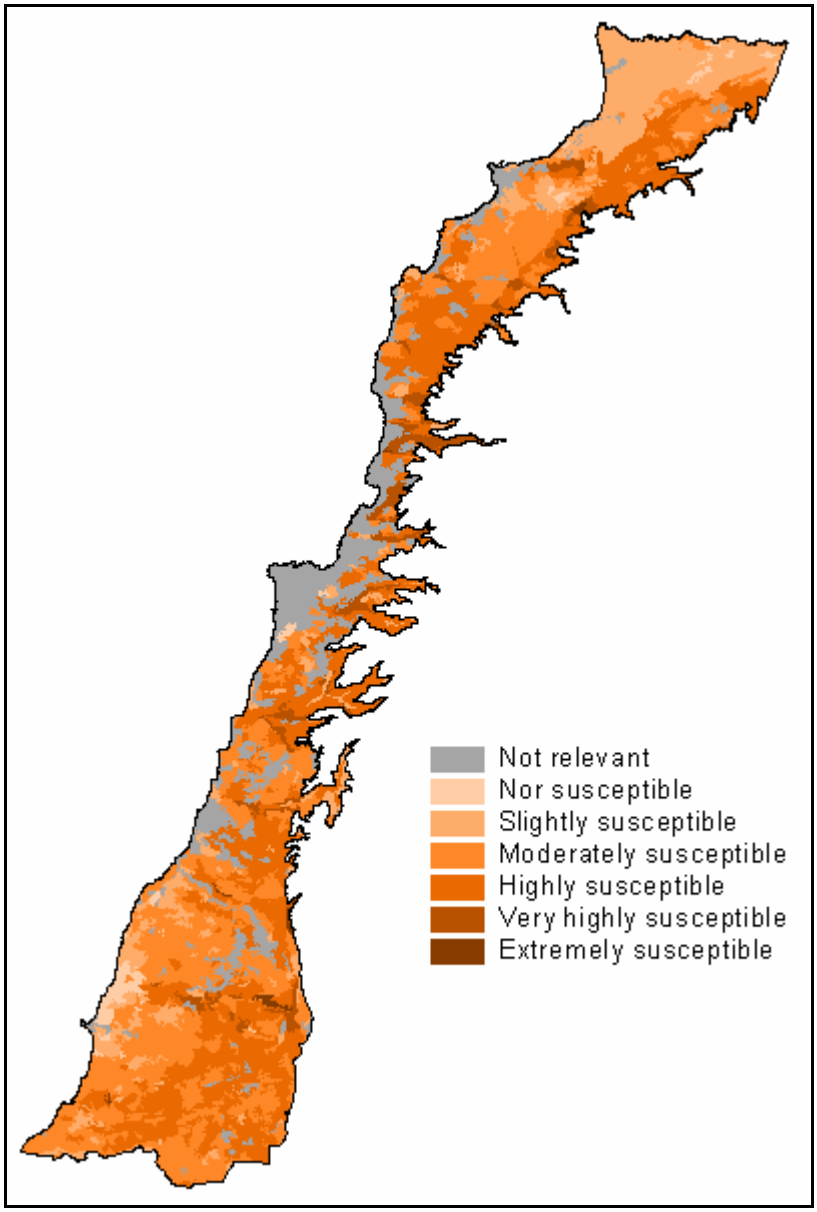
At lower altitudes, on the coastal plain, land use is characterised by tree plantations (especially citrus), intensive farming and field crops.



Map 3.2: Land use/land cover map (simplified legend) of the coastal area of Lebanon

3.4 RECOMMENDATIONS FOR THE MOST CRITICAL AREAS

Relying on the various combinations of the two above reported factors mostly affecting erosion risk, three main scenarios were highlighted in Lebanon for which some general management recommendations are hereinafter provided.



Map 3.3: Erosion risk map of the coastal area of Lebanon

3.4.1 Olive plantations on steep slopes

Steep slope gradient and olive plantations characterise a great part of the study-areas in Lebanon. For that area, field evidence clearly shows an extremely high weight of conservation practices in facing erosion risk.

Table 3.1 and Figure 3.1 show the distribution of olive plantations areas in the various erosion risk classes.

As estimated relying on field survey data, in Lebanon about 90% of slopes covered with olive plantations are managed through some kind of conservation practices (mainly contour stones terracing, but also bench terracing and contour ploughing).

The soil of olive production area is in general gravely and stony, and because the terraces are constructed to make the land levelled, the soil is not only protected against rain drop, but it is characterised by improved drainage condition and higher infiltration rate in comparison with the bare, not rehabilitated soil. Soil deepening on the terraces allows for water storage for the rain-fed crop and better recharge. However, this makes the system more vulnerable to any source of contamination.

In Lebanon, about 90% of sloping lands occupied by olive are terraced, and terraces are maintained by supporting walls. More intensively cultivated crops, like irrigated vegetables, fruit trees and plastic houses, occupy level lands, especially the low lands. Historically, the nature of the narrow coastal strip characterising the coastal Lebanese area and hill slopes to the east made local farmers divide the lands into small terraces without stonewalls for the cultivation of rainfed wheat. Even some forested areas were provided with some terraces.

Olive has always occupied marginal lands with higher vulnerability to erosion, thus the retaining stones were necessary, notably on hard limestone areas, where stones are available in situ. Only the areas with soft marls were observed to have terracing without contour stone, probably because of the transportation problem. Those unmanaged terraces on Bad Lands were observed to return into initial form with the sedimentation and colonisation of natural herbaceous and partly shrub vegetation.

Such practices play a key role in decreasing the surface water runoff and, as a consequence, in reducing erosion risk. Obviously, the effectiveness of such measures depends on slope steepness.

Table 3.1: Distribution of olive plantations in erosion risk classes

Erosion risk classes	Lebanon (ha)
1 - Not or insignificantly susceptible	0
2 - Slightly susceptible	6,276
3 - Moderately susceptible	26,417
4 - Highly susceptible	23,154
5 - Very highly susceptible	1,204
6 - Extremely susceptible	313

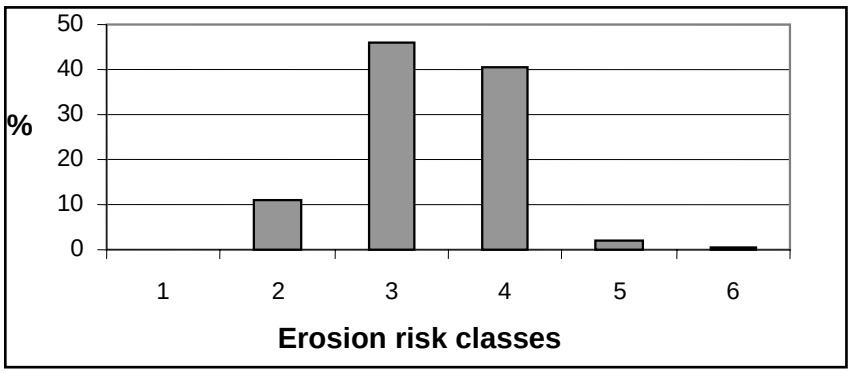
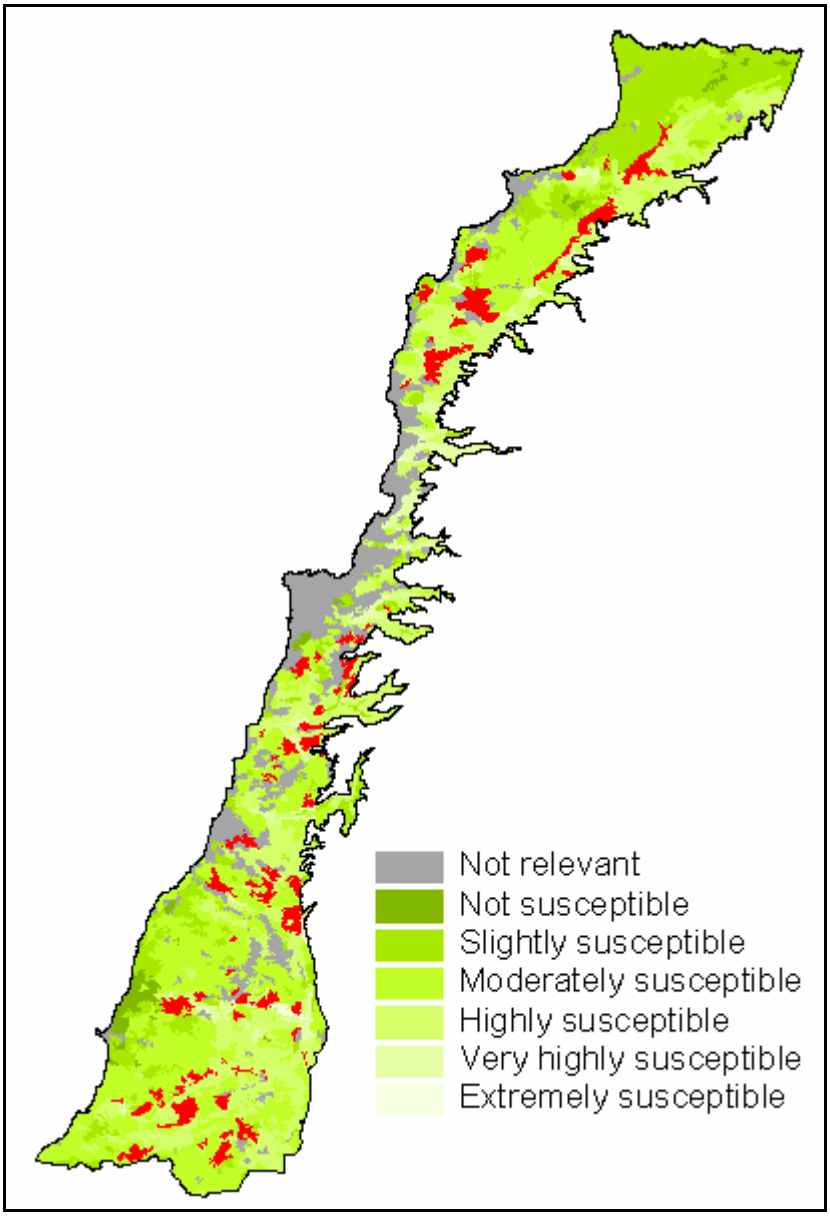


Figure 3.1: Distribution of olive plantations in erosion risk classes in Lebanon

As shown in Map 3.4, areas including olive plantations and falling into higher erosion risk classes (classes 4, 5 and 6) are mainly located in the eastern part of the study-area, where morphology is dominated by the more dissected landforms (erosion slopes, fluvial scarps, fault scarps, dissected sloping areas), i.e. where average slope values are higher, regardless of the Land System those areas belong to.

Field data show that, for all that area, erosion processes are much more active not only where no conservation practices are applied but also where such practices are not maintained.

A degraded or partly-destroyed terrace may cause or even accelerate intensive erosion processes, therefore, maintenance interventions such as repairing partially-collapsed terraces seem to have the same importance as the application of new land management measures.



Map 3.4: Erosion risk map: Areas with olive plantations falling into higher erosion risk classes (classes 4, 5, and 6) are shown in red

3.4.2 Naturally-vegetated steep slopes

Areas covered with natural vegetation (open or closed maki, herbaceous or forest) on steep and very steep slopes are zones highly susceptible to erosion and the presence of vegetation cover becomes the only protection against the rainfall impact.

In these areas the conservation of a good vegetation cover and the increase in vegetation density are fundamental and all actions aimed at increasing water infiltration and at reducing surface runoff should be encouraged.

In naturally vegetated areas it becomes clearly important to devote particular attention to soil protective factors: vegetation cover must be preserved or increased as much as possible, uncontrolled fuelwood collection and excessive grazing need to be always monitored and reduced.

Another very important factor to be kept under control in this area are man-induced forest fires which lead soil surface to a total exposure to erosive agents.

Especially in open and closed maki and under the climatic conditions typical of Lebanon, fire can easily expand over large areas and completely destroy these natural formations.

In forested areas, the creation and maintenance of fire break lines can be a very effective measure for reducing damages caused by forest fires.

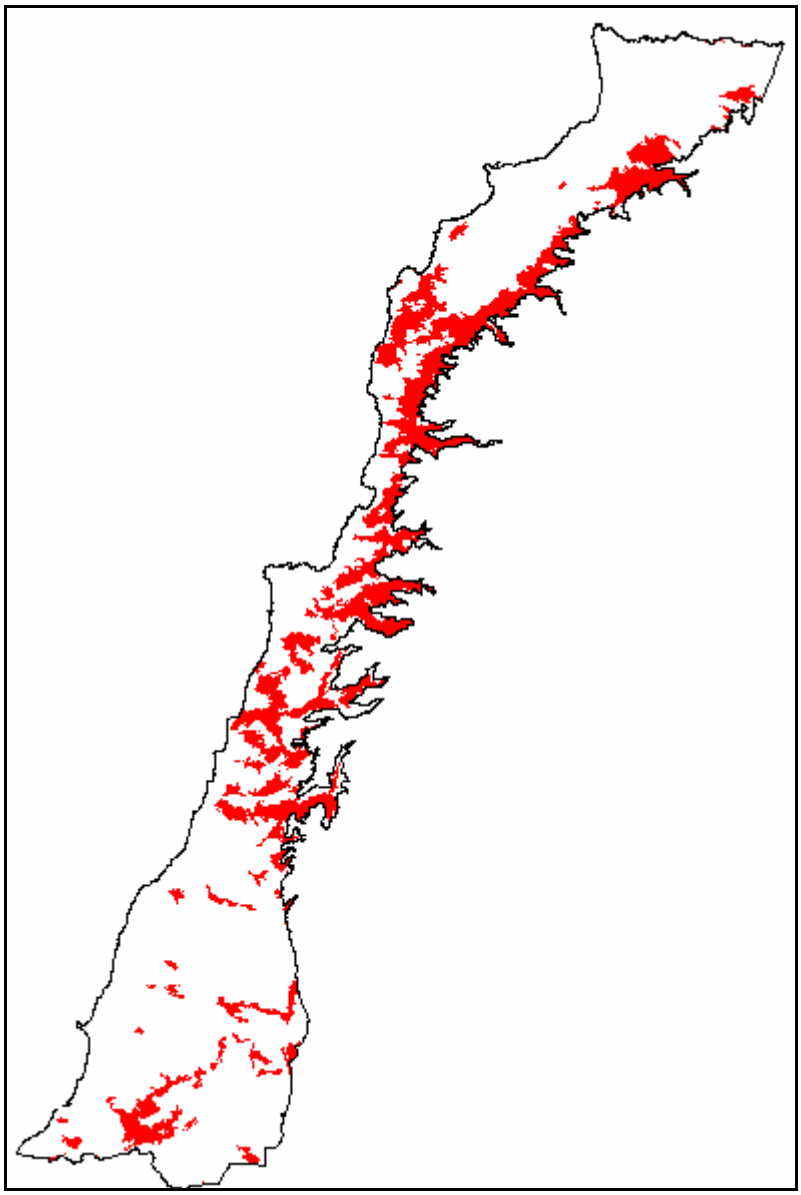
Furthermore, particular attention should be devoted to the following measures:

- Land use changes, such as forest cutting for agricultural purposes, must be totally prohibited.
- Establishing natural reserves should be encouraged in order to minimise the soil erosion rates and simultaneously protect the endangered plant species, as well as to keep the forestland productivity and biodiversity.
- In areas neighbouring forestlands, agriculture residues should be processed applying the principle of prescribed burning in order to minimise the risk of uncontrolled fires.

Map 3.5 shows the distribution of naturally-vegetated areas on steep slopes in Lebanon, while Table 3.2 reports the distribution of such areas in erosion risk classes.

Table 3.2: Distribution of naturally-vegetated areas on steep slopes in erosion risk classes

Erosion risk classes	Lebanon (ha)
1 - Not or insignificantly susceptible	0
2 - Slightly susceptible	3,532
3 - Moderately susceptible	16,933
4 - Highly susceptible	40,803
5 - Very highly susceptible	10,050
6 - Extremely susceptible	42



Map 3.5: Naturally-vegetated areas on steep slopes

3.4.3 Agricultural areas on moderate slopes

A third critical area is highlighted in the coastal plain, where high slope length - even if with a moderate slope gradient – combined with agricultural activities (in particular, citrus and other fruit trees plantations and field crops) may induce erosion phenomena.

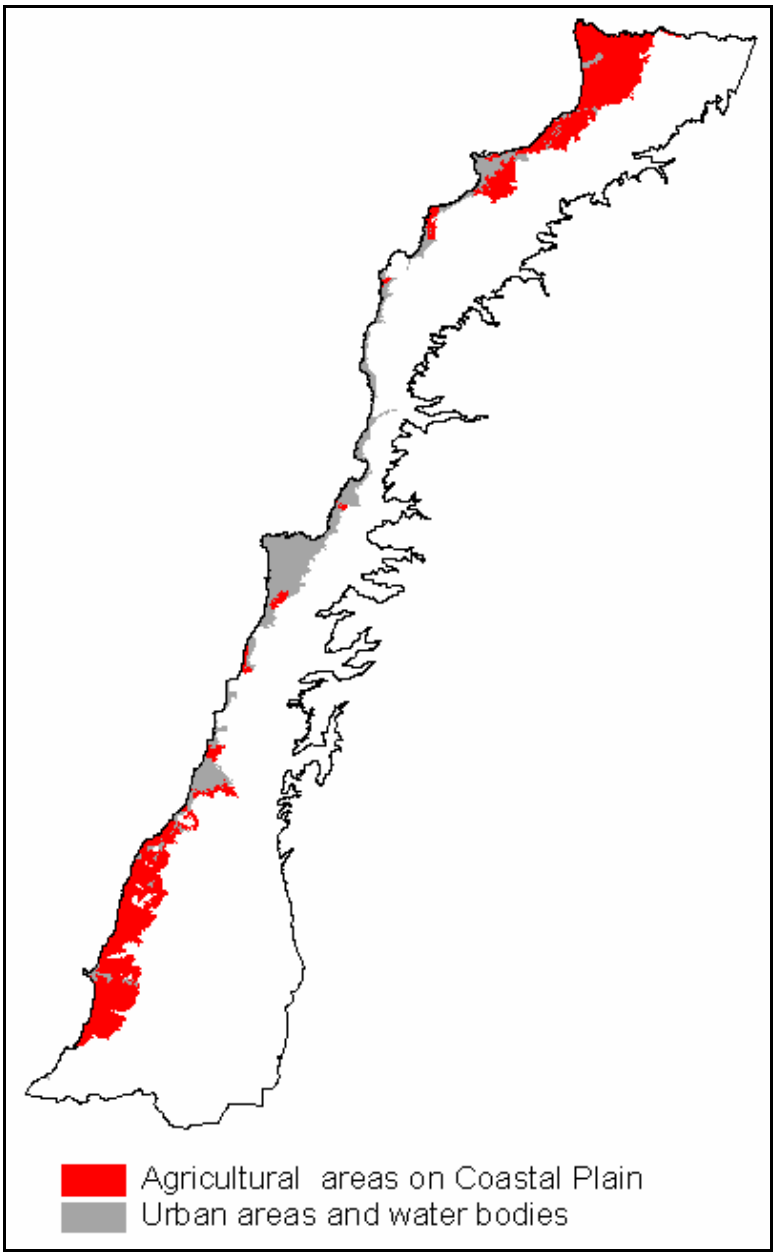
Generally speaking, in these areas suitable procedures should be taken to distribute and direct the agricultural activities according to the characteristics of soil and land morphology. Furthermore, the already existing agricultural practices for water management should be integrated, where necessary, with actions aimed at catching up surface water and at reducing sheet and rill erosion.

In this connection, the importance should not be underestimated of preserving the traditional means of management of agricultural lands, both in terms of materials and techniques used. As a matter of fact, such techniques are very often the result of the adaptation of human activities to the environment over a very long time and are more likely able to ensure the stability of agricultural lands with respect to erosion processes.

Table 3.3 shows the distribution of agricultural areas in the erosion risk class, while Map 3.6 shows their location.

Table 3.3: Distribution of agricultural areas on Coastal Plain in erosion risk classes

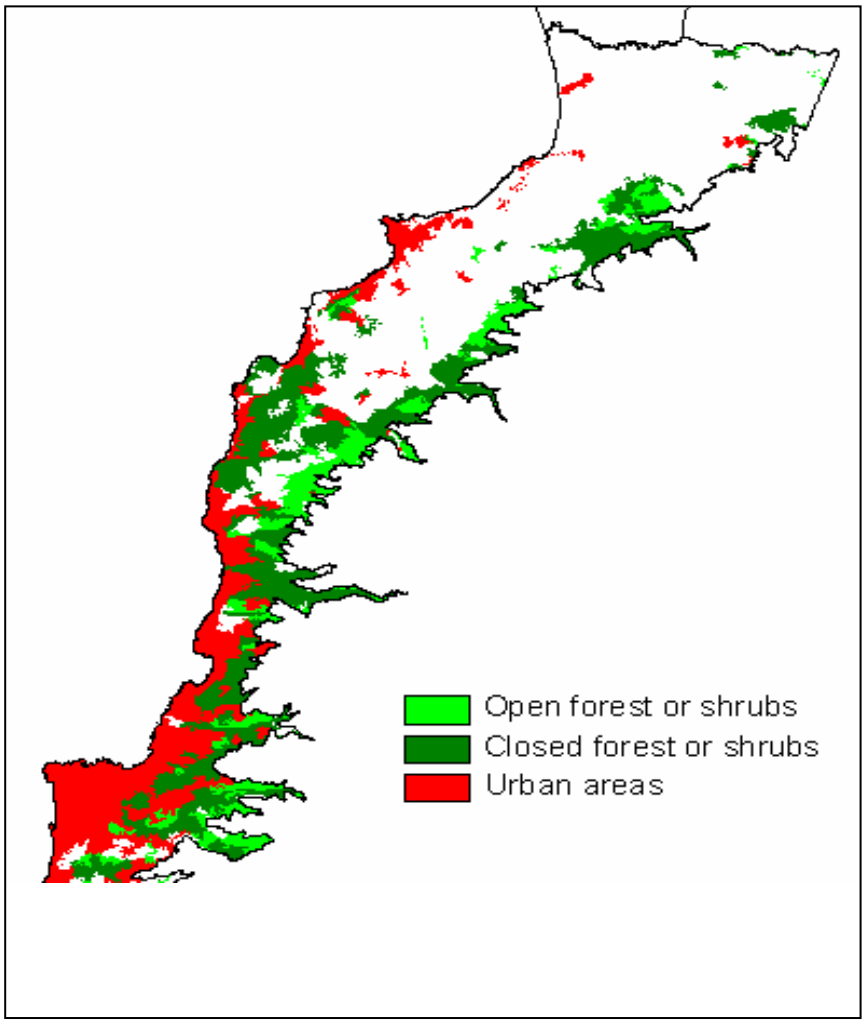
Erosion risk classes	Lebanon (ha)
1 - Not or insignificantly susceptible	4,126
2 - Slightly susceptible	22,447
3 - Moderately susceptible	11,624
4 - Highly susceptible	1,095
5 - Very highly susceptible	0
6 - Extremely susceptible	0



Map 3.6: Agricultural areas on Coastal Plain

3.4.4 Urban areas

Apart from the three above mentioned scenarios, the effects of urban areas have to be considered as well, in particular in the Lebanese coastal area which seems to be affected by the problem of uncontrolled urban growth, especially in the area north of Beirut and northward up to the Syrian border.



Map 3.7: Urban areas in Northern Lebanon

Such a region has a particular morphology, with a very narrow coastal plain bordered westward by a quite high mountain chain catching important amounts of rainfall. Map 3.7 shows (in red) the zones classified as "Urban areas" in northern Lebanon.

Furthermore, the inland highly dissected slopes are generally characterised by low values of vegetation cover, while surfaces covered with closed forest and/or shrubs have a moderate extension. Such environmental characteristics suggest a quite high risk to experience quick water concentration time and sudden water discharge. Therefore the need is felt for a sound land use and water management in order to avoid major hydrological disasters.

As a general recommendation, restrictions should be imposed in order to avoid urban expansion at the expense of areas with natural vegetation cover and of fertile agricultural lands.

4. DESCRIPTION OF PILOT AREAS

4.1 GEOGRAPHIC LOCATION

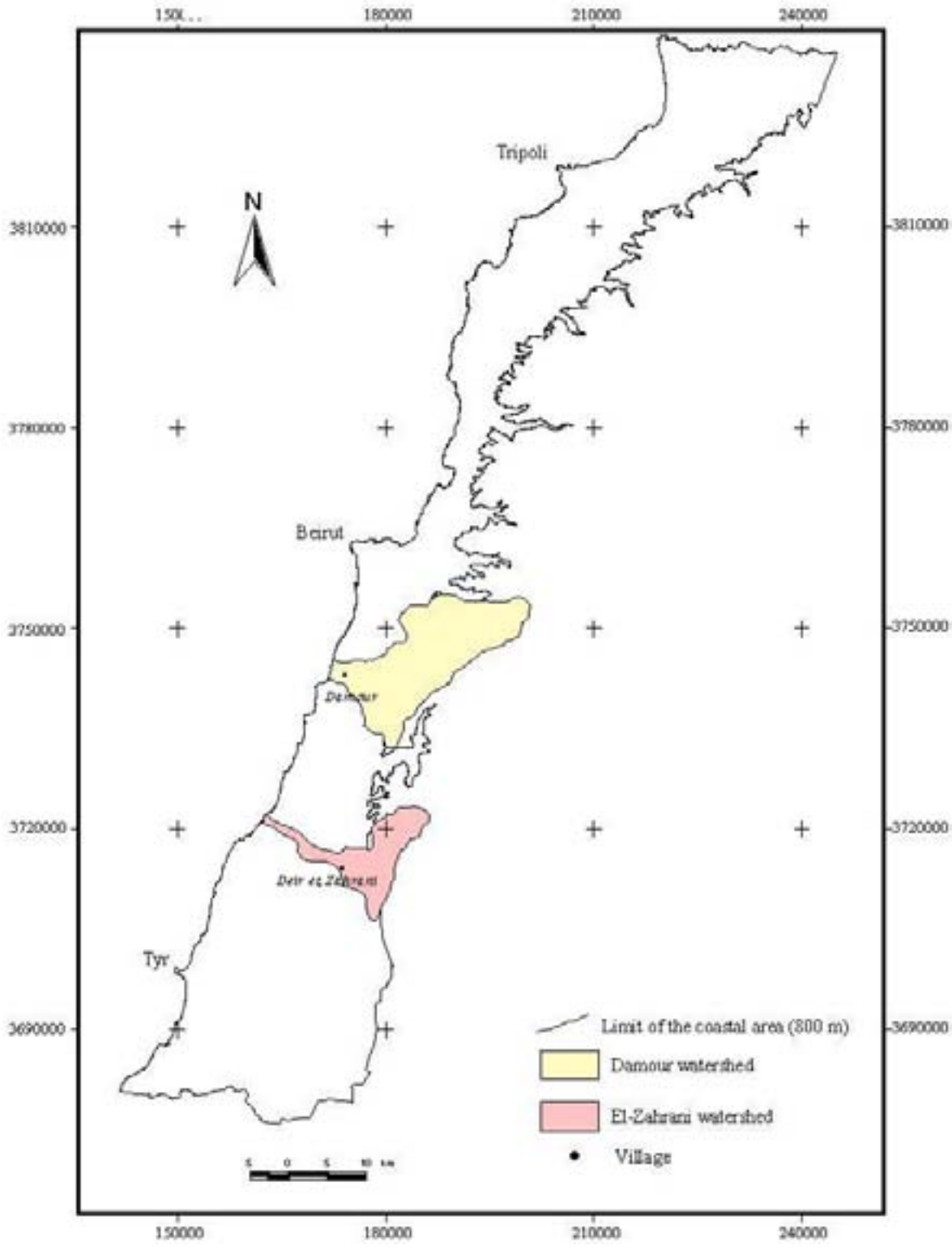
Damour and El-Zahrani watersheds are both river basins with permanent water courses. Damour watershed is situated in the central part of Lebanon, while El-Zahrani watershed is located in the southern part of the country. They extend from higher elevations in the east, i.e. some 1500-2000 m, and go westward, at a relatively short distance (< 25 km), opening their outlets into the sea (Map 4.1). Their outlets are separated by a distance of less than 25 km.

Damour watershed, occupying a total area of 333 km^2, is larger than El-Zahrani watershed (140 km^2).

4.2 VERIFICATION OF SELECTION OF TWO PILOT AREAS

The selection of the two pilot areas was based on a rating grid of a number of criteria chosen in order to have the most representative areas for the whole coastal region. These criteria are described in detail in Table 4.1 where the rating grid varies from 1 (lowest possible rating) to 5 (highest possible rating).

By applying these criteria with their corresponding rates to 4 possible watersheds (Beirut, Al-Jauz, Damour and El-Zahrani), the two pilot areas were identified as shown in Table 4.2. In fact, and despite the high rating of Beirut watershed, it was not chosen because a big number of studies are already covering it. And being a part of the central Lebanon as well as Damour watershed, the final decision was to take Damour watershed as the first pilot area.



Map 4.1: Location of the two study areas along the Lebanese coastal region

Al-Jauz and El-Zahrani watersheds have the same total by summing the rates of criteria; one is located in the northern part of the country and the other in the southern part, respectively. But due to the limited given timeframe, it was decided to choose one watershed and the watershed in the southern region was the second pilot area.

The criteria described in Table 4.2 will be discussed in full in the next paragraphs but as a briefing, the two selected watersheds are characterised by the following major points:

1. Obvious land degradation, especially in vegetation cover and soil accumulation as well as deterioration in water quality and decrease in rivers discharge.
2. Dramatic increase in the population rate, notably in the last two decades and certainly in the coastal stretch. This, accompanied by an increase in several human activities, almost led to harmful impacts on the environment.
3. Chaotic urban expansion, regardless of any planning control. This stimulates the geo-environmental decline in these basins.
4. The absence of any governmental solutions is clearly noted by the inhabitants. This mainly refers to the lack of resources management plans.

Table 4.1: Rating grid showing the extreme values for each criterion

Criterion	**Rating**				
	5	**4**	**3**	**2**	**1**
Intermediate zone	Fully in the intermediate zone				Only coastal strip or high mountain chain
Watershed	Complete coverage				Not fully situated in the study area (< 50%)
Size & form	8 to 12% of study area and typical form				Considerably bigger or smaller and non-typical form
Slope-relief hydrology-fluvial dynamics	Slopes between 8 and 25%				Less representative for selected range
Vegetation cover-pedology-geology	Typical mixture				Non-typical representation
Erosion processes-erosion risks	High occurrence of sheet erosion associated with occasional occurrence of mass movements				Non-occurrence of erosion processes
Land use	Typical mixture				Only one land-use type represented
Population	High population growth				No population dynamics
Practices	Typical representation of conservation practices (e.g. terraces)				Non-typical conservation practices
Availability of data	All necessary data available				No data available
Logistics	Favourable logistical conditions				Non-favourable logistical conditions

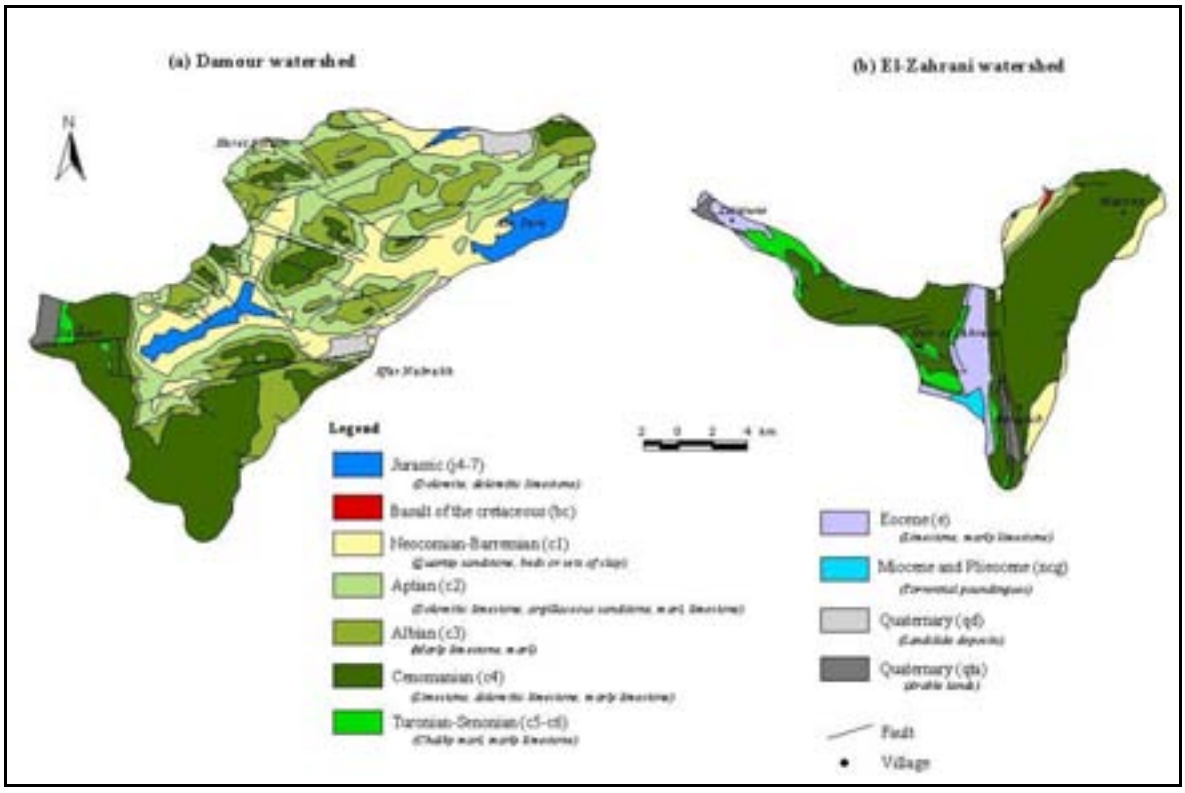
Table 4.2: Rating grid applied to the two pilot areas

Criterion	**Beirut watershed**	**Al-Jauz watershed**	**Damour watershed**	**El-Zahrani watershed**
Intermediate zone	4	4	4	4
Watershed	3	2	4	5
Size & form	4	3	4	3
Slope-relief hydrology-fluvial dynamics	5	3	4	2
Vegetation cover-pedology-geology	5	3	5	3
Erosion processes-erosion risks	5	3	5	3
Land use	5	3	4	3
Population	5	3	4	4
Practices	3	4	5	3
Availability of data	5	4	3	3
Logistics	5	3	4	2
Total	***49***	***35***	***46***	***35***
Strategic priority	**-**	**+**	**+**	**+**

4.3 PHYSICAL AND MORPHODYNAMIC CHARACTERISTICS

4.3.1 Geology

The description of the geology of the two watersheds, as well as of the whole Lebanon was compiled from the data taken from Dubertret (1953, 1955, 1966), Beydoun (1972, 1977, 1988), Awad (1983), Hakim (1985) and Canaan (1992).



Map 4.2: Geological maps of the two pilot areas

The outcropping stratigraphic sequence exposes the rock formations from the Middle Jurassic to Recent. According to the geologic map of Dubertret (1955) at a scale of 1/200000, eight rock formations can be identified in the Damour watershed, and 11 formations in the El-Zahrani watershed (Map 4.2).

Damour watershed:

The area begins from the Jurassic rocks (j4-7), which are thick bedded to massive, highly fissured, jointed, well karstified limestone and dolomitic limestone. They account for only 5% of the total area.

The Cretaceous rocks make the major rock body in this watershed. They occupy an area of about 304.5 km^2, which represents 91.6% of the total area.

- *Neocomain-Barremian (c1)*: Quartzitic and calcareous sandstones with intercalations of siltstone and lignitic clays covering 17% of the total area.

- *Aptian (c2)*: Moderately thick-bedded clastic limestone interbedded with marly and massive thick bedded, jointed, stylolitic, partly karstified limestone and dolomitic limestone constituting 27% of the total area.

- *Albian (c3)*: Thin bedded marly limestone and shales grading towards the top into moderately thick-bedded limestone, interbedded with marl comprising 22% of the total area.

- *Cenomanian (c4)*: Massive to thin bedded, highly fractured, jointed, chertified and well karstified dolomitic limestone and limestone with some thin marly beds comprising 24.6% of the total area.

- *Turonian-Senonian (c5-c6)*: Limestones, medium to thick bedded, and marl and marly limestone, changing from massive, jointed, fractured to soft friable in some localities.

The c4 and c6 formations are dominant in southern-coastal part of the watershed, while the c1, c2 and c3 formations are present in the northern part.

Two types of quaternary deposits are distinguished in the Damour watershed: *Arable lands (qta)* located in the coastal regions and *landslide deposits (qd)* present in the northern part of the watershed. They occupy only 3.4% of the total area.

El-Zahrani watershed:

Although the Cenomanian rocks (c4) constitute most of the area and the elevated regions of the watershed (67%), the c1 and c6 rock formations, as well as tertiary rocks are also there. The c1 and c6 rock formations occupy each 11 km^2, which represents 16% of the watershed. The Tertiary formations, with the prevailing Eocene rocks, are composed of chalky limestone and marly limestone, and cover 12% of the watershed. Some other facies of marl and silt, which are due to Miocene and Plieocene (ncg) rocks, are exposed (about 1%).

The j4-7, c2 and c3 rock formations, as well as arable lands (qta) are also present but in small patches. Some basaltic intrusions of the Cretaceous appear also (0.2%) marking the boundary between the Jurassic and the Cretaceous.

A set of faults, with around 10-15 km length, cut in the East-West direction, in addition to a number of smaller ones. Folded structures also exist, but almost locally. These structures create dense fracturing systems, notably in the hard rocks.

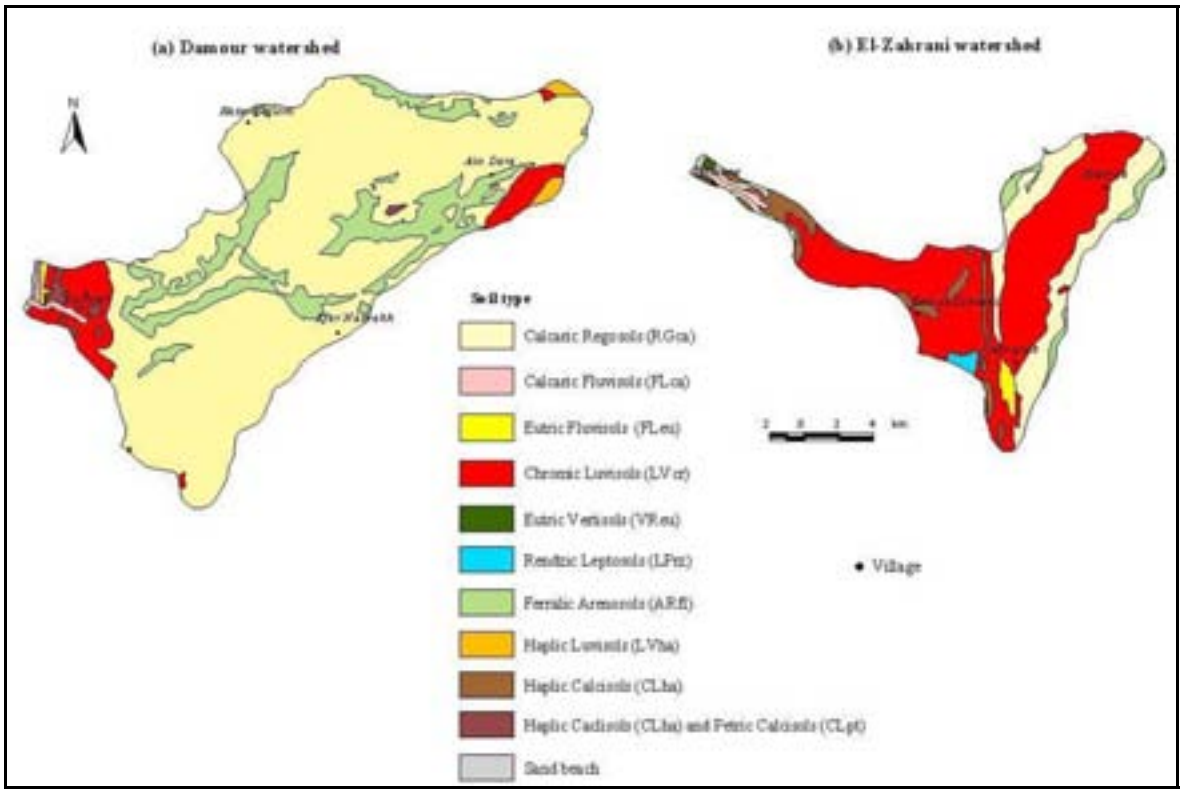
4.3.2 Pedology

The soils of Lebanon were studied by many researchers: Reinfenberg (1935, 1952), Gèze (1956), Lamouroux (1965, 1967, 1971, 1978), Lamouroux *et al.* (1968), Sayegh and Saliba (1969), Verheye and Osman (1974), Tarzi and Paeth (1975), Darwich (1986, 1987, 1988) and Darwich and Zurayk (1987).

The type of soils dominant in the two watersheds were determined from the soil map of Lebanon established by Darwich (2001) at a scale of 1/200 000 (Map 4.3). 8 soil units are identified in Damour watershed, while in El-Zahrani watershed, 9 soil units are described (Table 4.3). These soils are typically Mediterranean in character. The most widely represented soils in Damour watershed are *Calcaric Regosols* occupying an area of 255 km^2 (75%) and developed on Aptian and Albian rock formations. In El-Zahrani watershed, *Chromic Luvisols* or terra rossa (Red Mountain Soils) are predominant on Cenomanian rocks (62%).

Calcaric Regosols (RGca)

These soils are relatively deep (70 cm), developed on sloping and steep lands. Their surface is medium rocky and highly gravely with severe signs of sheet erosion. The soil structure is subangular blocky with a medium, sandy-clay texture. They are enriched with organic matter and have a basic pH value (7.7).



Map 4.3: Soil maps of the two pilot areas

Calcaric Fluvisols (FLca)

These soils, developed on quaternary alluvial deposits, are deep (>150 cm depth), weekly differentiated, slightly and medium calcareous ($CaCO_3$ between 20 and 35%) with a pH value around 8. They have a clay texture (35-55% clay), common gravels on soil surface, a relatively high organic matter content (2-3%), high water storage capacity and relatively high fertility level. They have a moderately low infiltration rate (0.5-2.0 $cm.h^{-1}$). They are suitable for intensive production (greenhouses and open vegetables) and fruit trees (exotic, citrus and bananas).

Table 4.3: Distribution of different soil types covering Damour and El-Zahrani watersheds

Types of soils	Damour watershed (%)	El-Zahrani watershed (%)
Calcaric Regosols (RGca)	75.00	23.00
Calcaric Fluvisols (FLca)	0.54	1.19
Eutric Fluvisols (FLeu)	-	1.39
Chromic Luvisols (LVcr)	6.40	62.00
Eutric Vertisols (VReu)	0.22	0.19
Rendzic Leptozols (LPrz)	-	1.00
Ferralic Arenosols (ARfl)	16.20	3.50
Haplic Luvisols (LVha)	0.70	-
Haplic Calcisols (CLha)	-	7.38
Haplic Calcisols (CLha) and Petric Calcisols (CLpt)	0.77	-
Sand beach	0.17	0.35

Eutric Fluvisols (FLcu)

These soils, developed on quaternary alluvial deposits, are deep (>150 cm depth), weakly differentiated, non-calcareous with a neutral pH value. They have a very fine clay texture (60% clay), common gravels on soil surface and adequate organic matter content (2%). They have moderate to strong structure and medium infiltration rate (2.0-3.0 $cm.h^{-1}$).

Chromic Luvisols (terra-rossa) (LVcr)

These soils are deep 140-165 cm, with developed profile. They occur in the rolling areas and karstic depressions, stones interstices (poudingues of Neogene) or in the decalcified pockets, as well as in the form of colluvium along the piedmonts. In mountainous areas, soils are discontinued with rock outcrops and become deep in depressions and piedmonts. They are in general decarbonated, rich in iron oxides (Hematite, Goethite), with neutral to slightly acid pH value, and high clay (from 30 to 50%) content. These soils are of strong surface structure, with medium gravel content, compacted in the subsoil, thus represent a moderate infiltration rate (2.0-6.0 $cm.h^{-1}$).

Eutric Vertisols (FLeu)

These soils occur in the central part of levelled areas. They are deep, black in colour with little gravel content. Upon drying, they form deep cracks, more than 1 cm in width and 75 cm depth. They are slightly calcareous and non calcareous, with neutral pH value. They are of strong structure and very fine texture with high clay and organic matter content. They have no salinity hazards and a high CEC value.

Rendzic Leptosols (LPrz)

These soils are relatively shallow (50 cm) and developed from poudingues. They are slightly rocky and low gravely, with moderate sheet erosion, and exposed surface horizon

of prismatic structure and sandy clay (fine) texture. With depth, these soils show no textural change. They are compact with a stratified subsoil gley indicating hydromorphism and poor drainage conditions. They are slightly calcareous (CaCO3=23%), saturated with exchangeable Ca and have a basic pH value (8.0).

Ferralic Arenosols (ARfl)

These soils are moderately deep (100-150 cm), with weakly differentiated profile. They are developed on Neocomian-Barremian rock formation (c1). Their surface is slightly gravely over a grainy massive structure, with low organic matter content (2.12%) and coarse texture. The content of sand exceeds 70% and the $CaCO_3$ is completely absent. Thus, these soils have a weakly acid pH value (around 5.5).

Haplic Calcisols (White and Grey Rendzinas) (CLha)

They occur on middle elevated sloping hills on soft marly lithological group. These are of medium texture, but rich in silt with considerable clay content. This causes low permeability, which results in seasonal water logging. They have different $CaCO_3$ content (from 45 to 60%) and weakly alkaline to alkaline pH values. The occurrence of low permeable layers represents a risk of landslide in case of absence of a drainage system. They have a moderately low infiltration rate (0.5-2.0 $cm.h^{-1}$). They are suitable for calcicol plants (olive, grapes and almonds), agroforestry and vegetables if properly managed (fertiliser application of acid forming material and modern irrigation). This soil group has a low to very low natural fertility and productivity; therefore, it needs a significant investment to improve the physico-chemical properties and fertility status.

Petric Calcisols (CLpt)

These soils are grey, very calcareous and shallow (< 25 cm depth). They are spread on sloping lands, developed from soft marl and subjected to water erosion. They have a low to moderately low infiltration rate (0.5-2.0 $cm.h^{-1}$). They are suitable for wildlife and agroforestry.

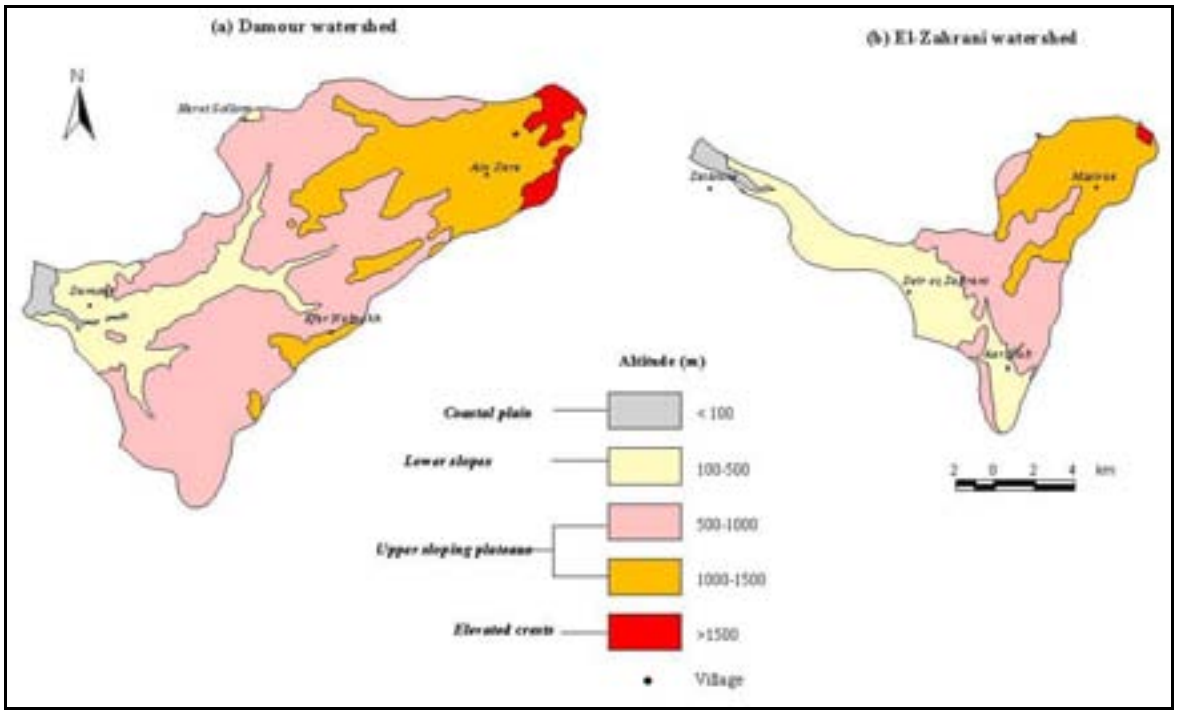
4.3.3 Geomorphology

Topographic surfaces

Topographic surfaces in these two pilot areas (Figure 4.4) are represented by two physiographic features:

1. In Damour watershed, the slope is sharp and steeply dipping seaward, with a gradient from east to west between 50-75 m/km.
2. In El-Zahrani watershed, the slope is gently dipping seaward, with a gradient of 20-30 m/km.

Since the two watersheds belong to the western Lebanon, their topographic features are similar to that part. Many authors described the topography of the western Lebanon with the order of west-east profile of the region. Hakim (1985) classified it as: elevated mountains (altitudes more than 1600 m), moderate mountains (altitudes between 900-1600 m) and lower mountains (altitudes between 300-900 m). Sanlaville (1977) ordered these surfaces with respect to the elevations and crests as: highly elevated region, high mountains and the western segments, while Abu El-Anin (1973) made his classification as coastal plain, deeply incised valleys and highlands. In a more detailed division, four topographic units can be identified. This division depends on different altitudes, surface relief and rock mass distribution. These are, in ascending order, the coastal plain, the lower slopes, the upper sloping plateaus and the elevated crests (Table 4.4 and Map 4.4).



Map 4.4: Simplified topographic maps of the two pilot areas

Table 4.4: Classification of topographic units in Damour and El-Zahrani watersheds

Topographic unit	Approximate predominant altitude	Predominant rock formations		Remarks
		Damour watershed	***El-Zahrani watershed***	
The coastal plain	< 100 m	Quaternary: Alluvial and beach deposits		These are narrow (< 5 km) and sometimes terminate at the coastline
The lower slopes plateau	100-500 m	Jurassic and Cenomanian limestone and dolomite	Cenomanian limestone and the overlying formations of the Senonian marls	This comprises a moderately elevated region that faces the sea. It has a width range, between 8-10 km
The upper sloping plateaus	500-1500 m	A variety of lower Cretaceous rocks, notably sandstone and clastic limestone	Tertiary rocks are prevailing, mainly the marly limestones, plus Cenomanian dolomitic limestone	This area shows sudden changes in elevation and is characterised by rugged karstic rock bodies. Deep valleys separate these rock accumulations. It has an average width of about 5-10 km
The elevated crests	> 1500 m	Jurassic and Cenomanian limestone and dolomite	Cenomanian limestone and dolomite are prevailing	These are scattered at the tops of the mountains. These appear to be levelled plains at the tops, forming streaked shapes

A predominant altitude in Damour watershed is from 500-1000 m, covering 55% of the total area. It is followed by an altitude range from 1000-1500 (24%), which makes the *upper sloping plateaus* the major topographic unit in this watershed.

In El-Zahrani watershed, the altitudes range between 100-500 m, 500-1000 m and 1000-1500 m covering equal areas, and representing 32% each.

The crests are represented by Jabal Barouk in Damour watershed to the east of Ain Dara village, that reaches 1980 m. In El-Zahrani watershed, there is Jabal Safi, west of Kfarhouna village, reaching 1400 m.

Slopes

The slope gradient maps covering the two watersheds are derived from DEM with an altimetric resolution of 30 m extracted from radar images (Map 4.5). Five classes can be distinguished: < 10%, 10-20%, 20-30%, 30-60% and > 60%. The percentage of areas having a slope gradient less than 10% is larger in Zahrani watershed (37%) than in Damour watershed (21%), while the areas with a slope gradient between 30-60% are larger in Damour watershed (32%) than in Zahrani watershed (22%).

The short distance over which the topography changes makes the general character of the terrain rather steep and prone to surface movements and erosion processes.

Valleys

The predominant slope direction seaward creates a prevailing E-W orientation of the incised valleys in the two watersheds. All of the valleys except those of the two major axes of the rivers (Damour and El-Zahrani) remain dry for more than ten months of the year. Some of these valleys are well developed and relatively deep; others are less defined, as they are in the initial stage of development. Rivers, streams or wadis follow valleys that are genetically of the three major classes:

- Consequent valleys or valleys whose original course is determined by/or dependent on geological structure or the form and slope of the land surface. These valleys could be also consequent upon faulting, forming fault valleys. In the studied areas, they are usually developed in rocks of different lithologies.
- Subsequent valleys represent streams whose courses follow weak lithologies or structures. Soft rocks (e.g. marls and sandstones) in the pilot areas show a wide variety of such valley types.
- Insequent valleys are those which have not developed due to initially determined factors and whose flow is irregular in direction. This is often developed on non-uniform rocks, notably at the contact of different formations, and appears through the karstic landforms of the pilot areas.

Karst

The dissolution of limestone by water is a widespread phenomenon in Lebanon, especially in Mount Lebanon, where huge outcrops of limestone are exposed. Hakim (1985) estimated that around 65% of the terrain in Lebanon is karstified with different scales and shapes. The karstification occupies a large areal extent in western Lebanon, which is about 3500 km^2, equalling about 70% of this area (Shaban, 2003).

Surface and subsurface karstic features characterise well the carbonate rocks in the pilot areas. They can be classified as follows:

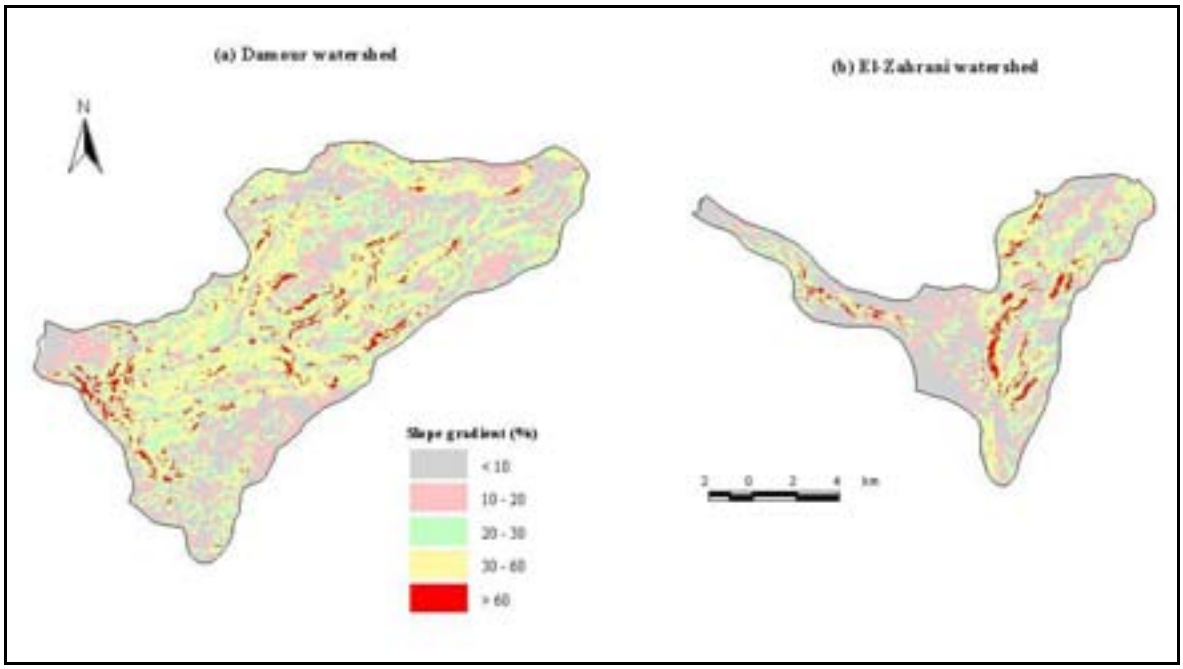
Surface karstification:

- Small-scale features almost covered by soils: rillenkarst, small depth cylindrical holes, furrows and pits. They mostly exist on the Cenomanian rocks at moderate and low altitudes.

- Large-scale features are also developed: sculptured linear and parallel, etching rock surfaces as lapies (huge rock bodies), rillenkarst, spitzkarst. They are developed on the Cenomaninan high altitudes. However, lapies “beauty stone” are dominant on Jurassic rocks of all altitudes.

Subsurface karstification: These are attributed to underground routes. Caves and cavities are tremendous among the hard carbonate rocks of the Cenomanian and Jurassic formations of the pilot areas. They extend from several hundred meters to several kilometres. They have diameters reaching up to 10 x 10 meters in some instances. Most of these routes are found to be good potential for groundwater.

A full categorisation of Lebanese karstic terrain was developed by Bou Kheir *et al.* (2003) and karstic terrains were considered as having a relatively low level of water erosion.



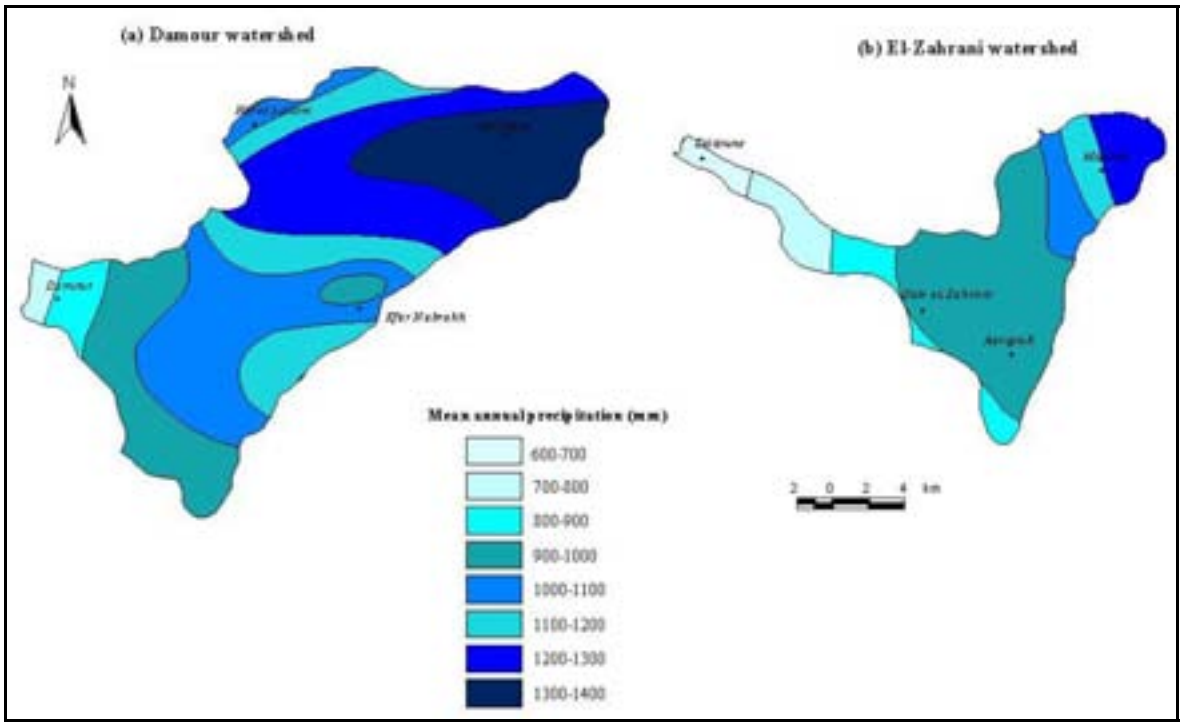
Map 4.5: Slope gradient maps of the two pilot areas

4.3.4 Climate

Like the whole Lebanon, the two watersheds enjoy a Mediterranean climate which, in general, is moderately cold and rainy in winter, hot and humid in summer, mild in spring and autumn. The available measurements of climatic conditions are still insufficient. The data on climate in the two watersheds relied only on the few local meteorological stations, and the stations nearby.

Precipitation

According to Plassard (1971) and Climatic Atlas of Lebanon "CAL" (1971, 1973, 1982), the annual precipitation rate ranges in Damour watershed between 700 mm on the coastal plain and 1400 mm over the crests (average 1050 mm/year), and in El-Zahrani watershed between 600-1300 mm (average 950 mm/year) (Map 4.6). As shown in this map, there is an increase in the amount of rain from west to east. Obviously, it is an altitude-related phenomenon. It is distributed generally as 600-800 mm in areas below 500 m; 800-1000 mm between 500 and 1000 m; and > 1000 mm at altitudes over 1000 m.



Map 4.6: Pluviometric maps of the two pilot areas

Recent data do not reflect this, and many concerned researchers agree on a value less than the above by a range between 150 to 200 mm (Mudallal, 1989; Hakim, 1993; Jaber, 1995; Khawlie, 1991). In addition to the reduced total amount of precipitation, rainfall is becoming more characteristically episodic and torrential.

Precipitation occurs during a short period: about 60-70 days per year (Climatic Atlas of Lebanon, 1973, 1982). It is often from October to March, reaching its climax in January, which, at some instances, yields about 160-180 mm/month. Snowfall is also included, occurring once/5 years at altitudes less than 200 mm; 5-10 days/year between 200-1000 m; 30-35 days/year over 1000 m (Sanlaville, 1977; Hakim, 1985).

Evapotranspiration

Unfortunately, in Lebanon as a whole, the estimated values of evapotranspiration differ with different authors. But as a norm, it averages about 50% of the precipitated water, and may go up to 75% in drought seasons (Jaber, 1995). According to Na'ameh (1995), the average rates of evapotranspiration in the two watersheds are 580 mm and 595 mm for the Damour and El-Zahrani watersheds, respectively. This is equivalent to around 58% of the precipitation volume.

Temperature

According to the Climatic Atlas of Lebanon (CAL, 1982), the mean yearly temperature is a function of altitude and decreases regularly with it. It can be classified as follows:

- 20º to 21ºC on the coast;
- 15ºC at 900 m altitude;
- 12ºC at 1800 m.

In the coastal zones, the maximum variation oscillates between 15 and 20º C in winter and between 28 and 35º C in summer.

Relative humidity

The relative humidity on the coast is mainly constant, oscillating around 70%, and a little lower in the South. But variations in the mountain are very significant: 60% to 80% in winter and 40% to 60% in summer.

Wind

The two watersheds enjoy the same wind oscillations. A relatively moderate wind speed (10-20 km/h) is known, which is almost dominantly from the West and Southwest directions.

4.3.5 Hydrology

Physical and hydrological properties of watersheds

Watersheds in western Lebanon are divided into three principal types: major, intermediate and minor, depending on their configuration, volume of discharge, altitude of the headwater and area of the basin. According to this classification, Damour and El-Zahrani watersheds are considered as two major ones out of 19 major watersheds of western Lebanon (Shaban, 2003). As shown in Table 4.5, they share different physical and hydrological properties.

Like most coastal Lebanese watersheds, they are characterised by their funnel-like shape as a result of the influencing surface morphology and geologic-structure controls, which prevail in the whole western part of the country.

The relief gradients, drainage densities and width/length ratio are calculated for each watershed. The relief gradient represents the ratio of upland to lowland elevations calculated on the alignment along the primary water courses. It is higher in Damour watershed than in El-Zahrani. The drainage density, which constitutes the total length of tributaries per unit area, is measured on topographic maps of 1:50000 scale (DAGG, 1963). It is similar for the two watersheds.

Table 4.5: Physical and hydrological properties of Damour and El-Zahrani watersheds

Major hydrologic characteristics	Damour watershed	El-Zahrani watershed
Average annual discharge (Mm^3/year)	256	202
Volume of precipitated water (Mm^3/year)	337	137
Volume of evapotranspirated water (Mm^3/year)	198	80
Relief gradient (m/km)	51	28
Drainage density (km/km^2)	0.95	0.94
Average width: length ratio (%)	21	19

The ratio of width (W) to length (L) in a drainage basin is a reflection of the time that runoff effectively reaches the major watercourse. The higher the W/L ratio, the higher the runoff duration, i.e. more infiltration time interval. In the case of the pilot areas, the W/L ratio is low, which implies more losses into the sea.

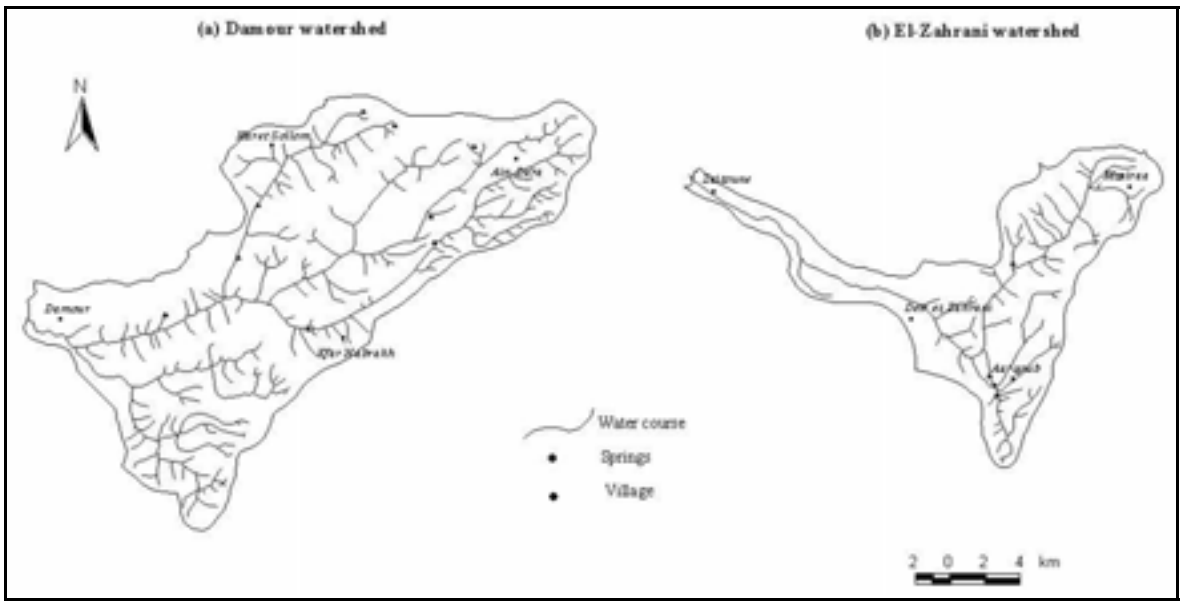
The relationship between the precipitated water and their discharges is measured (Shaban, 2003). It has been proved that there is no obvious correspondence between the precipitation and discharge. This can be attributed, in addition to climatic conditions, mainly to geology and human exploitation of surface water.

Rivers

Damour and El-Zahrani rivers are two perennial rivers that flow over the coastal part of the Lebanese terrain. They are relatively short, i.e., 45 and 36 km for the Damour and El-

Zahrani rivers, respectively, and have a prevailing seaward flow direction with a general E-W orientation. The drainage systems were extracted from topographic maps at a scale of 1/50000 (DAGG, 1963) (Map 4.7).

Based on Way classification (1978), the dentrictic type of drainage patterns is the most common type in the two pilot areas. It occupies around 70% in Damour river and 60% in El-Zahrani river.



Map 4.7: Drainage networks of the two pilot areas

Springs

A remarkable number of springs issue in the pilot areas. Mainly, they are ordinary and karstic spring types, thus the fault springs are found. In addition to these springs, which are almost perennial, seepages are also known.

Damour river is fed mainly from Safa spring (karstic spring) which has an average discharge equal to 1.42 m^3/sec, i.e. 45 million m^3/year. It is due to Jurassic rocks, namely the Callovian "J4" (UNDP, 1970). El-Zahrani is fed mainly from Tasseh spring (karstic spring) with a discharge of about 0.80 m^3/sec, i.e. 25 million m^3/year. It is attributed to Cenomanian rocks. The gauging stations are located in Jisr el Qadi for Damour river and on the river mouth of El-Zahrani river.

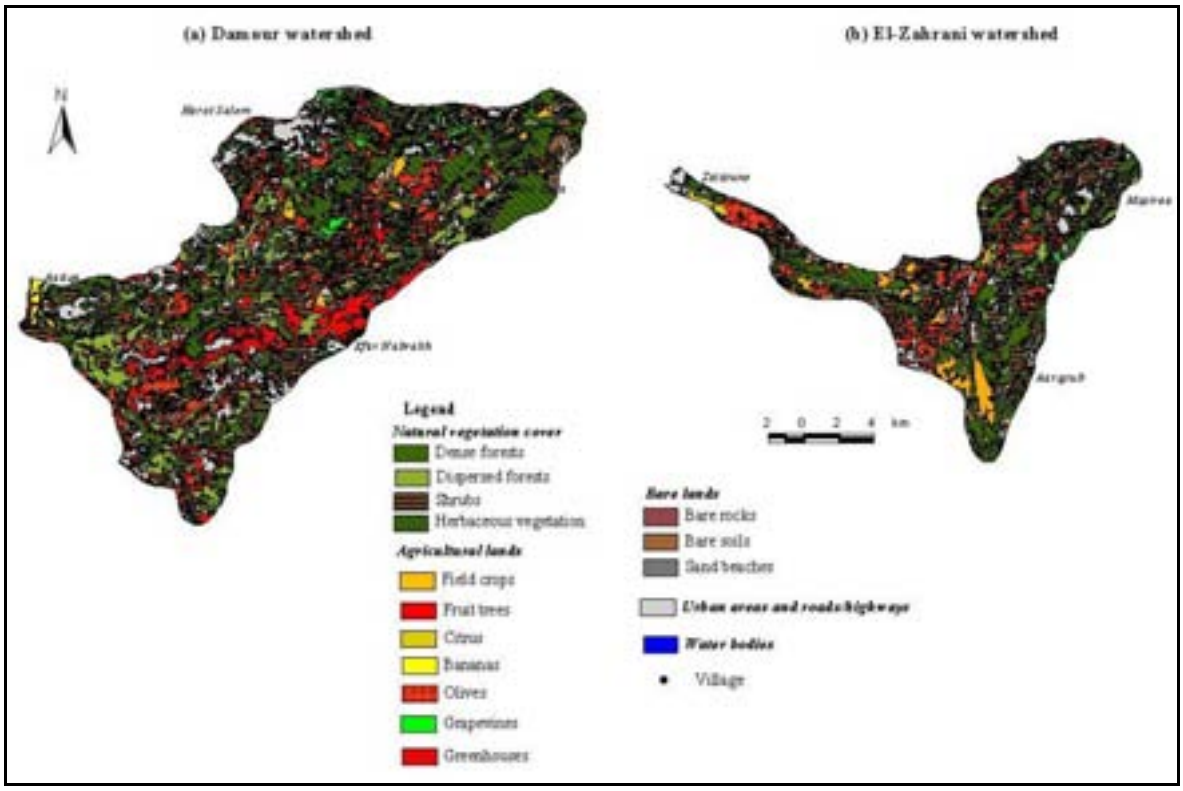
4.3.6 Land cover/land use

A land cover/land use map at a scale of 1/20 000 was adopted from a project done by the National Centre for Remote Sensing and the Lebanese Ministry of Agriculture (2002) based on CORINE Land Cover methodology (level 4). This map was accomplished using high-resolution satellite images IRS (5 m) acquired in October 1998. Mainly five codes were used, in which the related divisions are described in the Map 4.8.

Principally, these are natural vegetation cover, agricultural lands, bare lands, water bodies and human practices. In each class, there are a number of sub-classes:

1) Natural vegetation cover involves forests, shrubs and herbaceous vegetation.
2) Agricultural lands include field crops, orchards (fruit trees, citrus, bananas, olives and grapevines) and greenhouses.

3) Bare lands are ascribed to non-used terrain, which is dominated by rocks or soils.
4) Water bodies are attributed to water surface (lakes, reservoirs, etc. and rivers.
5) Human settlements regrouping urban areas and roads/highways.



Map 4.8: Land use/land cover of the two pilot areas

Natural vegetation cover occupies the largest portion of the two watersheds: 55.5% in Damour and 52% in El-Zahrani. It plays an important role in reducing water erosion, especially with two major effects: the umbrella medium or surface medium (Bou Kheir *et al.*, 2000, 2001a). The former is expressed as water retention by the leaves cover. This in turn depends on the leaves size and density, the higher they are the less impact of water on the soil surface. The latter medium is the surface body itself which acts either as a direct coat on the soil, such as shrubs or grass, or as tightening agent through roots.

In Damour watershed, 20.5% of forests are constituted by *Pinus* and *Quercus* species among which 7% are very dense; 13% are attributed to shrubs and 22% to herbaceous vegetation. In El-Zahrani watershed, 8% belong to forest trees with 1% densely covered; 23% are ascribed to shrubs, and 21% to herbaceous trees.

Agricultural lands are less widespread than natural vegetation, covering about 30% in Damour watershed and 27% in El-Zahrani watershed (Table 4.6).

On the other hand, bare lands are present with a proportion equal to 2% in Damour watershed and 1% in El-Zahrani watershed. These bare lands do not affect similarly the response to water erosion and desertification. Rocks of different lithologies have different effects on water flow and infiltration, and have different responses to surface processes. For example, the massive, hard, karstic carbonate rocks are found to be highly fractured, thus enhance infiltration potential and show a high stability to water erosion, while soft rocks of marls and clays behave in the opposite way and are easily dissected by water, producing badlands. This also applies to soils. For example, thick and high clay content

soil can serve in reducing the infiltration rate, hence active run-off will occur. Moreover, on the exposed high fissured rocks, mass movements are widely common leading to water erosion on their accumulated colluvial deposits.

Table 4.6: Estimated agricultural lands in Damour and El-Zahrani watersheds

Type	Damour watershed (%)	El-Zahrani watershed (%)
Field crops	3.27	9.45
Fruit trees	11.00	1.47
Citrus	1.00	1.04
Bananas	0.56	0.06
Olives	10.66	13.23
Grapevines	2.40	1.32
Greenhouses	0.28	0.04

Water bodies are present as very small patches occupying 0.3% of each watershed. Human settlements, which constitute one of the major elements influencing water erosion and desertification, occupied in 1998 an area of 44 km^2 in Damour watershed and 9 km^2 in El-Zahrani watershed, which represent proportions of 13% and 6%, respectively. As shown in Map 4.9, the density of urban settlements is mostly on the coastal stretch. The negative impact of humans also includes chaotic excavation for quarrying and forest clearance by logging and fires, as well as by overgrazing (Bou Kheir *et al.*, 2000). Recent studies indicate that the percentage of quarries has increased in the Lebanese mountainous coastal region by 8% between 1987 and 1997 (Khawlie *et al.*, 1999). Values plotted by the Lebanese Ministry of Agriculture (1998) show 1000 ha of barren lands in 1995 out of a total area of 21 300 ha of forests in Lebanon.

4.4 SOCIO-ECONOMIC CHARACTERISTICS

Rapid urban chaotic growth is one of the major factors affecting living conditions and the environment in Lebanon. The pattern of urbanisation changed during the war period. On the coastal stretch, about 200 km in length and 8 km in width, more than 24% of the terrain is urbanised (Huybrechts, 1997).

The distribution of the cities as well as roads in the studied watersheds are given in Map 4.9. In Damour watershed, the population increased from 40% in 1980 to 51% in 2000 compared to 1970 and is expected to attain 68% by 2020 (Table 4.7). This watershed comprises 151 villages that are part of three cazas Aley “71 villages”, Chouf “66” and Baabda “14” belonging to Mount Lebanon. Deir Qammar and Baaqline villages, situated in Chouf caza, had the highest number of people in 2000, each was equal to 17243 (16% of the watershed).

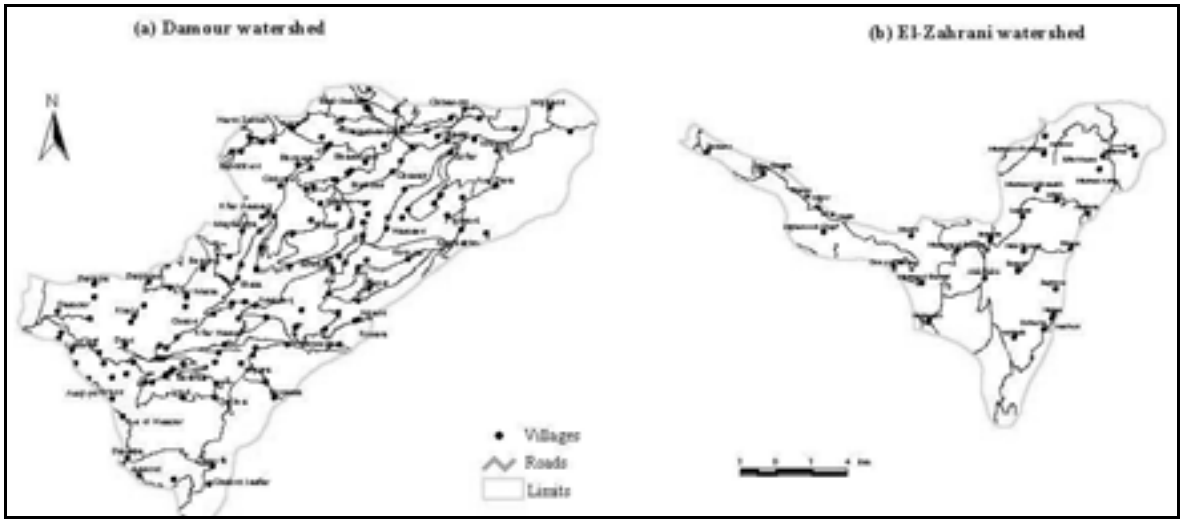
El-Zahrani watershed, the population increased by 32% in 1980 but decreased later between 1980 and 1994 due to the Israeli aggressions, and is expected to reach 49% by 2020 (Table 4.8). It comprises 33 villages that are part of three cazas Jazzine (18 villages), Saida (6 villages) and Nabatieh (9 villages). Habbouch village located in Nabatieh caza represents, with respect to the number of persons in 2000, 16% of the watershed.

Table 4.7: Population increase in Damour watershed between 1970-2020

Year	1970	1980	1994	2000	2005	2010	2015	2020
Population	110,928	183,077	197,840	225,330	251,247	280,278	312,862	349,353

Table 4.8: Population increase in El-Zahrani watershed between 1970-2020

Year	1970	1980	1994	2000	2005	2010	2015	2020
Population	23,564	34,475	26,777	30,391	33,775	37,566	41,819	46,591



Map 4.9: Settlements of the two pilot areas

4.5 EROSION AND LAND DEGRADATION PROCESSES

According to UNEP (1995), desertification is a bundle of land degradation problems in arid, semi-arid and dry sub-humid areas due to climatic changes and human activities affecting the terrain, its natural resources, ecosystems and the society (NAP, 2003). Lebanon is considered among those Middle East countries suffering symptoms of desertification, and where human interference contributes significantly to land degradation (Khawlie, 2000; Bou Kheir *et al.*, 2001a, b, c; Masri *et al.*, 2001). The arid and semi-arid zones in the country constitute about 24.1% of the land (Safi, 1999), and are exposed to a multitude of stresses. These include gullying (Shaban *et al.*, 1999), soil erosion (Bou Kheir *et al.*, 2001a, b, c), decreasing land fertility, salinisation (Atallah *et al.*, 2000) and an expected deficit of 800 Mm^3 in water availability by the year 2015 (Darwich *et al.*, 1999; Khawlie 2001). The costs of undesirable desertification effects can be estimated over the past fourteen years at 30-40 million $ per year (Khawlie, 2000). A *National Action Program to combat desertification* in Lebanon was implemented in 2001 by the Ministry of Agriculture defining long-term strategies and priorities together with the required legal and institutional frameworks (NAP, 2003).

Soil erosion by water is one of the major processes of land degradation in Lebanon. Erosion rates can reach 70 tons/ha/year in areas of high topographic relief (FAO, 1986). This value is high as it exceeds soil pedogenesis under the actual climatic conditions, and constrains seriously any possibility of carrying a healthy vegetal cover. The consequences

of such process are tremendous and damaging. They include decline of crop production, sedimentation of eroded soils in undesirable localities, reduction and degradation of arable lands, silting of dams, pollution of water courses and damage to property by soil-laden runoff.

Aside from recent works carried out at the National Centre for Remote Sensing (Bou Kheir, 1998, 2002), this theme has not been studied in detail in Lebanon. According to these studies, 88% of the central Lebanese karstic mountains (Qartaba-Jbeil area) are moderately eroded, and 36% of central Lebanon starting from the coast at the capital Beirut going eastward through the mountains is under high level of water soil erosion caused by water. This indicates the extent of the problem, which threatens an integral element of natural resources in Lebanon. In addition to this severe situation, appropriate management plans are still lacking. Only minor and local protection procedures are being applied, and no protection strategies have been designed yet. Some available studies describe the gravity of water erosion problem (Gèze, 1956; Lamouroux, 1967, 1971; Khawlie, 1983, 1991; Darwich and Zurayk, 1997), the measures taken to reduce it (Ryan, 1982, 1983; Zurayk, 1994) and suggestions for future (Khawlie *et al.*, 2001).

Sheet erosion, a removal of the soil upper layer, develops on Lebanese lands with undulating landforms, weak soil structure and limited water holding capacity. V-shaped gullies form in materials that are resistant to erosion. This might be due to clay illuviation and accumulation in the soil type like the Red Mountain soil “terra rossa” on Cenomanian rocks. U-shaped gullies form in materials that are decreasingly resistant to erosion with depth (rendzinas on Senonian parent materials forming what is called Bad Lands).

Piping erosion may occur in soils with subsurface horizons or layers that are more subject to entrainment in moving free water than in surface horizon or layer, such as in sandy and clastic volcanic soils.

Bou Kheir (2002) indicates that erosion risks depend first on the lithologic character of rocks. Very high risk characterises terrain covered by the sandy soil of the Neocomian-Barremian sandstones and the mixed soils corresponding to the outcrops of the Lower Aptian and the Albian clastic limestones, while the very low risk characterises the terrain covered by limestone and dolomitic limestone.

Mass movements are also very common in Lebanon, and the process is considered a significant aspect of surface instability contributing to land degradation. Four types characterise the physiography of Lebanon: rock/debris fall, earth creep, earth flow and slump (Khawlie, 2000). Studies dealing with this problem in Lebanon are scarce and mostly descriptive. Searle (1972) detailed the geotechnical properties of the unstable Cretaceous clay-shale formations in Lebanon. Tavitian (1974) studied the Aqoura earth-flow giving the engineering properties of the materials and slope stability. Khawlie and Hassanain (1979, 1984a, 1984b) carried out a study of prominent landslide areas in Lebanon relating them to cliff-making rock units or to inherently weak materials, giving their types and distinctive features.

5. DETAILED ANALYSIS RESULTS

The detailed analysis, which constitutes one of the main components of the CoLD project, depended heavily on the methodology developed by PAP/RAC and FAO published as "UNEP/PAP/MAP: Guidelines for erosion and desertification control management with particular reference to Mediterranean coastal areas". The outcomes and findings from the field work of the detailed analysis will serve as an input for arriving at a strategy and giving recommendations in the following chapters of this report. The significance of public participation has always been given due consideration in the process, especially in view of the requirements of integrated coastal zone management. The following sections reflect on activities encompassing the detailed analysis of the two pilot areas.

5.1. MAPPING METHODOLOGY AND RELATED FIELDWORK

According to the methodology recommended in the above Guidelines, the mapping for the detailed analysis was based on the principal distinction of:

- Stable, non-erosion affected areas, i.e. areas with no evidence of any active erosion processes, due to the predominant stabilising effect of one or several landscape components thus generating a state of morphodynamic equilibrium, and
- Unstable, affected areas, i.e. areas where one or several active erosion processes occur.

The following classes were used for the classification of the situations found in the two pilot areas. The complete legend of the PAP/RAC Guidelines is reproduced in Annex 1.

SITE-DESCRIPTIVE MAPPING: GRADE OF STABILITY/EROSION PROCESSES

I. Stable, non-erosion-affected areas (*)

00	**stable, non-used wasteland** (rock outcrops, cliffs, stony or sandy areas)
01	**stable, unmanaged areas with potential for forestry use only**
02	**stable, unmanaged areas with agricultural potential** (crops and pasture)
03	**stable, managed areas with forestry use only**
04	**stable, managed areas with agricutural use** (crops and pasture)

• **Rehabilitated areas by means of:**

05	**natural or artificial re-vegetation**
06	**physical infrastructures** (terraces, check dams, etc.)

***Grade of instability risk**

Assessment of **instability risk** for all **stable** environments (00 to 04) and of risk for **rehabilitated** environments, i.e. 05+06 (i.e. a risk in the first years of rehabilitation) to be expressed by a complementary digit (0 to 3) to the original **stable units'** code:

0: No risk (= highest grade of **stability**)
1: Low to moderate
2: High
3: Areas in hazardous/precarious/critical state (Stability threshold = highest grade of **instability risk**)

Example : 03 = **stable** managed areas with forestry use only
Example : 032 = **stable** managed areas with forestry use only with a high **erosion risk**

***Identification of main causative agents**

Instability risk assessment may be reinforced by the identification of its most probable/ prevailing **causative agents** inherent in the **landscapes'** main basic components, i.e.:
t: Topography
g: Geology
v: Vegetation
h: Human activities
Example: 023 **g** = stable unmanaged areas with agricultural potential with erosion risk mainly due to geologic factors.

II. Unstable areas (**)

• ***Sheet erosion***

L1	**localised**
L2	**dominant**
L3	**generalised with soil profile removal**
Lx	**= unreclaimable areas due to total soil removal**

• ***Rill erosion***

D1	**localised**
D2	**dominant**
D3	**generalised**

• ***Gully erosion***

C1	**individual gullies**
C2	**localised gully networks**
C3	**dominant**
C4	**generalised**
Cx	**= unreclaimable areas due to generalised bad lands**

• **M*ass earth movements***

M1	**local gravitational soil creep/solifluction**
M2	**localised land slides/mudflows**
M3	**dominant**
M4	**generalised**
MX	**= unreclaimable areas due to total slope slides**

• ***Water or sediment excess***

W1	**areas periodically flooded and/or sediment buried**
W2	a**reas permanently flooded and/or sediment buried/waterlogged areas**

• ***Associated processes ("Multiple processes")***

P1	**localised**
P2	**dominant**
P3	**generalised**
Px	**= unreclaimable areas**

****Erosion expansion trend (rate)**

Assessment of erosion rate/trend for all **unstable** erosion-affected areas to be expressed by a complementary digit (0 to 3) to the original **unstable units'** code:

0: Trend to **stabilisation, recession** or limitation of spatial **expansion**
1: Trend to local **expansion** or **intensification**
2: Trend to widespread **expansion** or **intensification**
3 : Trend to increase **generalised degradation** towards an **irreversible state**

Example:
L2 = dominant sheet erosion
L23 = dominant sheet erosion with a trend towards generalisation and an irreversible state (Lx type units)

The class P for associated processes was used for describing a situation of different closely interacting erosion processes, namely the combination of rill and gully erosion, sometimes also associated with signs of mass movement. This was a typical situation for some areas in the Damour watershed.

The polygon identification was based on the predictive maps produced. Sometimes two nested polygons were joined or one polygon was subdivided in the terrain on the map. Detailed topographic maps (1:20.000), detailed images and GPS helped in delineating the new subpolygons belonging to a new map unit. In many cases, land use (terraces) and land cover (forest, rock outcrops) gave direct indication on the borders of the new unit.

The classification of the different categories was implemented in the following way. In the case of stable areas, the attributed polygon ID was the dominant unit, whereas in the descriptive mapping of unstable areas, the dominant erosion process gave its name to the mapped unit. For example, in case mass movement (M) was dominant with localised erosion processes, it was classified as a pure unit representing major risk of land instability. When rill erosion (D) was dominant or general, with a trend to widespread intensification, and gully erosion (C) was individual with trend to local expansion only, the polygon was characterised as rill erosion.

In all cases, because sheet erosion (L) in a mountainous area rarely occurs alone, this process was considered as accompanying other processes and representing low potential risk compared to others more evolved erosion processes. Therefore, this category was often not separated into an individual mapping unit. Nevertheless, the same polygons were differentiated by the rate of expansion trend, added as a third digit after the polygon symbol. In addition to the original PAP/RAC mapping legend, it was found useful to apply the identification of causative agents also to the unstable areas. So, unstable areas were also differentiated by their causative factors (e.g. “t” for topography, “g” for geology, “h” for human interference), added at the end of the polygon name in order to facilitate the derivation of indicators for different remedial measures and onsite monitoring.

With regard to the classification of non-used wastelands, the code 00 was attributed to areas with no or very low potential for agricultural production or forestry use. However, with high investment costs also these areas might be rehabilitated (e.g. by terracing and transport of fertile soil to the site), notably for certain types of agricultural production such as orchards with grapes or fruit trees, or forestry use such as plantation of Lebanese cedars. These types of rehabilitation have already been demonstrated in some parts of Lebanon.

The whole study area of the CoLD project was defined as covering the coastal area up to an elevation of 800 m. This restriction was conditionally workable in the Damour watershed, as land cover is represented by forest stands for almost half of the area. The upper areas in the watershed above 800-m line represent either forest or non-used wasteland with low to moderate risk of erosion. However, in the Zahrani watershed this approach did not work as the 800-m line passed immediately above the main river source (Naba Tassi), Not only human settlements occur above this line but also several geomorphologic units formed from Cenomanian and Albian rocks spread over slopping and steep lands. Winter streams bring into rivers main body sediment and maybe polluting agents. Naba Tassi is the main source of drinking water in the South besides irrigation of adjacent lands. For this reason the area of the watershed was expanded to cover the divide line in the surroundings of the source. However, it must be noted that the detailed analysis covered only a part of the whole watershed. This needs to be taken into consideration when discussing recommendations and related actions because the

watershed system was only partly analysed and most of the upper parts of both watersheds were not assessed.

The field work for the descriptive erosion mapping took place from November 2003 to June 2004. As intermediate step between modelling and describing soil erosion, two predictive erosion maps have been produced. After consulting the first map based on several factors like slope gradient, soil depth, soil texture and land cover, and reconsidering the two main factors of soil erosion, like land cover/use and slope gradient, a second “preliminary” semi-descriptive erosion map was produced.

The field work was then based on the predictive soil erosion maps and the application of the above mapping legends to the polygons identified in the predictive mapping. Where the need arose, borders of the polygons from the predictive mapping were revised or polygons were split up into several polygons in order to properly represent the situation found in the field. This was done in view of the need for representing a homogenous situation within one polygon.

Later on, as part of the analysis, a comparison of the results of predictive mapping and descriptive mapping was also executed on an exemplary basis for the Damour watershed in order to see if and how the two assessments match each other. The detailed results of this exercise are reproduced in Annex 2. The following methodological conclusions can be drawn from these results:

- Many areas, classified in the descriptive mapping as stable areas, were in the preceding predictive mapping classified as areas highly susceptible to erosion. The differing assessment notably occurred for forest lands on steep slopes and agricultural areas on sloping lands. This might be explained by an overestimation of the factor “slope” and an underestimation of the factor “land use / land cover” in the predictive mapping. Matching between the expected erosion risk and the actual situation in the field occurred mainly in bare lands prone to mass movement that had been classified as medium and high erosion risks. Also for the case of slight slope gradient and medium soil depth, more than 70% of wasteland matched the predictive erosion map.
- In the predictive mapping, the sloping lands were mainly classified as highly susceptible to erosion. Such prediction did not consider the presence of old traditional terracing. However such data could have been identified using high resolution remotely sensed data.
- For the unstable areas, the matching between the expected and actual erosion showed less difference. For example, more than 80% of the observed cases with gully erosion matched the predictive erosion map. For rill erosion the situation was similar. The highest degree of conformity was noticed for mass movement. Equally, all areas classified as affected by multiple processes were considered in the predictive map as highly susceptible to erosion.

As a conclusion it can be stated that considerable parts of the areas classified as highly susceptible to erosion in the predictive mapping did not show active erosion processes in reality due to the conserving effects of land cover and human practices (terracing). On the other hand, for unstable areas there was a high degree of conformity between the predictive and descriptive mapping.

In the field work, the team was faced with the complex morphology and land fragmentation resulting in a wide variety of erosion types and association of stable and unstable areas. In many instances locations were unreachable, thus a binocular was used for the description.

Map 5.1: Damour soil erosion map

Map 5.2: Zahrani soil erosion map

Map 5.3: Damour erosion dynamics map

Map 5.4: Zahrani erosion dynamics map

An average of 7 field visits per month were executed between November 2003 and August 2004. A total of 14 man-days were spent monthly on fieldwork. The team carried the earlier produced land unit map, the detailed recent land cover use map, topographic map, cameras, and field observation format for the registration of remarks (Annex 3). The sheet included two tables that incorporated detailed attributes, inferred from the methodology, to be described as observed in reality. GPS readings of the point of observation and photo numbers were also registered for further reference. A special attention was paid to the noticed remedial measures and socio-economic factor (land use value) to facilitate the elaboration of potential land use and to propose remedial measures. In several areas the limitation created by road accessibility was overcome by the use of binocular from a high place and through discussion with local people on historical and current land use. The possible presence of mines within the upper part of Zahrani watershed also limited the free movement of the team along the riverbanks despite the ongoing demining efforts of the international community and local authorities.

5.2 DESCRIPTION OF DESCRIPTIVE EROSION MAPS

The soil erosion map for Damour watershed is represented in Map 5.1, and the soil erosion map for Zahrani watershed is given in Map 5.2. Maps 5.3 and 5.4 present the erosion dynamics in the watersheds. The results of the descriptive mapping of both watersheds are described below.

5.2.1 Damour Watershed

The Damour watershed is characterised by morphological complexity, notably by the alternation of stable and unstable areas in one geomorphologic unit (Table 5.1).

For stable areas (73.3% of the assessed area), both unmanaged and managed areas are found:

- Only small parts of non-used wasteland (00) were identified (1.9% of the assessed area, i.e. 2.76 km^2) notably around the urban areas at the outlet of the watershed and along the coastal strip. The areas situated on the hilltops are characterised by a sparse land cover with range and sparse shrubs. These areas are completely abandoned and have a low to slightly increased instability risk. The coastal wastelands representing sand dunes and lands with potential recreational use are subject to erosion from seawater.
- A large part (45.6%, i.e. 67.32 km^2) of the assessed area of Damour watershed was classified as unmanaged area with forest potential only (01), where natural forest with rare fruit trees and shrubs occupied the land even on steep slopes. These areas are characterised by a low instability risk. However, a small area in the watershed (0.5%, i.e. 0.79 km^2) was characterised by high-risk trends due to the scarcity of the cover and unstable geological material.
- Stable managed areas cover forestry use (03) as well as agricultural use (04) and frequently there is an association of forest and agricultural lands. Due to the sporadic forest fires, larger areas with reforestation are limited. The forest areas (5.4% of the assessed area, i.e. 8.07 km^2) are mainly open forest associated with shrubs and terraced olives, mainly found in the eastern upper parts of the watershed. Pine is associated with shrub lands and terraced olive orchards. Some old terraces under pine are observed. About 4.7% (i.e. 6.97 km^2) of the watershed was classified as high risk due to the steep landform and geology. In this context, several localised unstable spots would require wall rehabilitation before further deterioration takes place.
- The Damour watershed is dominantly sloping and steep lands, and early agriculture is possible mainly with terracing practice. Where these physical structures are maintained, the areas are classified as rehabilitated area (06). A high instability risk

for the rehabilitated spots (5.8% of the assessed area, i.e. 8.6 km^2) was observed due to the slope, type of geology and human interference. Due to the complex Lebanese topography and intensive faulting system crossing (roughly) the country from South to North and West to East, not only bare lands are moving, but also terraced areas. In fact the best orchards are located on colluvial deposits subjected to periodic mass movement too. Slope and mainly low permeability subsoil is the main cause for this damage.

- The stable agricultural areas (16% of the assessed area, i.e. 23.74 km^2) with old terraces and the lowland areas with agricultural activities in the downstream level Damour plain are classified as managed area with agricultural use (04). In case of land abandonment and deterioration of terraces, the main observed erosion process classified the area (see below). On areas with old terracing signs of erosion and sedimentation could be noticed that returned the land almost into its initial shape. The coastal lands near the river mouth and on the Damour plain are characterised by dominance of banana production and green housing. This area is of low instability risk. The only risk comes from human activities in form of urban expansion on the plain and mismanaged cultural practices in greenhouses resulting in soil salinisation and possible NO_3 leaching towards the groundwater.

For unstable areas (13.9% of the assessed area), several active erosion processes have been identified:

- Mass movement (M) is a recurring phenomenon in the Damour watershed (as in many parts of the Lebanese mountains), notably where lithology and nature of the quaternary cover on steep slopes represent a striking example of causes of unstable areas. About 8.4% (i.e. 12.51 km^2) of the assessed area in the watershed with local to widespread expansion trend falls within this category. In these areas, geology and topography represent the main causative factors of mass movement. Coupled with human mismanagement and poor land cover, the areas represent a highly fragile ecosystem with boulders movement down slope. The risks are aggravated by a trend to widespread intensification and dominance with increased influence on adjacent lands due to the total absence of any remedial measures. The negative effect of mass movement is enhanced by inappropriate human intervention in form of insufficient physical infrastructures (terracing) and absence of water diverging canals and water harvesting practices. In less affected areas, localised landslides characterise the situation.
- Gully erosion (C) was observed on 2.3% of the assessed areas (i.e. 3.38 km^2). A grass/shrub land cover alternating with terraced agriculture and steep slopes with localised, intensified and dominant gully erosion, and trend to local expansion and widespread intensification characterise these areas. Topography and geology, beside the poor vegetation cover and human interference, are the responsible causative agents. Sometimes, an increased expansion trend was observed. Then, the main localised gully network was associated with signs of mass movement that have a trend to widespread expansion. Another type of gully erosion affected area was additionally characterised by extreme risk to the surrounding areas.
- Two polygons (0.9% of the assessed area, i.e. 1.36 km^2) were identified with dominant rill erosion (D) associated with a few signs of gully erosion. Rill erosion had a trend to widespread expansion due to the type of geology characterised by low stability. Rare bushes and isolated trees and grass mainly cover the area. For this reason, an increased impact on surrounding areas was observed.
- Two polygons (1.1% of the assessed area, i.e. 1.68 km^2) were characterised by the presence of multiple erosion processes (P), like rill erosion, gully erosion and mass movement with localised expansion trend and unexpectedly low noticed impact on

adjacent areas. The main causative agents are topography, vegetation and human interference.

- The low lands or depressions (1.1% of the assessed area, i.e. 1.56 km^2), situated mainly along the river stream, with relatively narrow and shallow banks and adjacent to sloping unstable lands, were classified as areas with sediment or water access (W).

The Damour erosion map clearly reveals diversity in classes, with a dominance of stable areas and with unstable areas mostly in the northern and eastern parts of the watershed. This reflects the influence of geology/topography, but locally it shows the influence of human interference. The spreading of human settlement is obvious all over the area. The unstable areas tend to be uniform where they occur, i.e. dominant mass movement, or gully erosion, etc., which makes application of remedial measures easier.

Table 5.1: Distribution of stable and unstable areas in Damour Watershed

Type	Erosion situation	Erosion risk/ expansion trend	Code	No. of polygons	Area	
					(Km^2)	(%)
Stable areas (75.3%)	Non-used wasteland	Low to moderate	001	36	2.76	1.9
	Unmanaged areas with potential for forestry use only	Low to moderate	011	98	67.32	45.6
		High	012	1	0.79	0.5
	Managed areas with forestry use only	Low to moderate	031	1	1.10	0.7
		High	032	4	6.97	4.7
	Managed areas with agricultural use	No	040	40	4.93	3.3
		Low to moderate	041	97	18.81	12.7
	Rehabilitated areas	High	062	14	8.60	5.8
Unstable areas (13.9%)	Sediment or excess water	Local	W11	2	0.01	0.0
		Widespread	W12	19	1.55	1.1
	Rill erosion	Widespread	D22	2	1.36	0.9
	Localised gully erosion	Local	C21	17	2.10	1.4
		Widespread	C22	1	0.09	0.1
	Dominant gully erosion	Widespread	C32	1	1.19	0.8
	Localised mass movement	Local	M21	9	10.24	6.9
		Widespread	M22	3	0.39	0.3
	Dominant mass movement	Local	M31	2	0.92	0.6
		Widespread	M32	2	0.96	0.6
	Localised associated processes	Local	P11	2	1.68	1.1
Not relevant				159	15.94	10.8
Total				**510**	**147.73**	**100.0**

5.2.2 Zahrani Watershed

The Zahrani watershed is distinguished by less complicated morphology than the Damour watershed, notably at its central and lower parts. Despite the resulting lower natural potential erosion risk, it presents also a larger area of soft marl characterised by higher susceptibility to erosion.

For stable areas, both unmanaged and managed areas are found (Table 5.2):

- A large part of non-used wasteland (00) was identified, notably around the agricultural areas in the upper watershed parts and along the river stream in the middle and at the outlet of the watershed near the coastal strip. About 28.5% (26.52 km^2) of the assessed area of the watershed is non-used wasteland. The areas situated on the hilltops are characterised by frequent rock outcrops and sparse land cover with range and sparse shrubs. These areas are completely abandoned and have a low to highly increased instability risk.
- A smaller part (8.8%, i.e. 8.23 km^2) of the assessed area of the Zahrani watershed was classified as unmanaged area with forest potential only (01), where natural forest and shrubs occupied the land even on steep slopes. The dominant part of this class (8%, i.e. 7.47 km^2) is characterised by a low to moderate instability risk (due to the land cover and geological material. Only a small area (0.8%, i.e. 0.76 km^2) in the watershed was characterised by high-risk trends due mainly to forest fires that were caused by war operations before 2000.
- The Zahrani watershed is dominantly sloping lands, and recent large rehabilitation is practised with terracing. Where these physical structures are maintained, the areas are classified as rehabilitated area (06). The dominant part of this watershed (42.1%, i.e. 39.16 km^2) is of low instability risk due to the maintenance of supporting stonewalls. However, a small non-maintained area (0.1%, i.e. 0.09 km^2) without stones represented a high instability risk due to the slope, type of geology and human abandonment.
- The stable areas with old terraces and the lowland areas with agricultural activities in Zahrani watershed are classified as managed area with agricultural use (04). They occupy only 1% (0.97 km^2) of the area. On areas with old terracing signs of erosion and sedimentation could be noticed that returned the land almost into its initial shape. The coastal lands near the river mouth are characterised by dominance of banana and citrus production. This area is of low instability risk. The only risk comes from human activities in form of urban expansion on the coastal plain and mismanaged cultural practices. There was one area (0.4%, i.e. 0.34 km^2) identified as area with agricultural potential (02) with a low to moderate instability risk.

Table 5.2: Distribution of stable and unstable areas in Zahrani watershed

Type	Erosion situation	Erosion risk/ expansion trend	Code	No. of polygons	Area	
					(Km^2)	(%)
Stable areas (80.9%)	Non-used wasteland	No	000	1	4.66	5.0
		Low to moderate	001	13	9.77	10.5
		High	002	3	12.09	13.0
	Unmanaged areas with potential for forestry use only	Low to moderate	011	17	7.47	8.0
		High	012	1	0.76	0.8
	Stable, unmanaged areas with agricultural potential	Low to moderate	021	1	0.34	0.4
	Managed areas with agricultural use	Low to moderate	041	5	0.97	1.0
	Rehabilitated areas	Low to moderate	061	40	39.16	42.1
		High risk	063	1	0.09	0.1
Unstable areas (13.1%)	Localised sediment or excess water	Local	W11	8	5.72	6.1
	Generalised sheet erosion	Widespread	L32	8	2.04	2.2
	Dominant rill erosion	Local	D21	4	1.38	1.5
		Widespread	D22	4	3.69	4.0
Not relevant				54	4.96	5.3
Total				**160**	**93.10**	**100.0**

For unstable areas, several active erosion processes have been identified (Table 5.2):

- Four polygons (4%, i.e. 3.69 km^2) were identified with dominant rill erosion (D) associated with a few signs of gully erosion. Dominant rill erosion had a trend to widespread expansion due to the type of geology characterised by low stability. Rare bushes and isolated trees and grass mainly cover the area. For this reason, an increased impact on surrounding areas was observed. However, some areas (1.5%, i.e. 1.38 km^2) were characterised by localised rill erosion processes with local expansion only.
- Eight polygons (2.2%, i.e. 2.04 km^2) were characterised by the presence of sheet erosion (L), with generalised expansion trend up to soil profile removal. Impact on adjacent areas was clearly noticed. The main causative agents are topography, geology, vegetation and human interference.
- The low lands or depressions (6.1%, i.e. 5.72 km^2), situated mainly along the river stream, with relatively narrow and shallow banks and adjacent to sloping unstable lands, were classified as areas with sediment or water access (W).

The Zahrani erosion map clearly reveals low diversity in classes, with a dominance of stable areas and with unstable areas mostly in the northern and eastern and southern parts of the watershed. This reflects the influence of geology/topography, but locally it shows the influence of human interference. The spreading of human settlement is obvious all over the area. The unstable areas tend to be uniform where they occur, i.e. absence of mass movement, gully erosion and multiple processes. This also facilitates the application of remedial measures.

5.2.3 Conclusions for the whole study area

Both watersheds show a majority of stable areas despite the higher proportion in Zahrani watershed. While mass movement is a major problem in Damour watershed threatening the human settlements by debris and stones fall, this process is not observed in Zahrani watershed. But, this area shows a higher percentage of non-used wasteland that indicates an old land abandonment caused probably by the inconvenient historical situation in South Lebanon. On the other hand, rehabilitation activities take place with recent urban expansion in the surroundings of the villages located in the Zahrani watershed.

While Damour watershed is distinguished by a large dominance of natural (unmanaged) pine forest areas (46%), Zaharani watershed represents a limited area with natural (unmanaged) forest oak land (almost 9%). This indicates the need for forestation in the area. The areas are also different in the proportion of slopping and steep lands, where Damour watershed is steeper. Current land cover/use in this watershed with alternating forest and olive grown on terraces provide the economic and social background for the conservation of ecosystem diversity. Large areas in Zahrani watershed are now planted with olive and grape indicating limitation in water resources.

Based on land cover/use and geomorphologic characteristics, the Damour and Zahrani watersheds are representative for the Lebanese coastal area with similar occurrence of wastelands and problems of active erosion processes demanding appropriate management.

5.3 RELEVANT SOCIO-ECONOMIC FACTORS

According to the field observations and in compliance with the findings of the participatory programme of the CoLD project (see related National IPP Report), socio-economic factors have a dominant influence on land degradation in the two pilot areas.

The participatory assessment revealed that the mismanagement of resources and resulting land degradation seems to be the result of a general lack of land use planning, reinforced by other causes such as overlapping of prerogatives between ministries, non-application of existing environmental regulations and weakness of municipalities resulting in a lack of enforcement of laws. In this respect the role of planning of natural resources development is of crucial importance. Also the frequent occurrence of forest fires seems to be of general importance for land degradation in the pilot areas. The resulting destruction of vegetation cover is not the only negative consequence. Fire also enhances soil erosion and ecosystem degradation for a long period of time. On the other hand, there seems to be considerable awareness of the importance of proper forest management and integrated forest management. In addition to forest fires, urban expansion and uncontrolled quarrying are considered to be more destructive for land resources than deforestation or overgrazing and forest logging. Improper agricultural activities such as improper irrigation, agrochemical usage and monoculture are considered by the stakeholders as less important for land degradation. This also applies to water stagnation and the inhibited infiltration as well as the salinity. Furthermore, there seems to be a major problem with regard to inadequate wastewater treatment. Installed treatment plants seem to be ineffective. Despite the damages caused by the coastal privatisation (presence of big and small ports, refineries, electrical power plants and industrial plants) in many coastal areas of Lebanon, it seems that this is not a problem which is perceived by the local population of the two watersheds.

In both Damour and Zahrani watersheds, the majority of the population (which are growing at an average rate of 1.6 percent per year) and economic activities are concentrated in the coastal zone. Land is affected by all economic activities. Deforestation, overgrazing, poor agricultural and soil conservation practices, improper road construction and inappropriate urbanisation contribute to accelerating soil erosion. The most pertinent land based pressures from population and economic activities leading to land and soil degradation are summarised as follows:

Forest:

- Abuse felling, overgrazing, urban development, fires and pests threaten forest area.
- Some arborous species are preferentially felled for the production of coal. Overgrazing reduces total biomass forest and endangers its regeneration. The proliferation of forest pest has over the past years caused extensive damage to several forests, with an apparent rise in population of these pests in recent years. Urban development and forest fires chiefly threaten Forest area. Forest fires rage between August and early October. Between 1998 and 2000, approximately 11 km^2 of forest in South Lebanon were recorded as affected by fires (compared to 35 km^2 in Lebanon). Lack of funds at the fire control unit at the Ministry of Agriculture have caused frequent delays in combating fires. On the other hand, the Lebanese Air Force has been assuming a growing role in combating forest fires by acquiring fighting buckets which are mounted to helicopters.

Agriculture:

- Urban development, land abandonment, and agricultural mismanagement have led to the intensification of soil erosion on agricultural land.
- The growth of population, industry, and tourism increased demand for land. Fertile land is being lost to construction. Urban encroachment on agricultural lands is most severe in the coastal zone. Coastal segments are currently consumed by illegal construction, beach resorts, sea embankments and other potential tourism facilities. In recent years, tourism and recreation are increasingly practised in natural settings such as forests, protected areas, valleys and mountain areas.
- Abandoning agriculture is leading to the degradation of agricultural terraces. Over recent decades, and particularly during the years of conflict (1975-1990), neglect and rural-urban migration led to land degradation. Terrace walls fail unless properly maintained, potentially leading to very high rates of soil erosion. Today, the maintenance of terraced land is labour intensive and requires communal efforts when carried out on a large scale.

Agricultural mismanagement:

- Agriculture in Lebanon has traditionally faced a number of basic constraints that have hindered its development: protection policy implications; lack of education at the farmer's level; high level of land fragmentation and general market conditions.
- Excessive use of surface and ground water for irrigation is causing seasonal water shortages, salinity in agricultural soils and reduced crop productivity, while the excessive application of agro-chemicals is causing contamination of ground water with pesticides and nitrates.

Quarries:

- Quarries exert significant pressures on the environment. They disrupt the natural landscape and also damage or destroy natural habitats and vegetation. Moreover, quarrying has altered or destroyed underground geologic formations (caves, abysses). Finally, quarrying is also threatening sensitive ecosystems near natural heritage sites.

Sand dredging and coastal erosion:

- Sand extracting activities on beaches and gravel quarrying in river bed lead directly to sediment depletion on the shore front and to the gradual disappearance of sandpits and intralittoral sandbars at river mouths and their adjacent shores, thus causing and exacerbating further coastal erosion.

All in all, the identified problems are caused by major socio-economic processes, namely by:

- Population dynamics, resulting in rural exodus and land abandonment in many parts of the two watersheds as well as overexploitation (e.g. improper agrochemical usage, monoculture, and excessive irrigation with wastewater) and urban expansion in other parts near to the urban centres.
- Human-induced destruction of vegetation cover by forest fires, overgrazing and forest logging.
- Land tenure conditions preventing investments in publicly owned land (state owned or communal) as well as in leased land, notably for the investment in water harvesting practices.

- Unfavourable market conditions for agricultural crops, especially olives, resulting in a decreased profitability of agricultural production and a lack of investment in agricultural lands.
- Changes in agricultural production such as progressing mechanisation resulting in the abandonment of agricultural lands which are not suitable for the new type of production (such as terraced lands which cannot be accessed any more with the new machinery).
- Lack of enforcement of environmental legislation resulting in uncontrolled quarrying and building activities as well as improper waste treatment.

More specifically, the following socio-economic dynamics apply to the two watersheds in particular. For stable areas, the below socio-economic conditions are of importance to the different identified mapping units:

- The non-used wasteland (00), situated on the hilltops with sparse land cover with range and sparse shrubs, is not subjected to direct human interference due to the difficulty of roads. However, grazing and hunting are general frequent activities on such lands. Furthermore, bee keeping and ecotourism could be additional land use types. With regard to the coastal wastelands representing sand dunes and lands with potential recreational use, an increase in the recreational use of these areas might contribute to degradation and environmental pollution.
- The unmanaged area with forest potential only (01), where natural forest with rare fruit trees and shrubs occupies the land, are along with the stable managed areas with forestry use (03), frequent subject of forest fires and resulting destruction of vegetation cover. Furthermore in the presence of old terraces, non-maintenance of these structures results in their collapsing which increases considerably the instability risk of these areas.
- The managed areas with agricultural use (04) are exposed to different influences. On sloping lands, instability risk is induced by human mismanagement, i.e. bad agro-practices, and absence of physical infrastructures or returning of formerly terraced areas into their initial form, respectively. The low lands are occupied by more intensive cropping systems, like irrigated vegetable production, fruit trees and greenhousing. Here a risk of inundation was observed during the fieldwork that implies protection measures from seasonal water and/or sediment excess. Also negative consequences of overexploitation might occur such as pollution with agrochemicals, improper irrigation and resulting salinisation, or leaching of nitrate into the groundwater. On the other hand, the area of arable lands is reduced in the country due to chaotic urban sprawl. Farmers are selling the highly priced lands in the coastal and inner plains and go for the rehabilitation of highly calcareous hills.
- The rehabilitated areas (06) are constrained by the low market conditions of olive oil in the country, aggravated by the weak marketing (labelling and appellation). Olive has always been occupying marginal lands with higher degree of erosion, thus the retaining stones were necessary, notably on hard limestone areas, where they are available. Today, the low profitableness of the land use is causing rural exodus and poor maintenance of the terrace structures.

For unstable areas, the following socio-economic conditions are of importance to the different identified mapping units:

- Mass movement (M) is partly due to the total absence of remedial measures and partly to the destructive effect of land management and the interrupted measures of land reclamation. The negative effect of reduced infiltration capacity of several rock materials is not solved by appropriate water diverging canals and/or drainage system within a context of water harvesting policy and related measures. Rock falling

interferes with the infrastructure and threats the adjacent lands, settlements and roads. Local authorities must face these problems which become stressing due to restricted financial resources of local rural population. Coupled with poor land management, physical conditions like lithology with restricted drainage cause boulders movement down slope that damages adjacent lands. Land abandonment and low land use value imply the application not only of preventive but also curative measures. Terracing, forestation and water control could stop and reverse land degradation

- Gully erosion (C), rill erosion (D), sheet erosion (L) and their association (P) are physically caused by poor land cover and steep slopes. However, land abandonment, rural exodus and non-maintenance of terraces in view of low profitability of agricultural activities are the main causative agents. The low land use value expressed by the unfavourable market conditions and absence of subsidies on mountainous fruit production aggravates the situation despite the high land suitability for agricultural activity and reforestation (agro forestry). Unless improving land use value by promoting agroforestry or agricultural production, it is difficult to implement efficient measures to reduce gully erosion.
- Areas with sediment or water access (W) are spread in lowlands along the riverbanks. Anti-flooding and protection measures against rock fall are costly measures, which cannot be undertaken by the simple effort of local community. Land tenure and low income often prohibit such measures.

In contrast to Damour watershed, the Zahrani area was additionally subject to war events and forest fires and clearing were practised. The area of forest cover in the Zahrani watershed in very limited (about 8%). The slope is usually steep and among causative factors of instability risk we noticed the rare cover and human impact. Even the terraced and agricultural areas are not well maintained due to conflicts, market conditions and low current land use value for the national policies. This is an indicator of multiplying physical risk and influence on surrounding area.

In summary of the above, the following socio-economic conditions were considered as crucial for the prioritisation of future intervention areas.

- Overexploitation / rural exodus: The population dynamics in the two pilot areas result in many parts in land abandonment and in a few other parts in overexploitation. Land abandonment, mainly caused by the unfavourable market conditions of the predominant agricultural productions systems, especially olive production, has then the effect that conservation structures such as terraces are not maintained anymore. On the other hand, mismanagement and overexploitation result in environmental pollution by bad agricultural practices, extensive use of agrochemicals and improper irrigation followed by salinisation.
- Land tenure: Unfavourable land tenure conditions prevent investments in publicly owned land (state owned or communal) as well as in leased land, notably for the investment in water harvesting practices.
- Other factors such as frequent occurrence of forest fires in forest areas, difficulty of access to remote areas and absence of appropriate infrastructure measures, presence of social conflicts, illegal urbanisation and quarrying, etc., to be applied as appropriate to individual units.

The identified socio-economic criteria are applied in the following chapter for the prioritisation of future intervention areas.

5.4 IDENTIFICATION AND PRIORITISATION OF FUTURE INTERVENTION AREAS ("HOT SPOTS")

Successful land degradation control is based on the efficient use of available resources and therefore needs the establishment of clear priorities for both identification and planning of future interventions in the framework of control programmes.

In order to facilitate this task, a prioritisation procedure was developed, integrating the results of the physical assessment and related descriptive mapping (see 5.2) with the aggravating socio-economic conditions (see 5.3) and further considering actual and potential land use values according to different views, notably the perception of the local population (see the results of the participatory programme of CoLD), established national policies and assessment of potential for forestry, agricultural use and other land use forms.

For the different criteria, a rating grid from 1 (lowest possible score) to 3 (highest possible score was applied. The detailed meaning of the scores for the different criteria is explained below.

A. Physical instability risk (for stable areas, in compliance with the descriptive mapping code): 1: no or low to moderate instability risk; 2: high instability risk; 3: Critical instability risk.
B. Extent of area affected by a specific degradation process (for unstable areas, in compliance with the descriptive mapping code): 1: localised extent, i.e. less than 30% of the area affected; 2: dominant extent, i.e. 30 to 60% of the area affected; 3: generalised extent, i.e. more than 60% of the area affected.
C. Expansion trend of a specific degradation process (for unstable areas, in compliance with the descriptive mapping code): 1: no expansion or only trend to local expansion; 2: trend to widespread expansion; 3: trend to generalised degradation towards an irreversible state.
D. Multiplicator for increased importance of unfavourable combination of causative agents (for stable areas) or for increased importance of a specific degradation process (for unstable areas): 1: no increased importance; 2: increased importance; 3: highly increased importance.
E. Influence on adjacent areas: 1: no or low negative influence on adjacent areas; 2: highly negative influence on adjacent areas; 3: critical negative influence on adjacent areas.
F. Overexploitation as aggravating socio-economic factors: 1: no or insignificant influence; 2: significant influence; 3: crucial influence.
G. Rural exodus as aggravating socio-economic factors: 1: no or insignificant influence; 2: significant influence; 3: crucial influence.
H. Land tenure as aggravating socio-economic factors: 1: no or insignificant influence; 2: significant influence; 3: crucial influence.
I. Other aggravating socio-economic factors: 1: no or insignificant influence; 2: significant influence; 3: crucial influence.
J. Value of current land use according to the point of view of the local population: 1: low value; 2: increased value; 3: high or crucial value.
K. Value of current land use according to the national policies: 1: low value; 2: increased value; 3: high or crucial value.
L. Potential for forestry: 1: low potential; 2: increased potential; 3 high or crucial potential.
M. Potential for agricultural use: 1: low potential; 2: increased potential; 3 high or crucial potential.

N. Other land use potentials such as recreational use, construction sites, industrial activities: 1: low potential; 2: increased potential; 3 high or crucial potential.

After giving a score for each criterion to the identified areas, the final prioritisation scores were calculated in the following way:

For stable areas: [(A * D + E) * F * G * H * I] + [(J + K) * L * M *N]

For unstable areas: [(B * C * D + E) * F * G * H * I] + [(J + K) * L * M *N]

In a final step, the final scores were grouped into priority classes:

- High priority for application of measures (priority class 3): 60 points and more as final score
- Medium priority for application of measures (priority class 2): 21 to 59 points as final score
- Low priority for application of measures (priority class 1): 20 points and less as final score

The results of the assessment and related scores are given for Damour watershed in Table 5.3 (stable areas) and Table 5.4 (unstable areas) and for Zahrani watershed in Table 5.5 (stable areas) and Table 5.6 (unstable areas). Furthermore, the distribution of prioritisation classes is shown on two maps, one for Damour watershed (Map 5.3) and one for Zahrani watershed (Map 5.4).

Table 5.3: Prioritisation scheme for stable areas in Damour watershed

Serial map N°	27	25, 28	6	8	10	13	15	16	17	23	20
Actual land use*	5	4/5/6	4	4	4	4	6/4	6/4	4/5/2	4/5	5/2
Code	001tgh	001g	011g	011tg	011gt	012tg	011tgh	011th	011tgv	011t	031tg
Prioritisation criteria (score)**											
Actual degradation risk of the area											
Physical risk (A)	1	1	1	1	1	2	1	1	1	1	1
Multiplicator for importance of causative agents (D)	1	1	1	1	1	1	1	1	1	2	2
Influence on adjacent areas (E)	1	1	1	1	1	1	2	1	2	2	1
Importance of aggravating socio-economic factors											
Overexploitation (F)	1	1	1	1	1	1	1	1	1	1	1
Rural exodus (G)	2	2	1	1	1	1	1	1	1	2	1
Land tenure (H)	2	2	1	1	1	1	2	2	1	2	1
Others (social conflict, market, prices) (I)	-	-	1	1	1	1	1	1	1	1	1
Total score for actual degradation risk (A * D + E) * F * G * H * I	**8**	**8**	**2**	**2**	**2**	**3**	**6**	**4**	**3**	**16**	**3**
Land use value (actual and potential)											
Value of the current land use-local population view (J)	1	1	3	3	2	2	1	1	2	1	2
Value of the current land use-national policies (K)	1	1	2	2	2	1	1	1	1	1	1
Potential for forestry (L)	-	-	3	3	3	3	3	3	3	3	2
Potential for agricultural use (M)	-	-	1	-	-	-	-	-	-	-	2
Other land use potential (N)	2	2	2	2	3	2	2	2	2	3	2
Total score for land use value (J + K) * L * M *N	**4**	**4**	**30**	**30**	**36**	**18**	**12**	**12**	**18**	**18**	**24**
Total final score [(A * D + E) * F * G * H * I] + [(J + K) * L * M *N]	**12**	**12**	**32**	**32**	**38**	**21**	**18**	**16**	**21**	**34**	**27**
Priority for application of preventive measures* **	**1**	**1**	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**

* Landuse: 1. Herbaceous, 2. Mixed crops, 3. Irrigation, 4. Forest, 5. Shrubs, 6. Range, sparse shrubs.

** Minimum score is 1. Maximum score is 3.

*** 1: Low Priority (score of 20 and less), 2: Medium priority (score of 21 to 59), 3: High priority (score of 60 and more).

Table 5.3 Prioritisation scheme for stable areas in Damour watershed (continued)

Serial map N°	21	22	2	3	7, 12	24	26	14
Actual land use*	4/5/2	4/5/2	2	1	4/2	2/5	2/3	2
Code	032tg	032tgv	041gth	041tgh	040h	041gtv	041h	062tgh
Prioritisation criteria (score)**								
Actual degradation risk of the area								
Physical risk (A)	2	2	1	1	-	1	1	2
Multiplicator for importance of causative agents (D)	1	1	1	3	1	1	1	1
Influence on adjacent areas (E)	2	2	2	3	1	1	1	1
Importance of aggravating socio-economic factors								
Overexploitation (F)	1	1	1	1	2	2	3	1
Rural exodus (G)	2	2	1	3	1	1	1	3
Land tenure (H)	2	2	1	1	2	1	2	2
Others (social conflict, market, prices) (I)	2	1	2	3	2	3	3	3
Total score for actual degradation risk (A * D + E) * F * G * H * I	**32**	**16**	**6**	**54**	**16**	**12**	**36**	**54**
Land use value (actual and potential)								
Value of the current land use-local population view (J)	1	1	3	1	3	3	3	1
Value of the current land use-national policies (K)	1	1	2	1	2	2	2	1
Potential for forestry (L)	2	2	-	-	-	-	-	-
Potential for agricultural use (M)	2	2	3	3	3	3	3	3
Other land use potential (N)	1	1	1	1	3	1	1	1
Total score for land use value (J + K) * L * M *N	**8**	**8**	**15**	**6**	**45**	**15**	**15**	**6**
Total final score [(A * D + E) * F * G * H * I] + [(J + K) * L * M *N]	**40**	**24**	**21**	**60**	**61**	**27**	**51**	**60**
Priority for application of preventive measures* **	**2**	**2**	**2**	**3**	**3**	**2**	**2**	**3**

* Landuse: 1. Herbaceous, 2. Mixed crops, 3. Irrigation, 4. Forest, 5. Shrubs, 6. Range, sparse shrubs.
** Minimum score is 1. Maximum score is 3.
*** 1: Low Priority (score of 20 and less), 2: Medium priority (score of 21 to 59), 3: High priority (score of 60 and more).

Table 5.4: Prioritisation scheme for unstable areas in Damour watershed

Serial map N°	29	30	31	32, 36, 46	33	34	37, 38	39	40	41	44	42	43, 45	9	18
Actual land use*	6	6	6	5	5	4/5	6	6	4/5	5/6	1/5	5	5	2/3	2
Code	M32tgh	M31tgh	M32gt	M21tg	M22tg	M21thgv	C21tg	C11t	C22tgh	C21tgh	C32tgv	P11tvh	D22gt	W12	W11
Prioritisation criteria (score)**															
Actual degradation trend of the area															
Extent of area affected (B)	3	3	3	2	2	2	2	1	2	2	3	2	2	1	1
Expansion trend (C)	2	1	2	1	2	1	1	1	2	1	2	1	2	1	1
Multiplicator for importance of degradation process (D)	3	3	3	2	2	2	2	2	2	2	3	2	2	1	1
Influence on adjacent areas (E)	2	3	2	2	2	2	2	2	2	2	1	1	2	1	1
Importance of aggravating socio-economic factors															
Overexploitation (F)	-	-	-	-	-	3	-	-	-	-	-	-	-	2	2
Rural exodus (G)	3	3	2	3	1	-	3	3	2	3	2	1	2	-	-
Land tenure (H)	2	2	2	2	1	1	1	1	2	2	2	1	2	2	2
Others (social conflict, market, prices) (I)	-	-	-	-	-	2	-	-	-	-	-	-	-	3	3
Total score for actual degradation risk (B * C * D + E) * F * G * H * I	**216**	**72**	**80**	**36**	**10**	**36**	**18**	**12**	**40**	**36**	**76**	**5**	**40**	**24**	**24**
Land use value (actual and potential)															
Value of the current land use-local population view (J)	1	1	1	1	1	1	1	1	2	1	1	1	1	3	3
Value of the current land use-national policies (K)	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1
Potential for forestry (L)	3	3	1	2	2	3	3	3	3	3	3	3	1	1	1
Potential for agricultural use (M)	1	3	1	2	1	1	2	2	3	3	1	1	3	3	2
Other land use potential (N)	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2
Total score for land use value (J + K) * L * M *N	**6**	**18**	**2**	**8**	**4**	**6**	**12**	**12**	**36**	**18**	**6**	**6**	**6**	**45**	**32**
Total final score [(B * C * D + E) * F * G * H * I] + [(J + K) * L * M *N]	**222**	**90**	**82**	**44**	**14**	**42**	**30**	**24**	**76**	**54**	**82**	**11**	**46**	**69**	**56**
Priority for application of remedial measures***	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**3**	**2**	**3**	**1**	**2**	**3**	**2**

* Landuse: 1. Herbaceous, 2. Mixed crops, 3. Irrigation, 4. Forest, 5. Shrubs, 6. Range, sparse shrubs.
** Minimum score is 1. Maximum score is 3.
*** 1: Low Priority (score of 20 and less), 2: Medium priority (score of 21 to 59), 3: High priority (score of 60 and more).

Table 5.5: Prioritisation scheme for stable areas in Zahrani watershed

Serial map N°	1	2	3	4	5	6	7	8	9	10	11, 12	13	14, 17	15, 18	20
Actual land use*	6	6	6	6	6	4	4	4/5/6	4/5	4/5	2/3	2	2	2	2
Code	000tv	001g	001tg	002t	002tv	011h	011t	011tv	012tv	021th	041t	061h	061t	061tg	063tgv
Prioritisation criteria (score)**															
Actual degradation risk of the area															
Physical risk (A)	-	1	1	2	2	1	1	1	2	1	1	1	1	1	3
Multiplicator for importance of causative agents (D)	2	1	2	2	3	2	2	2	3	2	2	2	2	2	3
Influence on adjacent areas (E)	1	1	1	1	2	2	2	2	2	2	2	2	1	2	3
Importance of aggravating socio-economic factors															
Overexploitation (F)	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1
Rural exodus (G)	2	2	2	3	3	1	2	2	3	3	1	1	3	2	3
Land tenure (H)	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2
Others (social conflict, market, prices) (I)	-	-	-	-	-	1	1	1	1	1	3	3	2	3	3
Total score for actual degradation risk (A * D + E) * F * G * H * I	**12**	**8**	**12**	**15**	**48**	**16**	**16**	**16**	**48**	**12**	**48**	**24**	**36**	**48**	**216**
Land use value (actual and potential)															
Value of the current land use-local population view (J)	1	1	1	1	1	2	2	1	1	1	3	3	2	2	2
Value of the current land use-national policies (K)	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Potential for forestry (L)	-	-	-	-	-	3	3	3	3	3	-	-	-	-	-
Potential for agricultural use (M)	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-
Other land use potential (N)	2	2	2	2	2	2	3	2	2	2	-	-	-	-	-
Total score for land use value (J + K) * L * M *N	**4**	**4**	**4**	**4**	**4**	**24**	**27**	**12**	**12**	**12**	**12**	**8**	**3**	**3**	**3**
Total final score [(A * D + E) * F * G * H * I] + [(J + K) * L * M *N]	**16**	**12**	**16**	**19**	**52**	**40**	**43**	**28**	**60**	**24**	**60**	**32**	**39**	**51**	**219**
Priority for application of preventive measures* **	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**	**3**

* Landuse: 1. Herbaceous, 2. Mixed crops, 3. Irrigation, 4. Forest, 5. Shrubs, 6. Range, sparse shrubs.
** Minimum score is 1. Maximum score is 3.
*** 1: Low Priority (score of 20 and less), 2: Medium priority (score of 21 to 59), 3: High priority (score of 60 and more).

Table 5.6: Prioritisation scheme for unstable areas in Zahrani watershed

Serial map N°	21	22	23	24	25	26	16, 19, 28
Actual land use*	6	6	6	6	5	5	2/3
Code	D21tg	D22gth	D22gtv	D22tgv	L32gtv	L32tgv	W11
Prioritisation criteria (score)**							
Actual degradation trend of the area							
Extent of area affected (B)	2	2	2	2	3	3	1
Expansion trend (C)	1	2	2	2	2	2	1
Multiplicator for importance of degradation process (D)	2	2	2	3	2	2	1
Influence on adjacent areas (E)	2	2	2	2	1	2	1
Importance of aggravating socio-economic factors							
Overexploitation (F)	1	1	1	1	1	1	2
Rural exodus (G)	3	3	3	3	2	2	1
Land tenure (H)	1	2	2	2	1	2	2
Others (social conflict, market, prices) (I)	1	1	1	1	1	1	3
Total score for actual degradation risk (B * C * D + E) * F * G * H * I	**18**	**60**	**60**	**84**	**26**	**56**	**24**
Land use value (actual and potential)							
Value of the current land use-local population view (J)	1	1	1	1	1	1	3
Value of the current land use-national policies (K)	1	1	1	1	1	1	1
Potential for forestry (L)	2	2	2	2	3	2	1
Potential for agricultural use (M)	1	1	2	1	1	2	3
Other land use potential (N)	-	-	-	-	-	-	3
Total score for land use value (J + K) * L * M *N	**4**	**4**	**8**	**4**	**6**	**8**	**36**
Total final score [(B * C * D + E) * F * G * H * I] + [(J + K) * L * M *N]	**22**	**64**	**68**	**88**	**32**	**64**	**60**
Priority for application of remedial measures***	**2**	**3**	**3**	**3**	**2**	**3**	**3**

* Landuse: 1. Herbaceous, 2. Mixed crops, 3. Irrigation, 4. Forest, 5. Shrubs, 6. Range, sparse shrubs.
** Minimum score is 1. Maximum score is 3.
*** 1: Low Priority (score of 20 and less), 2: Medium priority (score of 21 to 59), 3: High priority (score of 60 and more).

Map 5.5: Damour priority map

Map 5.6: Zahrani priority map

For Damour watershed, about 19% (28.12 km^2) of the assessed area fall into the high priority class whereas 65.8% (97.19 km^2) were classified as medium priority areas and 4.4% (6.48 km^2) as low priority areas. The remaining 10.8% (15.94 km^2) was urban areas. A summary of the prioritisation results is given in Table 5.7.

Amongst the high priority areas in Damour watershed interestingly the main part (16.9%, i.e. 24.94 km^2) was identified as stable areas thus needing specific attention with regard to the application of preventive measures. The stable areas with high priority comprise:

- stable, managed areas with agricultural use and a low to moderate instability risk (041) or even with no instability risk (040), and
- rehabilitated areas with physical infrastructures (terraces) and a high instability risk (062)

However, also some unstable areas (2.2%, i.e. 3.18 km^2) were identified as high priority areas. These areas showed active erosion processes such as:

- localised gully networks or dominant gully erosion with a trend to widespread expansion (C22 & C32),
- dominant mass earth movements with a trend to both local expansion (M31) or widespread expansion (M32), and
- areas periodically flooded and/or sediment buried with a trend to local expansion (W11).

In the medium priority class, the stable areas are also dominant (55.5% of the whole assessed area, i.e. 81.93 km^2). These areas mainly comprise unmanaged areas with potential for forestry use only and a low to moderate instability risk (011) and a small part with high instability risk (012). The remaining part is managed areas with forestry use and both low to moderate instability risk (031) and high instability risk (032) as well as managed areas with agricultural use and a low to moderate instability risk (041). With regard to unstable areas, 10.3% (i.e. 15.25 km^2) were identified as medium priority. These areas either showed localised gully networks with a trend to local expansion (C21), dominant rill erosion with a trend to widespread extension (D22), localised land slides with a trend to local expansion (M21) as well as are periodically flooded and/or sediment buried with a trend to widespread expansion (W12).

Stable, non-used wastelands with a low to moderate instability risk (001) and stable, unmanaged areas with potential for forestry use only and a low to moderate instability risk (011) were classified as low priority (3% of the whole assessed area, i.e. 4.41 km^2). Also, a small part of unstable areas (1.4% of the whole assessed area, i.e. 2.07 km^2), comprising areas with localised land slides with a trend to widespread expansion (M22) and dominant associated processes with a trend to local expansion (P21), was considered as low priority.

Table 5.7: Overview of prioritisation results of Damour watershed

Serial No.	ID	Polygon No.	Area (km^2)	%	Priority score	Priority class
7, 12	040h	40	4.93	3.3	61	3
3	041tgh	15	11.42	7.7	60	3
14	062tgh	14	8.60	5.8	60	3
Subtotal	**Stable**	**69**	**24.94**	**16.9**		**High**
40	C22tgh	1	0.09	0.1	76	3
44	C32tgv	1	1.19	0.8	82	3
30	M31tgh	2	0.92	0.6	90	3
31	M32gt	1	0.95	0.6	82	3
29	M32tgh	1	0.02	0.0	222	3
9	W11	2	0.01	0.0	69	3
Subtotal	**Unstable**	**8**	**3.18**	**2.2**		**High**
Total	**Stable/ Unstable**	**77**	**28.12**	**19.0**		**High**
6, 8, 10, 17, 23	011	95	65.67	44.5	32, 32, 38, 21, 34	2
13	012tg	1	0.79	0.5	21	2
20	031tg	1	1.10	0.7	27	2
21, 22	032	4	6.97	4.7	40, 24	2
2, 24, 26	041	82	7.39	5.0	21, 27, 51	2
Subtotal	**Stable**	**183**	**81.93**	**55.5**		**Medium**
37, 38, 39, 41	C21	17	2.10	1.4	30, 30, 54	2
43, 45	D22gt	2	1.36	0.9	46	2
32, 36, 46, 34	M21	9	10.24	6.9	44, 42	2
18	W12	19	1.55	1.1	56	2
Subtotal	**Unstable**	**47**	**15.25**	**10.3**		**Medium**
Total	**Stable/ Unstable**	**230**	**97.19**	**65.8**		**Medium**
25, 28, 27	001	36	2.76	1.9	12, 12	1
15, 16	011	3	1.65	1.1	18, 16	1
Subtotal	**Stable**	**39**	**4.41**	**3.0**		**Low**
33	M22tg	3	0.39	0.3	14	1
42	P21tvh	2	1.68	1.1	11	1
Subtotal	**Unstable**	**5**	**2.07**	**1.4**		**Low**
Total	**Stable/ Unstable**	**44**	**6.48**	**4.4**		**Low**
	Urban	159	15.94	10.8		

For Zahrani watershed, about 12.1% (11.45 km^2) of the assessed area fall into the high priority class whereas 66.9% (62.21 km^2) were classified as medium priority areas and 15.6% (14.49 km^2) as low priority areas. The remaining 5.3% (4.96 km^2) were urban areas. A summary of the prioritisation results is given in Table 5.8.

Amongst the high priority areas in Zahrani watershed the main part (10.2%, i.e. 9.62 km^2) was identified as unstable areas showing active erosion processes such as

- generalised sheet erosion with soil profile removal and a trend to generalised degradation towards an irreversible state (L32),
- dominant rill erosion with a trend to widespread expansion (D22), and
- areas periodically flooded and/or sediment buried with a trend to local expansion (W11).

However, also some stable areas (1.9%, i.e. 1.83 km^2) were identified as high priority areas, notably:

- rehabilitated areas with physical infrastructures (terraces) and a critical instability risk (063),
- stable, managed areas with agricultural use and a low to moderate instability risk, and
- stable, unmanaged areas with potential for forestry use only and high instability risk.

In the medium priority class, the stable areas are dominant (63.4% of the whole assessed area, i.e. 59 km^2). These areas mainly comprise rehabilitated areas with terraces and a low to moderate instability risk (061). A smaller part is unmanaged areas with a low to moderate instability risk, notably those with agricultural potential (021) or with potential for forestry use only (011). Also some non-used wastelands with a high instability risk fall into the medium priority class. With regard to unstable areas, only a small proportion has been identified as medium priority (3.5% of the whole assessed area, i.e. 3.21 km^2). These areas either showed generalised sheet erosion with soil profile removal and a trend to widespread expansion (L32) or dominant rill erosion with a trend to local expansion (D21).

Stable, non-used wastelands with varying degrees of instability risk (000, 001, 002) were classified as low priority (15.6% of the whole assessed area, i.e. 14.49 km^2).

Table 5.8: Overview of prioritisation results for Zahrani watershed

Serial No.	ID	Polygon No.	Area (km^2)	%	Priority score	Priority Class
9	012tv	1	0.76	0.8	60	3
11/12	041t	5	0.97	1.0	60	3
20	063tg	1	0.09	0.1	219	3
Subtotal	**Stable**	**7**	**1.83**	**1.9**		**High**
22, 23, 24	D22	4	3.69	3.9	64, 68, 88	3
26	L32tgv	2	0.21	0.2	64	3
16/19/28	W11	8	5.72	6.1	60	3
Subtotal	**Unstable**	**9**	**436**	**41.0**		**High**
Total	**Stable/ Unstable**		**11.45**	**12.1**		**High**
5	002tv	2	12.02	12.9	52	2
6, 7, 8	011	17	7.47	8.0	40, 43, 28	2
10	021th	1	0.34	0.4	24	2
13, 14/17, 15/18	061	40	39.16	42.1	32, 39, 51	2
Subtotal	**Stable**	**60**	**59.00**	**76**		**Medium**
21	D21tgv	4	1.38	1.5	22	2
25	L32gtv	6	1.83	2.0	32	2
Subtotal	**Unstable**	**10**	**3.21**	**3.5**		**Medium**
Total	**Stable/ Unstable**		**62.21**	**66.9**		**Medium**
1, 2, 3, 4	00(0,1,2)	15	14.49	15.6	16, 12, 16, 19	**Low**
27	Urban	54	4.96	5.3		

The majority of both watersheds were classified in a comparable proportion as medium priority. While the proportion of the study area receiving a high priority classification in Damour watershed was larger for stable areas, the same category in Zahrani watershed was larger for the unstable areas. Such difference can be explained by different land cover/use, which resulted to play an important role in land degradation compared to other physical factors. Indeed, more than 48% of the Damour watershed is covered by forest against 8.8% in Zaharani watershed characterised by certain instability risk. The Damour watershed shows larger variety of erosion processes, restricted in area and favoured by the steep slopes and mismanaged landuse. Given the fact that the Central Mount Lebanon is distinguished by a dominance of natural vegetation (forest, shrubs), the Damour represents well the Lebanese coastal mountainous area. The rest of the western watersheds are observed to be similar in land cover and landscape to the Zahrani watershed where a dominance of bare rocky lands over shrubs and open forest is observed. The topography of the Zahrani area is mainly hill slopes with gentle relief and dominance of calcareous rocks, including some soft marl. For this reason, sheet erosion was separated into independent map unit beside the prevailing rill erosion. Also, the unstable areas subjected to periodical inundation are greater in Zahrani indicating higher risk from erosion deposition. Prioritisation of measures elaborated for both study areas are applicable to other western Lebanese watersheds with slight adaptation to local conditions.

6. REMEDIAL MEASURES

There are numerous publications providing in-depth information on how to combat land degradation. The approaches and emphasis vary from place to place depending on the geography, focus on different practices, socio-economic conditions, different priorities for development, and existing regulations. In the following text, it is not envisaged to give a complete overview of the related discussion but to briefly state the currently applied measures in Lebanon and in the two pilot areas (Table 6.1), to further give an overview of the wide-range of possible measures (Table 6.2), to provide and complete an assessment procedure (Table 6.3) and to conclude with recommendations for suitable measures (Table 6.4).

6.1 CURRENTLY APPLIED REMEDIAL MEASURES

The identification of the currently applied measures was made according the general distinction between preventive, protective and curative measures (as stated in the following Table 6.1). The Table reveals specific themes that are significant when dealing with land degradation. Thus, for the environmental concern there are 4 relevant themes: soil, agriculture, forest and surface water. Similarly, for the concern on development the Table reveals 3 themes: urban, rural and land use. This approach is followed in an attempt to simplify the application of those measures and make them more pragmatic.

Having exposed those measures, it is interesting to note how they apply in the pilot areas. This was done in two ways: actual observation during fieldwork, and by interviewing farmers and other community people.

Overall, because of low profit from agriculture, lots of practices occur that result in increasing land degradation. Be it on the environmental front, as for example, considering forest as the only item of environmental concern, i.e. land users do not think of soil, or the polluted water, or deleterious agricultural practices as inducing major losses! They just take them for granted. This explains the large spans of agricultural lands that were once productive and are now abandoned. The awareness alone is not sufficient to overcome the problems and induced land degradation; an economic stimulus from the government should come to help solving the negative aspects of land abandonment. On the socio-economic front, it is often the case where the health and quality of living of rural communities are of lower standards than elsewhere, as was obvious in the field, especially in the Zahrani watershed. For development concerns, the rather chaotic expansion of human settlements and construction, both on slopes and on agricultural lands, are resulting in expanding land degradation quickly. The National Comprehensive Land Use Planning project, which is now underway, should give the authorities a strong means to control land degradation since it classifies the land into zones for specific sectors, e.g. forest, fruit trees, industrial, human settlements, protected lands, etc. But there is the necessity of proper implementation. As one can observe in the Table on national and local regulations, these have to be upgraded and their implementation properly executed (often this is not the case).

Furthermore, the practice of reclamation of stony hills is not rare in the country. The Green Plan (MoA) mandate is to subsidise farmers in the construction of terraces on bare rocky lands and water reservoirs. Investment is of course high but the best fruit trees orchards are located in the mountains usually (naturally) subjected to erosion and mainly mass movement. Terraces and water harvesting practices help stabilise the territory and keep farmers in the rural areas. On the other hand, the area of arable lands is reduced in the

country due to chaotic urban sprawl. Farmers are selling the high-price lands in the coastal and inner plains and go for the rehabilitation of highly calcareous hills, traditionally unsuitable for citrus, for example, and transport the soil material up on to terraces. This is also a costly measure but it is done in reality on the coastal area of South Lebanon. A large area of rocky lands is transformed into orchards with apple, grape (winery), animal production and so on. In the late sixties, the Green Plan planted hundreds of thousands of Lebanese Cedars on extremely eroded slopes of Lebanon mountain chain after terracing. Trees grow slowly but they survived. In general, land is either cheap in the so called Jourd areas, therefore no extreme land fragmentation is observed as in highly populated places, and/or the microclimate is adequate for reforestation or new production with less plant protection troubles. However, some problems with land tenure must be solved, like the community property on land and infrastructure. Moreover, the agro-biodiversity project of the UNDP is propagating terracing or contour ploughing and strip panting of hills in Anti Lebanon mountain chain with drier conditions to collect more water on a unit of area and avoid flush flood.

Table 6.1: Currently applied remedial measures to reduce erosion and desertification in Lebanon

Major concern	Themes	Remedial measures			Expected results
		Preventive	**Protective**	**Curative**	
Environmental	Soil	▪ Plantations (natural or man-made) are common, thus fixing soil materials (Z[·])	▪ Engineering practices are used, especially in settlement areas. Main of these practices are: ▪ Terraces of concrete and/or of stones (D, Z) ▪ Retaining walls (D, Z) ▪ Man-made channels	▪ Awareness campaigns through meetings and symposia for sustainable use of chemicals in soil ▪ Guidance from authorities on the proper use of fertilisers	Preserving the soil as a major natural resource, thus creating arable lands suitable for different agricultural purposes
	Agriculture	▪ Government encourages local cultivation by supporting farmers by seeds at low prices as well as finding appropriate market for the produced crops ▪ Crop rotation	▪ Constructing fences to prevent chaotic rural overgrazing ▪ Control agricultural crops diversity	*As above plus: ▪ Availing water in sufficient quantities for agricultural purposes (D) ▪ Cutting grasses, which function as parasites (Z, D) ▪ Following new irrigation approaches, such as sprinkler and drip irrigation	Preserving agricultural lands and trying to improve their areal extent and productivity
	Forest	▪ Preventing human activity in and nearby special forest areas (Cedars) (D) ▪ Laws to prevent trespassing and exploitation (Z, D)	▪ Establishing protected areas for some forests (D)	▪ Investigation to protect forests from any expected diseases (D)	Dense forest cover that enhances nature and shares stabilising climatic change
	Water*	▪ Preventing uncontrolled pumping from some springs (D) ▪ Diversions are not always allowed from rivers' tributaries (D, Z)	▪ Construction of walls to minimise water flow of springs and rivers from losses (D, Z)	▪ Awareness campaigns (D, Z) ▪ Water is subjected to chemical and bacterial control (D, Z)	Having sustainable water sources with acceptable quality that can cope with the community needs

[·] D is Damour; Z is Zahrani.

Socio-economic	Health	▪ Prevent forest destruction (D)	▪ Monitor quality of water (D, Z) & soil ▪ Protection from living near solid waste fills (D, Z) ▪ Medical controls on food products, notably meat and vegetables (D, Z)	▪ Local meetings and symposia relating to health awareness in municipalities (D, Z) ▪ Introducing government medical help, notably that serve against contagious diseases (D, Z)	Securing a society healthy conditions
	Quality of living	▪ Laws to prevent environmental degradation (D, Z) ▪ Fines to reduce damages (D, Z)	▪ Set & abide by U.N. human development standards	▪ Education is obligatory till the preparatory levels (Z, D) ▪ Introducing banking loans for different purposes (D, Z)	
Development	Urban	▪ Limiting the ratio of construction within the owned estates (D, Z)	▪ -Building codes (D, Z) ▪ -Creating new infrastructure, especially for sewage (D)	▪ Upgrading existing infrastructures (D, Z)	Develop living standards in order to reach a decent level
	Rural	▪ No clear preventive measures except general laws on degradation	▪ -Introducing modern living requirements, notably water, electricity, roads and construction of infrastructure	▪ Awareness and guidance campaigns through meetings for suitable ways of living	
	Land use	▪ Some preventive codes against interference in nature	▪ Some protected areas	▪ Environmental regulations by the Ministry of Environment. ▪ Land use codes by Directorate of Urban Planning	
Regulations	National	▪ General preventive regulations on national level with standard measures	▪ General protective national regulations	▪ No clear measures in this concern except some fines & incentives	Suitable regulations & control measures to reduce erosion and desertification
	Local	▪ Some old local regulations	▪ -Some old protective regulations ▪ -Management plans priorities to protect the environment	▪ None	

*Surface water sources

Most of the observed operations focus on the protective measures rather than on the less expensive preventive or curative measures. It is fortunate though that projects like “CoLD” and similar ones on coastal areas (example CAMP among others) are reaching to the community providing interactive knowledge on those problematic issues such as land degradation (soil erosion, desertification, ecosystem and resource deterioration, etc.). The construction of terraces, fences, diversion walls and channels is very common. However, the recently introduced wild boars cause huge damage to crops and soil.

It is hoped that the “message of CoLD” is permeating to the community so that more and more significance is given to preventive and curative measures as they are less costly, more effective and permanent.

6.2 Possible Preventive and Curative Measures

Improving soil structural stability by forestation and maintenance of terraces accelerates soil water retention capacity for improving and protecting the soil. A possible preventive measure against severe erosion is the building of water diverging canals (Table 6.2). This is necessary to mitigate earth movements such as rock falls, which cause severe damage in the urban settlements such as near Chartoun and Ghaboune, in the depression of wadi El Set and in the surrounding of Kfar Matta in the Damour watershed. For this reason water management issues must be given priority, including the controlled use of unconventional resources like water harvesting. Diverging and preservation are essential to prevent landslides and erosion, and provide additional sources of water. In this regard, a high risk of contamination represents the uncontrolled use of sewage waters. Together with the reduction of pesticide application in integrated plant production, the use of treated sewage water will ensure new and better market conditions that bring economic benefit and prevent land abandonment. In this context, the forestation of areas prone to mass movement occupies the second place in the priorities to prevent soil degradation. Increasing public awareness through local participation, activation of the role of NGO’s and local authorities through adapted legislation will ensure more sustainable land use. Table 6.2 gives an inventory of the possible remedial measures that are important for a sustainable land use by reducing or checking land degradation. Again, as before, the major concerns cover environmental aspects as well as socio-economic and development aspects since they all intrude upon attitudes and practices affecting the land, covering different themes for that purpose.

Table 6.2: Inventory of possible preventive and curative measures to reduce erosion and desertification in Lebanon

Major concern	Themes	Remedial measures			Expected results
		Preventive*	Protective**	Curative***	
Environmental	Soil	**Pv1**-Control use of soil cover **Pv2**-Well structured mixed plantation **Pv3**-Improved soil structural stability and water retention capacity: building of water diverging canals and water harvesting.	**Po1**-Active extension service **Po2**-Reduce slope stretch by introducing barriers **Po3**-Stabilization of soils by contour ploughing and strip planting on slopes. **Po4**-Constructing and rehabilitation as well as maintenance of terraces	**Cu1**-Active extension service **Cu2**-Land use based on soil capability and suitability. **Cu3**-Sustainable land management and integrated use of chemicals in soil **Cu4**-Soil, climate, environment and market oriented production **Cu5**-Establishment of sectorial farmers' association to allow for integrated large scale production and minimum mechanisation	Maintaining balanced ecosystem and durable agricultural production. Prevention of catastrophic earth movement and rock falling by mass movement**.** Protection of prime lands from sealing, depletion and degradation
	Agriculture	**Pv4**-Balanced development of rural areas. **Pv5**-Diversification of production **Pv6**-Government protection of local production and implementation of import/export calendar	**Po6**-Promote organic farming. **Po7**-Warning of epidemic plant diseases. **Po8**-Supporting balance between natural habitats and agricultural areas. **Po9**-Introduce indicators on eco-cost of land use conversion. **Po10**-Managing of water balance within watersheds. Controlled use of sewage water	**Cu6**-Agri-environmental land management units and agrozoning. **Cu7**-Introduce and subsidise quality food production and modern irrigation systems **Cu8**-Satisfy social needs for water and rational use of irrigation water involving non conventional resources **Cu9**-Good countryside road network for serving internal and regional markets or access roads for forest fire fighting	Increased fertiliser use efficiency, which reduces nutrient build-up, prevents soil depletion, secondary salinisation and groundwater contamination with nitrates. Reduced pesticide application in integrated plant production.
	Forest	**Pv7**-Preventive measures from forest fires, woodcutting and unbalanced change in land use, notably in highly populated areas. Forestation of areas prone to mass movement	**Po11**-Optimization of forest maintenance and exploitation	**Cu10**-Evaluate the environmental impact of agricultural and industrial activities on biota. **Cu11**-Maintenance of forest ecosystem **Cu12**-Promotion of eco-tourism	Dense and healthy forest cover which positively affects the air quality, protects the landscape and soil and improves regional water balance

* Pv, Preventive
** Po, Protective
*** Cu, Curative
The same measures are assessed by rating them, therefore, are referred to by their prefix: Preventive=Pv…etc. and their number.

Table 6.2: Inventory of possible preventive and curative measures to reduce erosion and desertification in Lebanon (continued)

Major concern	Themes	Remedial measures			Expected results
		Preventive	Protective	Curative	
Environmental	Water	**Pv8**-Prevent run-off from fields to surface and subsurface water resources which causes eutrophication and siltation	**Po12**-Improved water harvesting practices **Po13**-Creating protection zones around springs **Po14**-Collective irrigation network	**Cu13**-Sustainable water management practices **Cu14**-Protect water from pollution **Cu15**-Increase water use efficiency **Cu16**-Reuse of treated waters and wastes **Cu17**-Normal functioning of water supply for social and agricultural needs	Having sustainable water sources with acceptable quality that can cope with community needs. The controlled reuse of treated water minimises pollution hazards
Socio-economic	Health	**Pv9**-Teach people the safe use of low quality water **Pv10**-Preventing importing food products without any medical license **Pv11**-Prevent soil contamination **Pv12**-Prevent forest destruction	**Po15**-Regular spatial and temporal monitoring of air, water & soil quality **Po16**-Implement and properly adapt international health standards **Po17**-Analyze direct and indirect effect of management plans: Objective EIA of landfills, waste treatment plants. **Po18**-Proper medical and governmental controls on medicaments, chemicals, quality of food products, notably meat and vegetables **Po19**-Reduce noise and air pollution caused by heavy traffic	**Cu18**-Activate the role of schools in raising early awareness for hygiene and preventive medicine. **Cu19**-Local meetings and symposia relating to health awareness and family medicine in families associations, municipalities and media **Cu20**-Introducing general government social and medical insurance **Cu21**-Proper implementation of regulations	Securing a society with healthy conditions
	Quality of living	**Pv13**-Laws to prevent environmental degradation **Pv14**-Fines to reduce damages	**Po20**-Set & abide by U.N. human development standards	**Cu22**-Proper and modern education system **Cu23**-Introducing banking loans with low rates **Cu24**-Proper implementation of regulations **Cu25**-Incentives in tax system	Decrees for environmental laws issued and mechanisms for their implementation determined

Table 6.2: Inventory of possible preventive and curative measures to reduce erosion and desertification in Lebanon (continued)

Major concern	Themes	Remedial measures			Expected results
		Preventive	Protective	Curative	
Development	Urban	**Pv15**-Preventing chaotic construction expansion **Pv16**-Limiting the ratio of construction within estates	**Po21**-Building codes **Po22**-Land zoning **Po23**-Building some protective structures against natural risk, such as flood controls, and mass movement **Po24**-Creating new infrastructure, especially for sewage	**Cu26**-Upgrading existing infrastructures **Cu27**-Proper implementation of regulations	Improve living standards in order to reach a decent level
	Rural	Develop rural areas, provide larger power for local authorities to carry, assess and implement projects. Promote the participatory approach of rural community	**Po25**-Introducing modern living requirements, notably water, electricity, roads and construction of infrastructure. **Po26**-Create job opportunities in countryside	**Cu28**-Awareness and guidance campaigns through meetings for suitable ways of living. Raise the level of living by improving the farmer's income. Strengthen the feeling of security of former displaced to encourage them be involved in the rural economy	
	Land use	**Pv17**-Some preventive codes against interference in nature	**Po27**-Generate protected areas based on biota richness and rarity	**Cu29**-Environmental regulations by the Ministry of Environment. **Cu30**-Land use codes by Directorate of Urban Planning	Improve living standards in order to reach a decent level
Regulations	National	**Pv18**-General preventive regulations on national level with standard measures	**Po28**-General protective national regulations	**Cu31**-Fair national tax policy to alleviate poverty. **Cu32**-Boost institutional capacity building and role	Suitable regulations & control measures to reduce erosion and desertification
	Local	**Pv19**-Some old local regulations	**Po29**-Some old protective regulations **Po30**-Management plans priorities to protect the environment	**Cu33**-Enhance the role of local authorities	

6.3 ASSESSMENT PROCEDURES FOR REMEDIAL MEASURES

For assessment of remedial measure a rating grid was developed and applied to the structure of the previous table. The procedure consisted of giving different rating values to each identified measure, notably for the following criteria:

- Effect on reduction of degradation process;
- Prevention investment costs;
- Maintenance costs;
- Labour intensity;
- Suitability to development priorities at local level; and
- Suitability to development priorities at national level.

Possible ratings ranged from 1 to 5. The exact meaning of the rating values is explained in the footnotes of the tables. The assessment results are given in Table 6.3 for the preventive measures, in Table 6.4 for the protective measures and in Table 6.5 for the curative measures.

In summary, land use based on an integrated approach encountering soil capability and suitability, market oriented production, negligible use of chemicals and the foundation of sectorial farmers' association allows for large-scale production and minimum mechanisation, and provides better market conditions. For instance, the union of farmers in Shouf area (partly in Damour watershed), accounts for 500 farmers and 800,000 olive trees. The traditional land tenure and parcel fragmentation is overcome by agglomerating the landowners into a professional farmer association with standard oil extraction practice. Maintaining this sector is possible through upgrading oil storage and lowering the cost of production.

However, mixed plantations and diversification of production would help in facing the fluctuation of prices that can maintain farmer’s income. The proposed crop rotation to support soil productivity is relative in Damour watershed as the region main products are fruit trees, and the area occupied by field crops is very limited. Promoting organic farming in the watershed is extremely rewarding given the demand on organic foods. For this reason, rating and value of organic farming are increased to 4 for its higher effect on the reduction of degradation process and increased importance at national level, despite the increased maintenance cost to subsidise quality food production (Table 6.3).

The effect given to supporting the balance between natural habitats and agricultural areas was initially underestimated. A significant part of the Damour watershed revealed to be stable and covered by forest. Actually, it is one of the preferred locations of people entertainment and local tourism. The eco-cost of land use conversion is difficult to predict with the prime priority to prevent forest fires and improve the access to vulnerable areas. In the assessment procedure of remedial measures an increased rating of 5 and higher value is given to forest protection. This affects air quality, protects the landscape and improves regional water balance. Optimising forest exploitation must be accompanied by rural development with a governmental protection of local production and promotion of traditional Lebanese food.

Improved water harvesting practices will help local agricultural activities. Sustainable water management practices are secured through normal functioning of water supply for social and agricultural needs. This must be based on the protection of available water resources and construction of collective irrigation network and controlled reuse of treated waters together with improved efficiency of water use (Table 6.4). The curative effect of water management on land degradation was increased to a rating of 4 (Table 6.5). Similarly, the rate of teaching people the safe use of low quality water was increased to 4 to prevent soil and food contamination.

Preventing chaotic construction expansion and implementing land zoning, creating protected areas and upgrading existing infrastructures are priorities to create conditions for protection of natural resources. Suitable regulations and control measures will contribute to the efforts to reduce erosion and desertification.

Table 6.3: Criteria and rating for the assessment of preventive remedial measures of land degradation

Major Concern	*Themes*	*Remedial measures**	*Rating*				*Suitability to Development priorities at*****	
			*Effect on the reduction of degradation process **	*Prevention investment cost****	*Maintenance cost****	*Labour intensity*****	*Local level*	*National level*
Environmental	Soil	Pv1	4	4	5	4	4	5
		Pv2	3	4	5	4	3	4
		Pv3	2	5	5	5	3	3
	Agriculture	Pv4	4	3	4	5	4	4
		Pv5	3	4	5	4	3	3
		Pv6	4	3	4	4	4	5
	Forest	Pv7	5	3	4	3	4	4
	Water	Pv8	4	3	4	3	4	4
Socio-economic	Health	Pv9	4	3	5	4	4	4
		Pv10	2	4	5	4	3	3
		Pv11	4	4	5	4	4	4
		Pv12	5	3	4	3	5	5
	Quality of living	Pv13	4	4	5	2	4	5
		Pv14	2	3	4	3	3	4
Development	Urban	Pv15	4	3	4	4	4	4
		Pv16	4	4	5	5	3	3
	Land use	Pv17	4	3	3	3	4	4
Regulations	National	Pv18	3	3	4	4	5	5
	Local	Pv19	3	3	5	4	4	4

*The same referral is used here as in Activity 3 (see table) to express the remedial measures.
** Higher rating means more positive effect on alleviating land degradation.
*** The rating 5 means very low cost of the proposed remedial measure. 1 is very high.
**** The rating 5 is very low labour intensity, 1 is very high.
***** The rating 1 is not suitable for development. The rate 4 and 5 mean highly and very highly suitable.

Table 6.4: Criteria and rating for the assessment of protective remedial measures of land degradation

Major Concern	*Themes*	*Remedial measures**	*Rating*				*Suitability to Development priorities at*****	
			*Effect on the reduction of degradation process***	*Prevention investment cost****	*Maintenance cost****	*Labour intensity*****	*Local level*	*National level*
Environmental	Soil	Po1	3	3	4	3	4	3
		Po2	4	4	4	3	5	4
		Po3	4	4	5	3	4	4
		Po4	4	5	5	3	4	3
		Po5	4	3	4	4	4	5
	Agriculture	Po6	4	3	4	3	4	4
		Po7	5	3	4	3	4	2
		Po8	4	3	4	4	4	5
		Po9	5	3	4	3	5	5
		Po10	5	3	4	4	5	4
	Forest	Po11	4	3	4	3	4	4
	Water	Po12	4	2	4	3	4	3
		Po13	2	4	5	4	4	4
		Po14	3	2	3	3	5	4
Socio-economic	Health	Po15	3	3	5	4	4	4
		Po16	3	4	5	4	4	4
		Po17	5	4	5	4	5	5
		Po18	2	4	5	4	3	3
		Po19	3	2	3	3	5	5
	Quality of living	Po20	2	2	3	3	4	4
Development	Urban	Po21	4	4	5	4	3	4
		Po22	4	3	4	4	4	3
		Po23	4	4	5	5	3	3
		Po24	4	2	3	3	4	4
	Rural	Po25	3	3	4	3	4	3
		Po26	2	3	4	3	4	4
	Land use	Po27	4	3	3	3	4	4
Regulations	National	Po28	4	4	5	3	4	4
		Po29	3	3	4	4	4	4
	Local	Po30	5	3	5	4	4	4

* See the notes below Table 6.3.

Table 6.5: Criteria and rating for the assessment of curative remedial measures of land degradation

Major Concern	*Themes*	*Remedial measures**	*Rating*				*Suitability to Development priorities at*****	
			*Effect on the reduction of degradation process***	*Prevention investment cost****	*Maintenance cost****	*Labour intensity*****	*Local level*	*National level*
Environmental	Soil	Cu1	3	3	4	4	4	5
		Cu2	5	3	4	3	5	5
		Cu3	3	5	5	5	3	4
		Cu4	4	3	4	5	4	4
		Cu5	3	4	5	4	3	3
	Agriculture	Cu6	3	4	5	4	4	4
		Cu7	5	3	5	4	4	4
		Cu8	4	3	4	4	4	4
		Cu9	3	2	3	3	5	5
	Forest	Cu10	5	4	5	4	5	5
		Cu11	4	4	5	4	4	4
		Cu12	2	4	5	5	3	3
	Water	Cu13	3	3	5	3	4	5
		Cu14	4	3	4	3	4	4
		Cu15	4	3	4	3	4	4
		Cu16	4	3	3	3	5	5
		Cu17	3	3	4	3	4	4
Socio-economic	Health	Cu18	3	4	5	3	4	4
		Cu19	2	4	5	4	3	3
		Cu20	2	2	3	3	4	4
		Cu21	5	2	3	3	5	5
	Quality of living	Cu22	4	2	3	2	4	5
		Cu23	2	3	4	4	3	4
		Cu24	4	3	4	4	4	4
		Cu25	3	3	4	4	4	4
Development	Urban	Cu26	3	3	3	3	4	4
		Cu27	4	4	5	4	4	4
	Rural	Cu28	2	5	5	4	3	3
	Land use	Cu29	4	4	5	3	5	5
		Cu30	5	3	4	4	4	4
Regulations	National	Cu31	5	2	4	3	5	5
		Cu32	4	3	4	4	5	5
	Local	Cu33	5	3	5	4	5	4

* See the notes below Table 6.3.

6.4 RECOMMENDATIONS FOR REMEDIAL MEASURES

The previous sections and tables give a clear picture on the intervention areas and their remedial measures. Observations in the pilot areas do not reveal a wide variety of measures. This could be explained by the fact that some areas are naturally unstable and people do not want to waste money trying to stabilise them. Or, the farmers may not be aware of what is the optimum measure for specific cases. Field observations showed most farmers or rural communities resort to terracing, retaining walls and forestation, with few special instances of adding another type of soil (to change water retention), or planting barrier trees, or using mixed plantations.

Since the intervention areas are subdivided into two major types, i.e. the unstable, and the stable areas, it is understood that remedial measures on the former have to focus directly on the cause of instability, while on the latter they have to deal with indirect causes of land degradation, but in both cases optimisation in cost, in applicability and simplicity should be driving factors.

For the unstable areas, indirect measures have to deal with:

1. the steep topography, i.e. terracing;
2. the geology (many cases), i.e. weak lithology with use of retaining walls, or bad lands treated with forestation, or exposed rock cover treated with excavation, or moving grounds treated with barriers and water-diversion walls, or clayey grounds treated with mixing soil, etc.;
3. the vegetation cover treated through re-vegetation when bare, or mixing types that fix the soil, or densification, etc.;
4. the human interference, i.e. through abandonment or non-maintenance of terraces, or bad exploitation, or introducing elements of instability such as water saturation or quarrying or plant removal or road construction, etc.

The direct measures on the stable areas, focus on the inherent processes of instability, i.e. if it is the soil type, or the kind of plantations, or the amount of percolating water, or the extent or type of instability, such as how much gullying versus rill erosion, or how much earth flow versus rock debris fall, etc. Thus, each case is treated separately according to its specifications, which makes generalisation difficult.

For the stable areas, also recommendations for re-use of wastelands are given. Despite the high investment costs, and due to the shortage of highly productive lands (more than 60% of productive lands on the coastal area were sacrificed to building purposes), the re-use of wastelands has to be considered.

In view of the above, and choosing selective remedial measures from Tables 6.2 and 6.3 to 6.5 for optimum conditions, Tables 6.6 and 6.7 state the resulting measures for the intervention areas of the pilot zones.

Table 6.6: Recommended remedial measures for the unstable intervention areas

Intervention areas	***Optimum Remedial Measures***		
	Preventive	***Protective***	***Curative***
1. Dominant mass movements	Pv3	Po2, Po4	Cu2
2. Localised landslides	Pv3	Po2, Po3, Po4	Cu2, Cu3
3. Mixed (1 & 2)	Pv3	Po2, Po3, Po4	Cu2, Cu3
4. Dominant gullies	Pv1, Pv2, Pv3	Po1, Po2, Po3, Po4	Cu1, Cu2, Cu3, Cu4
5. Localised gullies	Pv1, Pv2	Po2, Po3, Po4	Cu2, Cu3
6. Mixed gullies, rill, movements	Pv3	Po2, Po3, Po4	Cu2, Cu4
7. Dominant rill, plus gullies	Pv1, Pv2	Po2, Po3, Po4	Cu2, Cu3
8. Dominant sheet erosion	Pv1, Pv2, Pv3	Po3, Po4	Cu2

Table 6.7: Recommended remedial measures for the stable intervention areas

Intervention areas	***Optimum Remedial Measures***		
	Preventive	***Protective***	***Curative***
1. Wasteland on hill tops	Pv1, Pv3, Pv5	Po1, Po8	Cu1, Cu2, Cu6
2. Wasteland on slopes	Pv2, Pv3, Pv5	Po1, Po2, Po3, Po4, Po8	Cu1, Cu2, Cu6
3. Unmanaged areas + forest potential	Pv2, Pv4, Pv5	Po1, Po4, Po7, Po8	Cu1, Cu2, Cu4, Cu6, Cu9
4. Unmanaged areas + agricultural potential	Pv1, Pv2	Po3, Po4	Cu2, Cu3
5. Managed areas + forest	Pv1, Pv2, Pv4, Pv5	Po2, Po4, Po7, Po8	Cu2, Cu4, Cu6, Cu9
6. Managed areas + agriculture	Pv1, Pv2, Pv4, Pv5	Po2, Po4, Po7, Po8	Cu2, Cu4, Cu6, Cu9
7. Low lands in wadis	Pv2, Pv3, Pv5	Po4, Po8, Po10	Cu2, Cu4, Cu6, Cu7, Cu8
8. Coastal agricultural plains	Pv2, Pv3, Pv5, Pv6	Po6, Po7, Po9, Po10	Cu2, Cu4, Cu6, Cu7, Cu8, Cu9
9. Rehabilitated areas	Pv1, Pv2, Pv4, Pv5	Po4, Po7, Po8	Cu2, Cu4, Cu6, Cu9
10.Coastal beaches	Pv1	Po2	Cu2

7. DRAFT MANAGEMENT PLANS

7.1 OUTLINE OF DRAFT MANAGEMENT PLANS

The experience gained in this project, be it from mapping methodologies, from the guidelines on erosion, or from the training workshops, was very helpful in arriving at assessing and mapping the erosion risks in the two pilot areas. This followed, of course, the earlier land-unit mapping and predictive erosion mapping of the whole coastal area under study. There is an added positive aspect about that, namely, the incorporation of socio-economic factors into consideration. Indeed, the two pilot areas are different in terms of their grade of priority of problems (see Tables 7.1, 7.2 and 7.3). In Damour, the foremost problems are unstable areas and burnt forests, while in Zahrani they are wasteland and degraded terraced land. This is immediately reflecting the socio-economic status because in Zahrani (an area in south Lebanon impacted by armed conflicts for twenty five years) lots of people had to leave their lands and homes. Furthermore, the project noted with great concern the remedial measures, whether being taken now (as observed in the field from pilot areas and elsewhere) or that are possible and commendable. Obviously, many of those measures need training and capacity building, so one has to understand the factors influencing institutional response to capacity building (see section 8), as well as encourage public participation for an effective implementation of those remedial measures.

This is what Tables 7.1 – 7.4 try to present as an outline of the needed aspects for a management plan for the pilot areas Damour and Zahrani. Tables 7.1 – 7.3 reveal the problems, their remedial measures, the basic required institutional arrangements, and the indicators for their successful implementation. Table 7.4, on the other hand, proposes activities within a management planning approach, like in project planning, to realise the above.

From Tables 7.1 – 7.4, the ranking of problems differs in the two areas. This is due to both natural and human causes. The topography and green cover in Damour area are quite different than those in Zahrani. There are denser and more widespread forests in Damour, and the overall landforms in Zahrani are more gentle and subdued. The widespread phenomenon of wastelands and abandoned terraced lands in Zahrani is quite distinctive, and is the result of political conflict. The remedial measures are generalised (in Table form) as they are given in more detail elsewhere (see section 6).

To protect arable lands, reforms like introducing mixed plantation with diversified production are needed to face the fluctuating market conditions. With the free trade, production must be competitive to ensure sustainable income and provide an income generating approach to combat desertification. The expansion of agricultural activities and rehabilitation of new lands must consider supporting the balance between natural habitats and agricultural areas to preserve agrobiodiversity and lands from erosion that will improve water harvesting and conservation. Such approach will ensure an environment and market-oriented production that can contribute to reversing land degradation. Land use based on soil capability and suitability will ensure planning for consigning lands their value and appropriate use. Poor fertility rocky lands with shallow soils could be allocated for urban expansion, while productive lands with deep fertile soil cover could be preserved for agricultural activities. A controlled use of soil cover will protect lands against chaotic urban expansion that reduce prime productive lands.

A balanced development of rural areas by promoting sustainable production and road network for serving internal and regional markets will create new working places. Improving the extension service will help in enhancing fertiliser and water use efficiency and promote integrated plant production and protection through early warning of epidemic plant diseases. Developing agro-industrial complexes (food technology, milk and cheese production, wine production) will contribute to limit rural abandonment and emigration to the cities. Agrozoning based on pedo-climatic conditions and socio-economic consideration will ensure planned agro-production with required quality that ensures local market needs and open opportunity for export.

Unstable areas could be managed by improving structural stability, by controlling land cover that enrich the soil with organic matter and by fighting against fires. These measures will improve soil structural stability and water retention capacity. This is possible through building of water diverging canals and reservoirs.

In Table 7.4, a project planning approach is to allow the relevant authorities and community in hot spots of the coastal area to assess and mitigate land degradation. It is designed further to understand its causes, establish a monitoring program, and involve the public in remediation. A reliable GIS database has to be established with due training and capacity building. The phases are essentially 4, covered through overlapping activities in 30 months. The different activities cover all requirements of preparatory settings, training, capacity building, socio-economic analysis, modelling, monitoring, and a management-strategy for the decision-maker/ manager/community. The project sustainability is checked through a set of deliverables.

Table 7.1: Summary of draft management plans for the two pilot areas Damour and Zahrani

	Problems & remedial measures			***Institutional/administrative arrangements***	***Monitoring indicators***
	Problem	***Priority***	***Remedial measures***		
Damour	▪ unstable areas ▪ burnt forest ▪ torrential water passage ▪ quarried sites ▪ degraded terraces ▪ wasteland	*** *** ** ** ** *	▪ stabilise by terraces or forestation & protect ▪ rehabilitate ▪ construct protection measures ▪ rehabilitate ▪ rehabilitate/cultivate ▪ cultivate or reforest	▪ National level: ▪ capacity building ▪ establish databases ▪ enforce regulations ▪ apply ICZM notably land use zoning & protection ▪ Local level: ▪ public participation/NGOs ▪ environmental awareness ▪ agro-co-operatives ▪ enhance agro-sector & socio-economic incentives	▪ areas are stabilised ▪ forest regenerated ▪ water ways controlled ▪ degraded sites are recovered ▪ terraces maintained & cultivated ▪ agro-sector is recovered ▪ improved living
Zahrani	▪ wasteland ▪ degraded terraces ▪ quarried/disturbed sites ▪ excessive interference ▪ unstable areas	*** *** ** ** *	▪ cultivate ▪ rehabilitate/cultivate ▪ rehabilitate ▪ control & protect ▪ stabilise & protect		

Table 7.2: Outline of draft management plan for Damour watershed

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
040h (7, 12)	High	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoA + MoW + + DGUP ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ pollution (volume) ▪ abandoned orchards ▪ CoLD stakeholders and participation Committee operational ▪ rural community welfare ▪ awareness of protected resources
041tgh (3)	High	▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Agri-environmental land management units and agrozoning (Cu6)	▪ MoA + MoW ▪ Municipalities ▪ NGOs ▪ Farmers	▪ loss of top soil (cm) ▪ abandoned, deserted terraces (occurrence) ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected natural resources
062tgh (14)	High	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Maintenance of terraces ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoA + MoW ▪ CDR + ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ pollution (volume) ▪ CoLD stakeholders Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
C22tgh (40)	High	▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4)	▪ MoA ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Donors and funding institutions ▪ Farmers	▪ Loss of top soil (cm) ▪ mass wasting (mass) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
C32tgv (44)	High	▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Active extension service (Cu1) ▪ Soil, climate, environment and market oriented production (Cu4)	▪ MoA ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Donors and funding institutions ▪ Media ▪ Farmers	▪ Loss of top soil (cm) ▪ mass wasting (mass) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources ▪ awareness
M31tgh (30)	High	▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Land use based on soil capability and suitability (Cu2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3)	▪ MoA + MoW ▪ Municipalities ▪ Private sector ▪ Farmers	▪ mass wasting (mass) ▪ landslides (occurrence) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
M32gt (31)	High	▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Reduce slope stretch by introducing barriers (Po2)	▪ MoA + MoW ▪ Municipalities ▪ Research organisations ▪ NGOs ▪ Private sector	▪ mass wasting (mass) ▪ landslides (occurrence) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
M32tgh (29)	High	▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Constructing and rehabilitation of terraces (Po4)	▪ MoA + MoW ▪ Municipalities ▪ NGOs ▪ Private sector	▪ mass wasting (mass) ▪ landslides (occurrence) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
W11 (9)	High	▪ Well structured mixed plantation (Pv2) ▪ Building of water diverging canals (Pv3) ▪ Diversification of production (Pv5) ▪ Managing of water balance within watersheds. Controlled use of sewage water (Po10) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Introduce and subsidise quality food production and modern irrigation systems (Cu7) ▪ Satisfy social needs for water and rational use of irrigation water involving non conventional resources (Cu8)	▪ MoE + MoA + MoW + MoPW ▪ CDR + MoE + MoTourism + DGUP ▪ Municipalities ▪ DGUP ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Donors and funding institutions ▪ Media ▪ Farmers	▪ pollution (volume) ▪ compaction & crusting (area) ▪ destroyed orchards ▪ CoLD stakeholders and participation Committee operational ▪ Floods ▪ awareness of protected resources
011 (6, 8, 10, 17, 23)	Medium	▪ Balanced development of rural areas (Pv4) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Access roads for fire fighting	▪ MoE + MoA + MoW + MoPW ▪ CDR + MoE + DGUP ▪ Municipalities ▪ DGUP ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Donors and funding institutions ▪ Media ▪ Farmers	▪ protected (area%) ▪ land cover (change%) ▪ NDVI (value) ▪ burnt forests ▪ forest & other natural cover (area%) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
012tg (13)	Medium	▪ Balanced development of rural areas (Pv4) ▪ Active extension service (Po1) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Active extension service (Cu1) ▪ Access roads for forest fire fighting	▪ MoE + MoA + DGUP ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Media ▪ Farmers	▪ protected (area%) ▪ land cover (change%) ▪ NDVI (value) ▪ burnt forests ▪ forest & other natural cover (area%) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
031tg (20)	Medium	▪ Reduce slope stretch by introducing barriers (Po2) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoE + MoA + DGUP ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Media ▪ Farmers	▪ mass wasting (mass) ▪ protected (area%) ▪ land cover (change%) ▪ NDVI (value) ▪ burnt forests ▪ forest & other natural cover (area%) ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources
032 tgv (21, 22)	Medium	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoE + MoA + DGUP ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Media ▪ Farmers	▪ protected (area%) ▪ land cover (change%) ▪ NDVI (value) ▪ burnt forests ▪ forest & other natural cover (area%) ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources
041 (2, 24, 26)	Medium	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoA + MoW ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ pollution (volume) ▪ salinisation (volume or area) ▪ CoLD stakeholders and participation Committee operational ▪ economic input from agricultural sector ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
C21 (37, 38, 39, 41)	Medium	▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4)	▪ MoA + MoW ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Donors and funding institutions ▪ Media ▪ Farmers	▪ loss of top soil (cm) ▪ mass wasting (mass) ▪ disrupted soils ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
D22gt (43, 45)	Medium	▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4)	▪ MoA + MoW ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Farmers	▪ loss of top soil (cm) ▪ mass wasting (mass) ▪ disrupted soils ▪ abstraction (volume) m^3 ▪ forest & other natural cover (area%) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
M21 (32, 36, 46, 34)	Medium	▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Land use based on soil capability and suitability (Cu2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3)	▪ MoA + MoW ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ mass wasting (mass) ▪ landslides (occurrence) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
W12 (18)	Medium	▪ Well structured mixed plantation (Pv2) ▪ Diversification of production (Pv5) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Managing of water balance within watersheds. Controlled use of sewage water (Po10) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Introduce and subsidise quality food production and modern irrigation systems (Cu7) ▪ Satisfy social needs for water and rational use of irrigation water involving non conventional resources (Cu8)	▪ MoE + MoA + MoW + MoPW + MoE + ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ pollution (volume) ▪ compaction & crusting (area) ▪ destroyed orchards ▪ CoLD stakeholders and participation Committee operational ▪ floods ▪ economic input from agricultural sector ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
001 (25, 28, 27)	Low	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Improved soil structural stability and water retention capacity: ▪ building of water diverging canals and water harvesting (Pv3) ▪ Diversification of production (Pv5) ▪ Active extension service (Po1) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Active extension service (Cu1) ▪ Land use based on soil capability and suitability (Cu2) ▪ Agri-environmental land management units and agrozoning (Cu6)	▪ MoA ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector	▪ land cover/use (change%) ▪ protected (area%) ▪ abstraction (volume) m^3 ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources
011 (15, 16)	Low	▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Active extension service (Po1) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Active extension service (Cu1) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoE + MoA + ▪ DGUP ▪ Municipalities ▪ NGOs ▪ Private sector	▪ land cover (change%) ▪ forest & other natural cover (area%) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
M22tg (33)	Low	▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Land use based on soil capability and suitability (Cu2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Sustainable land management and integrated use of chemicals in soil (Cu3)	▪ MoA + MoW ▪ Municipalities ▪ NGOs ▪ Private sector	▪ mass wasting (mass) ▪ landslides (occurrence) ▪ depth to water table (m) ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
P21tvh (42)	Low	▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Land use based on soil capability and suitability (Cu2)	▪ MoA + MoW ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Media ▪ Farmers	▪ loss of top soil (cm) ▪ mass wasting (mass) ▪ disrupted soils ▪ landslides (occurrence) ▪ abandoned, deserted terraces (occurrence) ▪ CoLD stakeholders and participation Committee operational ▪ awareness of protected resources
Urban	n.a.			

Table 7.3: Outline of draft management plan for Zahrani watershed

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
012tv (9)	High	▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Active extension service (Cu1) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for forest fire fighting	▪ MoE + MoA ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Media	▪ protected (area%) ▪ land cover (change%) ▪ burnt forests ▪ forest & other natural cover (area%) ▪ CoLD stakeholders Committee and participation operational ▪ awareness of protected resources
041t (11/12)	High	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoA + MoW + DGUP ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ pollution (volume) ▪ salinisation (volume or area) ▪ CoLD stakeholders Committee and participation operational ▪ economic input from agricultural sector ▪ awareness of protected resources
063tg (20)	High	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Maintenance of terraces ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoA + MoW + MoPW ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ land use (change%) ▪ abandoned, deserted terraces (occurrence) ▪ CoLD stakeholders Committee and participation operational ▪ proportion rehabilitated (area) ▪ Input from agricultural sector ▪ protection of resources ▪ awareness

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
D22 (22, 23, 24)	High	▪ Control use of soil cover (Pv1) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Land use based on soil capability and suitability (Cu2)	▪ MoA + MoPW ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ loss of top soil (cm) ▪ mass wasting (mass) ▪ disrupted soils ▪ land use (change%) ▪ CoLD stakeholders Committee and participation operational ▪ awareness of protected resources
L32tgv (26)	High	▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Land use based on soil capability and suitability (Cu2	▪ MoA + MoPW ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Farmers	▪ loss of top soil (cm) ▪ disrupted soils ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources
W11 (16/19/28)	High	▪ Well structured mixed plantation (Pv2) ▪ Improved soil structural stability and water retention capacity: building of water diverging canals (Pv3) ▪ Diversification of production (Pv5) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Managing of water balance within watersheds. Controlled use of sewage water (Po10) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Introduce and subsidise quality food production and modern irrigation systems (Cu7) ▪ Satisfy social needs for water and rational use of irrigation water involving non conventional resources (Cu8)	▪ MoA + MoW + MoPW ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ pollution (volume) ▪ compaction & crusting (area) ▪ mass wasting (mass) ▪ CoLD stakeholders Committee and participation operational ▪ Economic input from agricultural sector ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
002tv (5)	Medium	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Improved soil structural stability and water retention capacity: building of water diverging canals and water harvesting (Pv3) ▪ Diversification of production (Pv5) ▪ Active extension service (Po1) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Active extension service (Cu1) ▪ Land use based on soil capability and suitability (Cu2) ▪ Agri-environmental land management units and agrozoning (Cu6)	▪ MoE + MoA + MoW + MoPW ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector	▪ land use (change%) ▪ protected (area%) ▪ land cover (change%) ▪ CoLD stakeholders Committee and participation operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources
011 (6, 7, 8)	Medium	▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Active extension service (Po1) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Active extension service (Cu1) ▪ Good countryside road network for serving internal and regional markets (Cu9) ▪ Access roads for fire fighting	▪ MoE + MoA + ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ protected (area%) ▪ land cover (change%) ▪ burnt forests ▪ forest & other natural cover (area%) ▪ CoLD stakeholders Committee and participation operational ▪ awareness of protected resources
021th (10)	Medium	▪ Constructing and rehabilitation of terraces (Po4) ▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Land use based on soil capability and suitability (Cu2) ▪ Sustainable land management and integrated use of chemicals in soil (Cu3)	▪ MoA + MoW + MoPW ▪ Municipalities ▪ DGUP ▪ NGOs ▪ Private sector ▪ Media ▪ Farmers	▪ land cover/ use (change%) ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
061 (13, 14/17, 15/18)	Medium	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Balanced development of rural areas (Pv4) ▪ Diversification of production (Pv5) ▪ Maintenance of terraces ▪ Warning of epidemic plant diseases (Po7) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Land use based on soil capability and suitability (Cu2) ▪ Soil, climate, environment and market oriented production (Cu4) ▪ Agri-environmental land management units and agrozoning (Cu6) ▪ Good countryside road network for serving internal and regional markets (Cu9)	▪ MoA + MoW + ▪ Municipalities ▪ NGOs ▪ Private sector ▪ Farmers	▪ pollution (volume) ▪ CoLD stakeholders Committee and participation operational ▪ proportion rehabilitated (area) ▪ economic input from agricultural sector ▪ awareness of protected resources
D21tgv (21)	Medium	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Land use based on soil capability and suitability (Cu2) ▪ Sustainable land management and integrated use of chemicals in soil (Cu3)	▪ MoA ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector	▪ loss of top soil (cm) ▪ mass wasting (mass) ▪ disrupted soils ▪ land cover/ use (change%) ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness of protected resources
L32gtv (25)	Medium	▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Land use based on soil capability and suitability (Cu2	▪ MoA ▪ Municipalities ▪ Research and academic organisations ▪ NGOs ▪ Private sector	▪ loss of top soil (cm) ▪ mass wasting (mass) ▪ disrupted soils ▪ land cover (change%) ▪ CoLD stakeholders and participation Committee operational ▪ proportion rehabilitated (area) ▪ awareness protected resources

ID (Ser. No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
000,1,2 (1, 2, 3, 4)	Low	▪ Control use of soil cover (Pv1) ▪ Well structured mixed plantation (Pv2) ▪ Improved soil structural stability and water retention capacity: building of water diverging canals and water harvesting (Pv3) ▪ Diversification of production (Pv5) ▪ Active extension service (Po1) ▪ Reduce slope stretch by introducing barriers (Po2) ▪ Stabilisation of soils by contour ploughing and strip planting on slopes (Po3) ▪ Constructing and rehabilitation of terraces (Po4) ▪ Supporting balance between natural habitats and agricultural areas (Po8) ▪ Active extension service (Cu1) ▪ Land use based on soil capability and suitability (Cu2) ▪ Agri-environmental land management units and agrozoning (Cu6)	▪ MoE + MoA + MoPW ▪ Municipalities ▪ DGUP ▪ Research and academic organisations ▪ NGOs ▪ Private sector ▪ Media ▪ Farmers	▪ land cover (change%) ▪ CoLD stakeholders Committee and participation operational ▪ state/ development of action ▪ proportion rehabilitated (area) ▪ awareness of protected resources
Urban	n.a.			

Table 7.4: Outline of management planning activities for both Damour & Zahrani watersheds

Objectives	*Program Phases*	*Activities*	*Sustainability Deliverables of Control*
▪ main: assess land degradation processes to mitigate their impacts in hot spots of the coastal area ▪ understand causes of land degradation & processes ▪ establish monitoring program with public participation ▪ build up databases that serve the community & decision-makers with relevant maps ▪ do capacity building for assessing environmental impacts & building strategies ▪ design sustainable management plan focusing on priority areas	▪ Assessment & appraisal (6 months) ▪ Methodologies & application analysis + training (1 year) ▪ Monitoring & validation + training (1 year) ▪ Dissemination (8 months) **Total: 30 months**	▪ setting local teams, focal contacts, & screening data ▪ assign priority areas with different emphasis of land degradation ▪ training workshops: on assessing degradation, on indicators – data collection for monitoring, analysis of impacts & remedial measures ▪ capacity building of relevant authorities – National & local for institutional upgrading & GIS build-up ▪ socio-economic analysis in view of impacts of land use on natural resources, especially soil ▪ modelling land degradation processes in link with types & practices ▪ set up the monitoring program with authorities & public participation ▪ design management mechanism linking decision maker to agricultural authorities (+ others) & the local community ▪ upgrade & design relevant policies & strategy	▪ focal point & teams in place ▪ priority areas cover different types ▪ trained teams & community at different levels ▪ institutional upgrading & GIS database ▪ quality control ▪ analysis report ▪ public/authority response ▪ a working model ▪ testing evidence ▪ a working monitoring program ▪ a management plan ▪ a strategy with implementable policies

7.2 MANAGEMENT RECOMMENDATIONS FOR PILOT AREAS

Of course, different geographic regions have different natural and human characteristics as revealed in the two pilot areas. This implies differences in problems, affluence, in priorities, capacities and aspirations. That is what we have seen in the previous sections, especially trying to apply Tables 6.6/6.7 (recommendations of remedial measures on the various intervention areas) with Tables 7.1 – 7.4 (outline of management plan and activities). It is difficult to choose a specific remedial measure and try to make it sound like it is the best … rather, we have identified 15 specific intervention areas and suggested optimum remedial measures for each. It is the community, or authorities, or the farmer who would decide on the preferred measures … it will reflect his own understanding and interaction with ground conditions, in the suggested framework. Obviously, all the different recommended measures of Tables 6.6 and 6.7 fit into the general relevant column of Tables 7.1 – 7.3, i.e. remedial measures. The important aspect is to plan what institutional/administrative arrangements are needed (Tables 7.1 – 7.3), and then see where does that fit in the planning activities (Table 7.4). The requirements in terms of staff, expertise, technical skill, cost, pilot areas, etc. to implement the above will vary from place to place. Furthermore, the outcome of the practical applications will also vary, here it might come up good, there it might come up bad. The terms of application must be monitored closely with quality assurance performed to make sure the steps taken are correct.

Table 7.4, last column, presents the aspects to secure sustainability, or indicators that not only project planning is “delivering” as it should, but also that project performance is good. This assures what, in project implementation on remedial measures of land degradation, constitutes the risk element. That column adds reliability to the management planning activities.

Applying the remedial measures in the context of the management plan is crucial. Since the dominant problems are unstable areas, burnt forests, wasteland and degraded terraces, the remedy measures should be approached accordingly. The emphasis of central and local authorities should be efficiency and reduced cost as the farmers and land owners are not very well off. To begin with, the outline of draft management allocates areas of differential categories of priority: High, Medium and Low. No need to say areas of High priority should be given immediate attention. This means that in a region where the three categories exist, the financial base would decide on areas to be remedied or not (with enough money available, the community can opt for two categories, and choose a spectrum of measures, while if otherwise, restrictions are a must).

Thus, intervention areas like 040 (7, 12), 041 tgh (3), 063 tg (20), L32 tgv (26), etc. are all high category, therefore should be given attention. Their remedial measures are also open to choice, and the right decision is governed by the technical nature of the immediate problem at hand. Again here combinations of remedial measures are meant for more effectiveness as well as cost reduction. An example is in the area C22 tgh (40) where remediation could take different forms, i.e:

1. related to the soil itself (control use, stabilise, capability, integrated use of chemicals);
2. related to planting (well mixed plantation, rotation, strip planting, integrated management, etc.); and
3. related to engineering works (slope reduction, steepness modification, erosion barriers, terracing, etc.).

The optimum effects would certainly come from combinations of those remedial measures even in areas of medium priority. The area 012 tg (13), which represents such a category, has more remedial measures open to the community and/or to the relevant authorities. In that area there are, in addition to those mentioned above for C22 tgh (40), other measures to adopt, i.e. proper rural development, extension agricultural services, pest control through ecological means, market orientations, land use restrictions, etc.

Having explained the above, it is significant to give some remarks regarding the risks and reliability of management recommendations. Obviously, risk is inevitable whenever correction measures are carried out, as there are several options thereof. This is on one hand, and on the other hand, risk is due to the nature of the remedial measures themselves, where some deal with natural phenomena, others deal with human-made phenomena. Risk has to be well investigated otherwise the effects of the remedial measures may become counterproductive. The first step in this investigation is the assessment of the hazard which may be as follows:

1. inherent in the problem itself, with short- or long-term impacts;
2. due to humans handling wrongly the remedial measures;
3. mismanagement, be it in administering deficiencies or lack of resources, both human and financial.

The central and local relevant authorities, together with community representatives, should find out the possibilities that hazardous elements may result from the above three aspects. Indeed, the outline of draft management plan gives “monitoring indicators” a vital role for assessing the reliability and sustainability of the effect of the remedial measures taken. Indicators like regenerated forests, stabilised slopes, a healthy production, controlled erosion and pests, etc. all point out that the measures are reliable. In this context, it is recommended that the draft management plans are reviewed again before their realisation by applying a participatory approach in order to ensure that the measures are comprehensive enough and are supported by all relevant stakeholders.

In the management planning activities the above is secured through defining well the objectives of the plan: assess land degradation processes, understand their causes, establish a monitoring program, build up databases, choose the proper activities on a sustainable basis and design capacity building schemes. The range of activities reflects the large spectrum of remedial measures that can be taken by the community and authorities to face those degradation processes. When deliverables are obtained, it is proof that the plan, with its remedial measures, is working well. These deliverables include: working teams in place, priority areas assigned, trained personnel available, institutional upgrading, meaningful and GIS databases, frequent objective status reports, scientifically valid models, a monitoring program and a working strategy. Of course, the final say is the environmental sustainability of our precious natural resources.

8. PREREQUISITES FOR IMPLEMENTATION OF DRAFT MANAGEMENT PLANS

The success of land degradation control depends on favourable framework conditions. These framework conditions comprise appropriate organisational, institutional, legal and political structures and processes as basis for programme planning and implementation (UNEP/MAP/PAP, 2000). In the following text, the prerequisites for implementation of the proposed draft management plans (see previous chapter) are described and analysed in more detail in order to ensure that appropriate steps, such as capacity building efforts, are initiated as significant contribution to sustainable programme implementation. As a first step, the factors influencing institutional response to capacity building are analysed (8.1) in order to subsequently derive from it recommendations for both capacity building (8.2) and necessary participatory modalities (8.3). As a further contribution to programme sustainability, monitoring procedures and indicators are suggested (8.4). Finally, the applicable verification and approval procedures for draft management plans are outlined (8.5) and recommendations for funding of the proposed plans are given (8.6).

8.1 ANALYSIS OF FACTORS INFLUENCING INSTITUTIONAL RESPONSE TO CAPACITY BUILDING

The response to capacity building may be analysed by the application of a system approach which places emphasis on the different factors involved. Usually the perception of erosion and desertification problems leads actors to develop and implement strategies (typically against opposing target groups) under certain conditions. The outcome is then influenced mainly by the following factors (UNEP/MAP/PAP, 2000):

- actors;
- strategies;
- structural framework conditions;
- specific context of a single situation; and
- problems.

This requires defining who are the actors involved, and what are the goals we want them to arrive at. That implies the strategies those actors have to strive to reach. Successful degradation control depends highly on appropriate strategies in order to compensate the often weak promoting actors. For the context of Lebanon and the two pilot areas, Table 8.1 shows the different actors at Ministries, public agencies, the local governments (municipalities) plus NGOs and other groups. The strategies are quite diversified relating to the mandates of the actors covering training, awareness, planning and implementation. Table 8.2 focuses on the structural framework conditions for capacity building. These consist of several linked factors, notably, the available knowledge (as basis for problem perception, public awareness and subsequent policy generation) and the organisational, institutional and legal structures for institutionalisation and internalisation of rules and standards for effective degradation control.

Table 8.1: Actors and required vision (strategy) to consider for capacity building in land degradation

Actors	Strategies
MoE + MoA + MoW + MoPW	***Within 5 years plan:*** ▪ Public awareness campaign ▪ Help relevant NGOs ▪ Control environmental degradation in natural resources ▪ Protect forest & reforestation
MoA + MoW	▪ Fight desertification ▪ Establish and enforce pesticide regulations ▪ Promote marketing and agricultural research and extension
CDR + MoE + DGUP	▪ Promote integrated coastal zone management ▪ Prepare a National Land Use Plan ▪ Formulate and enforce masterplans
Municipalities	***Short-term*** ▪ Upgrade environmental service infrastructure, i.e. water, health... ▪ Control aggression against natural resources ▪ Protect forestry ▪ Greening of towns and villages ▪ Formulate and enforce masterplans
DGUP	▪ Develop & modify urban planning regulations ▪ Formulate and enforce masterplans
Research & acad.organizations	▪ Implement environmental projects addressing soil erosion ▪ Expand ideas in environmental programs and modify them
NGOs	▪ Training and public environmental awareness campaigns ▪ Implement environmental projects ▪ Protect forest, natural resources and biodiversity and combat desertification
Private sector	▪ Provide assistance and contribute to tackle environmental issues ▪ Implement environmental projects
Donors and funding institutions	▪ Finance environmental project activities covering institutional strengthening, resource management and conservation
Media	▪ Public awareness campaigns by spreading information about human and natural disasters, environmental abuses and their impacts on human health and the environment
Farmers	▪ Rehabilitation/maintenance of degraded terraces ▪ Improve agro-practices

Table 8.2: Structural framework conditions for capacity building

Actors	Knowledge base	Organisational, institutional and legal structures
MoE + MoA + MoW + MoPW	▪ Good perception of problems ▪ Some extension services ▪ Limited involvement in solution ▪ Limited indirect support	▪ Speciality divisions but lack of staff ▪ An established code of environment ▪ An amended forest code and banning pesticides regulation ▪ Poor control mechanism ▪ Poor implementation ▪ Need to upgrade environmental code
Municipalities	▪ Good perception of problems ▪ Some extension services ▪ Limited law enforcement	▪ An established building law ▪ Some prerogatives, i.e. approval of building permits and commission of construction works ▪ Need to enforce the manoeuvrability and action of Municipalities (they are under the auspices of MoInt) ▪ Need to upgrade building law ▪ Need to strengthen municipalities' capabilities for urban planning
CDR + DGUP	▪ Integrated planning & management to improve quality of living in coastal area	▪ Need for more co-ordinated actions ▪ Need for continuity in implementation ▪ Need for project performance assessment
Private sector	▪ Improve quality of living	▪ Need better involvement in environment-orientations
Media	▪ Monitoring development outcome & contribution to public awareness	▪ Need of specialised expertise ▪ Sometimes issues are politicised
Farmers	▪ Better agro-produce ▪ Wider market	▪ Some attempts in reforestation and terracing ▪ Lack of equipment and funds ▪ Need for advice on afforestation programs and on rangeland management techniques ▪ Lack of awareness on low-cost alternatives of terraces

A crucial structural framework condition is also the existing legislation. If the relevant and major codes to protect the environment and check land degradation are properly implemented, especially at the local level, a considerable portion of the damage will be reduced. Table 8.3 reveals those major codes and their implications for environmental protection.

It is important here to emphasise the first code listed, namely that on municipalities. This is because many of its clauses intersect with several of the other codes, e.g. with N°8 on pollution and general safety/health aspects; with N°5, 6 and 7 on forest protection; with N°s 2 and 3 on construction permits and residential settlements; with N° 4 on quarrying permits and site rehabilitation, etc. The simple implication is that if the people in charge of municipalities do actually impose implementing the details of those laws (which fall under their mandates and jurisdiction) a lot of the degradation will stop.

Table 8.3: Major codes relating to environmental protection of land degradation

N°	Code name and date of issue	Areas of concern
1	Municipalities code issued at 1977	Notification and organisation of municipal activities within the municipal boundaries and with related personnel and administrations
2	Land use planning code number 69 issued at 1983	Principles and basis of land use planning in cities, towns and villages for transport, industry, agriculture, habitat and commercial purposes
3	Code of urbanism issued at 1985	Legislative and organisational principles of urbanisation in light of administrative restrictions and environmental needs
4	Code (Marsoum) of quarries issued at 1994	Identification of areas adequate for quarries, excavation and legislative principles for its proper exploitation
5	Forest code issued at 1949	Forest identification according to its ownership, with adequate managerial planning for sustainable development
6	Code No 85 issued at 1991	Forbidding any kind of forest exploitation
7	Forest protection code no 558 at 1996	Concerning management of protected areas
8	Code of environmental protection No 444 at 2002	Basis and principles of total (marine and terrestrial) environmental protection in Lebanon through legislative measurements

Furthermore, the specific context of a single degradation situation describes the variable short-term conditions of action such as urgent problems which, for instance, might cause direct public pressure. In the two pilot areas, short term problems emanate from nature, i.e. floods, mass movements, droughts, and from humans, i.e. excessive grazing, disruption of water availability, bad agro-practices, removal or weakening of soil cover...etc. These are very common in the two pilot areas, causing damages and pressures, and yet the mechanisms, capacities and means to face their impacts are limited. It is important to emphasise that control measures and preventive approaches can be effective and should be given priority.

Also, the general character of the degradation problem influences considerably the capacity building process. In this respect, it is unfortunate that the awareness of the seriousness of erosion and desertification problems mainly remains within the scientific community or within a limited group of decision-makers. Although farmers or NGOs are aware of some of the degradation consequences, the fact is that the existing lack of capacities prevents them often from doing even small interventions for conservation purposes. This indicates that strong awareness raising and participatory campaigns are needed. A capacity building programme enhancing the municipalities attitudes and capacities and empowering also available local NGOs and CSOs as their support is likely to produce considerably good results

8.2 RECOMMENDATIONS FOR CAPACITY BUILDING

In view of the different aspects exposed in Tables 8.1 and 8.2 revealing the actors, visions, and structural organisations needed for capacity building, Table 8.4 reflects the main lines of recommendations needed for that purpose.

The Table gives the scientific and professional support, the intervention level, the indicators of status of capacity building and thematic areas for that.

Table 8.4: Recommendations for capacity building

Scientific/professional support		Intervention level	Indicators for status of capacity building		Areas for capacity building	Recommendations
			Positive	Negative		
A. Stimulate participatory approaches	Rehabilitate and maintain terraces	National, sub-national and local	▪ Maintained terraces are productive	▪ Lack of systemic maintenance and rehabilitation plans	Productivity, technical nature, prioritisation, planning	▪ Prioritisation of a rehabilitation program ▪ Co-ordination of NGOs with all agencies ▪ NGOs informed of all environmental activities and equipped with electronic means ▪ Development of rural + farmers co-operatives
	Strengthen existing agricultural extension services and NGOs		▪ Locally established, an efficient organisation already provided services help to farmers	▪ Weak institutional, management and technical capabilities, and heavily under financed ▪ Insufficient integration ▪ Framework for desertification control remains fragmented	Information, guidance management, co-operation, integration	
	Public awareness on degradation issues		▪ Local involvement of NGOs and the public in environmental awareness, and in identifying local needs. ▪ Competent lobbying ▪ Erosion and desertification problems widely reported in the media	▪ Limited role of NGOs in national rehabilitation ▪ Limited resources and lack of administrative and technical capabilities ▪ Greed and lack of education at farmers' level	Training and awareness campaigns	▪ Show economic and social losses due to desertification and mismanagement ▪ Introduce economic incentives
B. Strengthen administrative knowledge:	Establish national database or GIS	National & local	▪ Related data are available	▪ Scattered or irrelevant data	Management and information/ database training	▪ Ministries equipped with GIS systems ▪ Establish an advanced environmental data base accessible to the public
	Establish and enforce regulations on pesticide use and quarrying	National and local	▪ Regulations already exist	▪ Weakness of law enforcement ▪ Environmental - laws need to be updated and consolidated	Control mechanism	▪ Establish standards for pesticides and liquid effluent emissions ▪ Rehabilitate quarry sites ▪ Update and enforce environmental law

Scientific/professional support		Intervention level	Indicators for status of capacity building		Areas for capacity building	Recommendations
			Positive	Negative		
	Strengthen and enhance existing planning control mechanism	National	▪ Previous plans were established	▪ Lack of vision for sustainable development and conservation ▪ Involvement of the private sector and NGOs in desertification management is insufficient and unorganised	Control mechanism	▪ Adopt and enforce zoning and building codes ▪ Introduce full cost recovery for environmental services and implementation of cost recovery policies
C. Generate technical knowledge:	Develop network of tree nurseries, afforestation and reforestation programs, with an integrated plan to manage forests, including protecting them from fires	National, sub-national and local	▪ Afforestation and reforestation programs already exist	▪ Many of the ongoing tree planting projects are planting scattered trees in a non-targeted manner which has little, if any, impact of the conservation of soil, water or biodiversity.	Planning, zoning, impact assessment	▪ Launch a national forestation program ▪ Develop tree types best suited to conditions ▪ Need for land use/spatial planning; zoning of areas for development and conservation
	Establish a functional unit of Soil Research within the MoA	National	▪ Relevant institutions already exist	▪ No central responsibility and lack of clarity in responsibilities ▪ Lack of co-ordination between different ministries	Co-ordinating, technical nature, impact assessment	▪ Better co-ordination between institutions ▪ Introduce impact assessment studies
	Develop appropriate crops, technologies and practices	National and local	▪ Traditional crops technologies and practices are used	▪ Local of systemic plans, notably lack of follow-up	Management, technical nature of agro-practices	▪ Lower cost technologies must be used: economic incentives ▪ Encourage organic farming and train the farmers to use natural methods and support the marketing of organic farming produce though specialised co-operatives ▪ Educate and train farmers about water conservation techniques
	Rangeland management program	National, sub-national and local	▪ Local areas with positive results	▪ General degradation of rangelands	Training, technical nature	▪ Training to farmers and foster an understanding among communities of the importance and sustainability of soils
	Conduct social studies to assess & improve quality of living					▪ Assess the perceptions and the views of rural communities and farmers regarding agricultural practices and new approaches to land conservation

The recommendations focus on 5 main areas where capacity building is needed. They are the following:

A. strengthen co-operation among the concerned communities and relevant authorities and thus encourage rural co-operatives and enhance institutional co-ordination;
B. Assure technical upgrading with training, enforcement of standards and securing/disseminating databases;
C. Upgrade regulations, enforce the relevant laws including proper land use zoning, environmental assessment and policies;
D. Start a rehabilitation program with priorities on needs and costs for certain geographic areas, including forestation;
E. Come up with alternatives of economic incentives to encourage the rural community to fix the land.

Concerning our two pilot areas, the Damour watershed needs considerable capacity building in facing their prime degradation problems, i.e. unstable lands, forest fires and effects of torrential rains. The Zahrani community and relevant agencies require focusing on rehabilitating their wastelands, degraded/abandoned/terraced and quarried lands. Obviously, their municipalities need a lot of upgrading, notably on: 1. empowering them, 2. strengthening their technical and human resources, 3. feeding their budgets, and 4. upgrading policies and legislation to enhance better integration and community participation.

8.3 RECOMMENDATIONS FOR PARTICIPATORY MODALITIES

The main purpose of the IPP programme is to illuminate widely on land deterioration as a possible irreversible process leading to natural resource losses, and to encourage local initiatives in formulating plans and activities to combat desertification on a watershed basis. According to this insight, the IPP programme did 3 consecutive steps: field trips around the pilot areas interviewing locals, filling the questionnaire, and seminar discussions. All these activities were achieved separately in the two pilot watersheds, Damour and Zahrani. The findings were formulated in the IPP report.

Then followed an evaluation meeting where the local participants were informed again on the project, its components with focus on the outcome of the 3 steps above, and were asked to evaluate that outcome. They were glad to have a chance to participate in this manner, and especially they saw the merit of bottom-up communication. They noted that although it was a foreign funded project, it was nevertheless carried by national experts who understood the real issues, which is a commendable aspect. They emphasised the importance of the project dealing with environmental protection through tackling existing laws and regulations. Notably, they liked making them aware of relevant legislation and how to benefit from them. In this regard, they valued highly the re-alignment of the law of forestry re-focusing on allowing exploitation in a sustainable manner. They also stressed their benefit from the technical assessment formats used in field trips for describing land degradation status. They expressed their concern to have something similar but simpler and in Arabic. They were happy to know that such material would be eventually supplied.

It is worthy to note in this context that on September 14, 2004, the Minister of Agriculture declared a ministerial decree n° 277/1 that allows forest exploitation according to the more appropriate Forest Code issued in 1949. This new decree has cancelled the previous one having the number 42/1 that forbids any kind of forest exploitation. The “Order of Lebanese Engineers” and the “Syndicate of Italian pine workers” have highly appreciated this declaration. Many municipality heads and NGO activists communicated to the CoLD team their satisfaction and appreciation of the right perception of the CoLD project. For

better evaluation of the importance of such decree, the project team had demanded from Dr. Masri to prepare a scientific contribution entitled: “Suggested Mechanisms for Forest Code Applications”. This contribution is to be published in the proceedings of the “Second National Agricultural Engineers Conference” taking place in Beirut on November 19, 2004.

A common meeting gathering all stakeholders from the pilot areas was arranged presenting these findings. For this reason, a one-day workshop was organised on August 21, 2004 in Saida, (see photos) a coastal city situated geographically between the 2 pilot areas. The IPP programme was evaluated positively, with recommendations as follows:

- During implementation of degradation assessment a good communication and confidence should be established between the responsible authorities and all stakeholders.
- The steps to be done by the people should be clear enough and very well comprehended, making a good description of the actual environment and prioritising hot spots on a watershed basis.
- The role of the local community in natural resources management should be well identified through a review of major Lebanese codes related to environmental protection of lands.
- Those responsible for implementation should be aware of this legislation.
- A capacity building project has to be formulated to complete the IPP programme on a broad national level.
- “Field farmer school” oriented towards forestry and improving agricultural practice must be one of its essential components.
- The concerned people in such a project are: 1- forest rangers from the Ministry of Agriculture, 2- local municipal inspectors, 3- representatives of non governmental organisations, 4- representatives of concerned ministries and institutions such as: Environment (MoE), Ministry of water resources, the Green Plan, etc.
- Appreciate the conception about forest exploitation as a better way for its conservation and sustainable development.
- Enhance interaction and co-ordination between relevant institutions representing the land authorities and those of the community.
- Avail a rehabilitation program focusing on priority areas.

8.4 MONITORING PROCEDURES AND INDICATORS

Environmental protection can be effective only on long-term basis, especially when dealing with the issue at hand, i.e. land degradation. Facing that issue properly, usually a part of combating desertification, requires three main inputs: 1. long-term data on the totality of the environment (physical, chemical and biological), therefore, monitoring, 2. the stakeholders concerned about their land being degraded, therefore who does the monitoring, and 3. the need for tools of observation, reflecting the extent of degradation, therefore, the indicators. This is what Table 8.5 reveals for monitoring degradation, while how is that implemented is shown in Table 8.6. But in addition, the two Tables show also the “Features” which allow identifying that indicator, as well as the “Frequency” of observing/monitoring that indicator.
Referring back to Table 8.1 which reveals the major land degradation problems in the two Pilot Areas Damour and Zahrani, it becomes obvious that some indicators are much more important than others, i.e. relating to water erosion, physical deterioration, land use, forests and human practices in exploiting the land. In spite of that, the other indicators can not be excluded, such as climate, vegetation and water.

Table 8.5: Monitoring indicators for actual erosion/degradation process

Category	*Indicator & Unit*	*Features*	*Frequency*	*Source*	*Collected by*	*Documentation & Distribution*
Soil Factor						
(water erosion)	Loss of top soil (cm)	▪ scarps ▪ rills ▪ gullies	Wet season	Field observation	NCRS	NCRS
(wind erosion)	Ditto	▪ deflation surface ▪ hollows ▪ hummocks ▪ dunes	Seasonal	Field observation	NCRS	NCRS
(chemical deterioration)	▪ pollution (volume) ▪ salinisation (volume or area)	▪ excessive chemicals ▪ salt accumulation	Seasonal	Field observation	NCRS + NGO+ Farmers	NCRS
(physical deterioration)	▪ compaction & crusting (area)	▪ compact surface ▪ depleted humus	Seasonal	Field observation	NCRS + NGO + Farmers	NCRS
	▪ mass wasting (mass)	▪ steep/curved bare slopes	Monthly	Field observation		
	▪ aridification (area)	▪ no moisture	Monthly	Field observation		
(biological deterioration)	▪ destroyed orchards	▪ crop losses	Daily	Field observation	Farmers NGO	Co-operatives Municipalities
	▪ disrupted soils	▪ bored land	Daily			
Other Factors						
Climate	▪ Aridity index	▪ P/ETP	Annual	Meteo Bureau	NCRS	NCRS
	▪ Torrential rain (frequency)	▪ intensity ▪ extent	Wet season	Meteo Bureau		
Land	▪ land use (change%)	▪ urban, green cover, bare land, forest, irrigation, etc.	Annual	Remote sensing	NCRS	NCRS
	▪ protected (area%)	▪ land cover categories within area	Annual	Remote sensing	NCRS	NCRS
	▪ landslides (occurrence) ▪ abandoned	▪ distribution ▪ frequency ▪ waste land	Annual	Field observation Remote sensing	NCRS	NCRS
	▪ deserted terraces (occurrence)	▪ distribution ▪ frequency ▪ degraded	Annual	Field observation Remote sensing	NCRS+ NGO + Farmers	NCRS

Category	*Indicator & Unit*	*Features*	*Frequency*	*Source*	*Collected by*	*Documentation & Distribution*
Vegetation	▪ land cover (change%)	▪ land cover categories ▪ bare surfaces	Annual	Remote sensing	NCRS	NCRS
	▪ NDVI (value) ▪ burnt forests	▪ distribution ▪ frequency ▪ distribution ▪ recurrence	Annual	Remote sensing		
Water	▪ depth to water table (m)	▪ extent change	Annual	Field observation	NCRS+ NGO	NCRS
	▪ abstraction (volume) m^3	▪ extent change	Annual	Field observation		
	▪ balance in study area (m^3)	▪ extent change	Annual	Field observation		

Table 8.6: Monitoring indicators: implementation program

Category	*Indicator & Unit*	*Features*	*Frequency*	*Source*	*Collected by*	*Documented & Distributed*
Action-oriented:						
a. Natural						
Climate	(as in "A" above)	(A)	(A)	(A)	NCRS	NCRS
Soil	(as in "A" above)	(A)	(A)	(A)	NCRS	NCRS
Natural vegetation	▪ forest & other natural cover (area%)	different categories	Annual	Remote sensing	NCRS	NCRS
b. Human	▪ CoLD stakeholders Committee operational	▪ status ▪ multidisciplinary character ▪ functions	Seasonal	Field observation	NCRS+ stakeholders	NCRS
	▪ state/ development of action plan(CoLD)	▪ level of achievement ▪ improving conditions ▪ wider knowledge	Seasonal	Field observation	NCRS+NGO	NCRS
	▪ stakeholders participation in plan (CoLD)	▪ nature & scope of work ▪ level of achievement ▪ extent of participation ▪ improving conditions	Seasonal	Field observation	NCRS+ stakeholders	NCRS

Category	*Indicator & Unit*	*Features*	*Frequency*	*Source*	*Collected by*	*Documented & Distributed*
	▪ Effectiveness of local capacity building	▪ involvement by local community ▪ level of involvement ▪ value added procedures ▪ natural resources ▪ managed/protected- ▪ adoption of technology at ▪ local level	Seasonal	Field observation	NCRS+ NGO+ Farmers	NCRS
	▪ Institutional support	▪ adoption of measures to strengthen institutional framework ▪ adoption of measures to strengthen capacities ▪ level & nature of adopted ▪ measures ▪ co-ordinated linkages ▪ level & nature of co-ordination	Annual	Field observation	NCRS + stakeholders	NCRS
Effect-oriented:						
a. Natural Climate change	▪ Rain ▪ PET ▪ Floods ▪ Droughts	▪ distribution ▪ extent ▪ frequency	Annual	Meteo Bureau Field observation Remote sensing	NCRS	NCRS
Soil	▪ proportion rehabilitated (area)	▪ distribution ▪ extent	Annual	Field observation	NCRS	NCRS
Natural vegetation	▪ proportion rehabilitated (area)	▪ distribution ▪ extent	Annual	Field observation Remote sensing	NCRS	NCRS
b. Human	▪ socio-economic aspects ▪ agricultural sector status ▪ rural community welfare ▪ living standards ▪ Improvement of environmental conditions ▪ protection of resources ▪ better infra- services ▪ availability to all ▪ awareness	▪ distribution ▪ extent	Annual	Field observation	NCRS+ stakeholders	NCRS

8.5 Outline of Verification and Approval Procedure for Draft Management

Before any program for management starts, it is important for the success of the remedial operations at the pilot areas to assure that the following aspects are considered:

a. they are pragmatic and simple to be carried out by the stakeholders,
b. we are aware of on-going activities related to erosion/land degradation for co-ordination and information exchange,
c. relevant authorities are notified of the operations and acknowledged both the procedures and time-frame,
d. the stakeholders are aware and confident in their participation,
e. both stakeholders and authorities are made familiar with the verification and procedures for approval of program.

In order to verify the remedial measures, assessment will take into account four major concerns: the environment concerns, the socio-economic concerns, development-oriented concerns and regulations-oriented concerns (Table 8.7) and observe functional issues related to them, especially in view of their status, planning and management. For each major concern, indicative parameters will be used to evaluate the effectiveness of those measures as shown in the Table.

If the environmental concerns are taken in the two pilot areas, it becomes clear that there are more severe problems in agriculture and water in the Zahrani area than in the Damour area. On the other hand, the Damour area has more problems with forest fires and soil losses on unstable lands. These have special implications regarding the functional issues, i.e. status, management and planning. Similarly, the other concerns vary between the two areas, and the approach to verify them would require different emphasis, e.g. a tendency for high rate of urban expansion in Damour, a lower standard of living in Zahrani, etc.

There remains the need to secure approval of the procedures of remedial measures by the different stakeholders, which is shown by Table 8.8. The Table reveals the themes of the focus of the work plan, i.e. the main environmental resources affected by and effecting land degradation, both natural and human, and the implications from socio-economy, development and regulations. The Table shows who the authorities concerned are, where funding can be obtained, the indicators to check whether objectives have been met, and reviewing that process with relevant stakeholders. Again here, the fact that the two pilot areas have different priority problems means a different focus on plan of action, stakeholders and indicators.

Table 8.7: Verification procedure of remedial measures

Major concern	*Indicative parameters*	*Functional Issues (National)*			*NCRS collaborating with*	*NCRS public consultation with*
		Status	*Management*	*Planning*	*Pilot Area*	
Environmental	a. Water quantity Water quality	▪ balance ▪ compliance with standards	▪ efficiency of securing needs ▪ measures of compliance	▪ short & medium term plans	▪ Ministry of Water ▪ Ministry of Environment ▪ CDR*	▪ Municipalities ▪ NGOs
	b. Soil	▪ extent of primary classes ▪ extent of erosion	▪ conservation measures	▪ agro-practices ▪ land use	▪ Ministry of Agriculture ▪ Dir. Gen. Urba.**	▪ Municipalities ▪ Farmers ▪ Researchers
	c. Forest	▪ extent of healthy areas	▪ conservation ▪ measures ▪ forest fires	▪ agro-practices ▪ land use ▪ protected areas	▪ Ministry of Agriculture ▪ Ministry of Environment ▪ DGU** ▪ Dir. Geog. Aff.***	▪ Municipalities ▪ NGOs
	d. Agriculture	▪ level of produce ▪ terracing maintenance ▪ grazing ▪ market	▪ efficiency of securing needs	▪ agro-agenda	▪ Ministry of Agriculture ▪ Ministry of Economy ▪ Chamber of Commerce	▪ Researchers ▪ Farmers ▪ Municipalities ▪ Private sector
Socio-Economic	a. Health	▪ water-related diseases ▪ contaminated food	▪ efficiency of health control system ▪ setting standards	▪ short & medium term plans	▪ Ministry of Environment ▪ Ministry of Health ▪ Syndicate of Doctors	▪ Municipalities ▪ NGOs ▪ Researchers
	b. Quality of living	▪ UN standards	▪ trend analysis	▪ projections 25 years	▪ CDR ▪ UNDP ▪ Dir. Gen. Statis.*	▪ Researchers ▪ Private sector ▪ NGOs
Development	a. Urban	▪ % areal extent ▪ available services	▪ trend analysis	▪ projections 25 years	▪ CDR ▪ DGU ▪ Dir. Gen. Statis.	▪ Municipalities ▪ Private sector ▪ NGOs
	b. Rural	▪ % areal extent ▪ available services	▪ trend analysis	▪ projections 25 years	▪ CDR ▪ Ministry of Agriculture ▪ Dir. Gen. Statis.	▪ Municipalities ▪ Farmers
	c. Landuse	▪ % areal extent	▪ trend analysis	▪ projections 25 years	▪ CDR ▪ DGU ▪ Ministry of Environment	▪ Municipalities ▪ Private sector ▪ Researchers

Major concern	*Indicative parameters*	*Functional Issues (National)*			*NCRS collaborating with*	*NCRS public consultation with*
		Status	*Management*	*Planning*	*Pilot Area*	
Regulations	a. National	▪ extent of modern or upgraded applicability	▪ efficiency of control measures	▪ short & medium term plans	▪ CDR ▪ Ministry of Environment ▪ Parliament Commission ▪ Ministry of Inter.	▪ Municipalities
	b. Local	▪ availability ▪ applicability	▪ efficiency of control measures	▪ short & medium term plans	▪ Ditto	▪ Municipalities

* CDR: Council for Development & Reconstruction
** DGU: Directorate General of Urbanisation
*** DGA: Directorate of Geographic Affairs (Army)
* DGS: Directorate General of Statistics

Table 8.8: Approval procedure of remedial measures

Workplan	*Authorities*	*Funding*	*Indicators to check meeting objectives*	*Frequency (Time Table)*	*Review costing*
I. Resources (securing availability & quality)					
a- Natural conservation					
Water	MoW	Local, Intl.	▪ efficiency of water use	Seasonal	▪ with local water authorities
Soil	MoA	Local, Intl.	▪ conservation of high capable land ▪ conservation of high soil classes	Seasonal	▪ with Farming Syndicates
Forest	MoA, MoE	Local, Intl.	▪ extent healthy forest cover	Annual	▪ with MoA & MoE
b- Human-made (sustainability)					
Agriculture	MoA	Local, Private	▪ controlled agro-practices	Seasonal	▪ with MoA & Farming Syndicates
II. Implications (securing health control systems & standards)					
Socio-economy (efficiency)	MoE, MoH, Syndicates	Local, Private	▪ efficiency of health systems in implementing standards	Annual	▪ with MoE & MoH
Development (upgraded services) for quality of living	CDR, DGU, MoE	Local, Private	▪ extent & efficiency of services	Annual	▪ with CDR
Regulations (control)	CDR, MoE, Parl. Comm., MoInt.	Local	▪ efficiency of control measures	Annual	▪ with Parliament Commission

MoW: Ministry of Water, MoA: Ministry of Agriculture, MoE: Ministry of Environment, MoH: Ministry of Health, MoInt.: Ministry of Interior

8.6 RECOMMENDATIONS FOR FUNDING DRAFT MANAGEMENT PLAN

It is important to point out how the proposed management plan (Table 7.2) could be funded. As shown in that Table, the plan extends over 30 months in 4 phases and 9 activities. These activities relate to several stakeholders whose capacities vary, as shown in Tables 8.1 and 8.2. In order to be able to take the financial considerations into account, a more detailed work plan and timetable for this programme have to be prepared, allowing for a realistic estimation of programme costs. After comparing it with the availability of funds and the expected cash flow, a revision of the initial work plan, timetable, cost sharing might be necessary.

In general lines, the programme will imply different types of expenditures:

- increased expenditures of responsible administrative structures;
- investment and other costs related to programme implementation; and
- increased costs of the monitoring programme and of the initial and regular post implementation activities.

The potential sources of funding, to be usually taken into consideration, are:

- budgets at various levels;
- charges, taxes, fees;
- other, conventional and non-conventional sources; and
- external, international sources.

The costs of programme implementation could be allocated to the different stakeholders, which can be grouped into 3 major groups:

1. All agencies of the Central Government (blocks 1 and 2 of Table 8.1), 2. The private and research sector, 3. The local community (municipalities, NGOs and farmers. This division allows to facilitate the local funding in the order given as one suggested alternative: It means that all 3 groups could contribute to the funding on a certain multiplicative factor. Example: the local community could come up with X$, then the private sector could put in 2X$, and the central government could triple that amount at 6X$. It all depends on the area, size, problems, affluence, etc. One option, which also facilitates the funding when money is difficult to obtain, is in-kind contribution, i.e. all those stakeholders who are involved (in different ways) would contribute their staff, time, efforts, land, management, monitoring, etc. for free but is considered part of the running cost. Taxes, user fees, charges, polluter charges, entrance fees, etc. might be a valuable source of funding, providing their approval through the relevant legal procedure. Other sources might be secured through donors' contribution, public raising campaigns, support of indirectly involved or affected institutions or stakeholders, etc.

It is likely that the greater part of expertise to do the training, and overlooking of the quality output of the operations would be available in Lebanon, especially among the research centres and universities. The possibility for a need of some foreign expertise remains open, however, and could thus be the basis for asking external/international help. In fact, there are several UN programs who are concerned with land degradation monitoring, i.e. FAO, GEF, UNEP, Drought Regional Points, UNCCD, etc. who could extend or cover such needed help, as well as other financing for special monitoring and field testing equipment. In addition, there are bilateral opportunities, and also possibilities with the European Commission programs.

The international funding of such programmes presupposes a number of prerequisites:

- internationally accepted concepts and principles to be respected and applied;
- the nature of programme to comply with funding criteria;
- a proper programme design and format;
- in some cases, certain tools and techniques to be applied;
- declaration of priority to be provided by national authorities;
- partial funding, in some cases; and
- other specific requests, if required by the funding agency or institution.

Should international funding be envisaged, the potential donor(s) or partner(s) have to be informed and, if possible, involved from the early stage of programme formulation.

9. CONCLUSIONS

This Report reflects the work achieved in Lebanon through the EC-funded Life Program on the project “Improving Coastal Land Degradation Monitoring in Lebanon and Syria” N° LIFE TCY/00/INT/00069/MED. The project covered the general coastal zone inland to an elevation of 800m through a component of the project termed “Diagnostic analysis”. This assessed the general land degradation in the zone due to natural and human interference causes producing predictive erosion maps. Then it focused on two pilot coastal areas, the Damour river and Zahrani river watersheds where another component “Detailed analysis” is done. A third component of the project is “Integrated Public Participation” which is concerned with encouraging public involvement in understanding land degradation and monitoring/checking its impacts. Throughout the work, the project allowed training workshops for the National team to upgrade its capacities and technical know-how in improving monitoring land degradation through remote sensing and field work.

From the Diagnostic analysis, training was given to the National team which resulted in both mapping and participatory work. The former produced land unit map upon which the predictive soil erosion on the coastal zone was made. The latter went through social attitudes and institutional organisations, as well as public interest in land degradation and policies to produce an integrated participatory action plan for helping in monitoring land degradation.

Detailed field analysis was done on the two pilot areas, Damour and Zahrani watersheds, which have different characteristics, i.e. natural and human interference. The predictive erosion map was checked in the two pilot areas with focus on stability/soil erosion criteria reflecting the above characteristics. A detailed erosion map has been produced for the two areas. This allowed prioritisation of intervention areas. Fifteen such “hot spot” areas were determined among the unstable and stable areas, for which evaluation of remedial measures are given. Those measures were studied with respect to current and optimum use, and what best to apply, i.e. preventive, protective or curative approaches. They are assessed and rated as best applicable from field work in the two areas, and accordingly recommendations are given for that purpose.

The problems, priorities, remedial measures and institutional issues are linked to develop a management plan. Thus, management planning activities are given, with focus on involvement by the community, as they contributed to the work in both areas. The pre-requisites of training and capacity building are clarified for the different stakeholders and recommendations given, including participatory modalities. Furthermore, indicators on different factors affecting the output of the plan are given, and approval procedures are presented as well. The last step for securing possible funds is introduced and local sources are clarified.

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ANNEX I: BASELINE ECONOMIC DATA FOR LEBANON

Demographic data

Distribution of Population by Mohafaza (1997)
Source: CAS Study, No. 9/1998

Mohafaza	Population	Percent	Surface Area (km^2)	Population Density
Beirut	403,337	10	20	20,167
Beirut Suburbs	899,792	22	233	3,862
Rest of Mount Lebanon	607,767	15	1,735	350
North	807,204	20	2,025	399
Bekaa	539,448	13	4,161	130
Nabatieh	275,372	7	1,098	251
South	472,105	12	930	508
Total	**4,005,025**	**100**	**10,202**	**393**

National growth rate: 1.97
Source: تقرير التنمية الانسانية العربية للعام 2002 UNDP
Potential active population rate 1997 in:

Lebanon:	34.0%
Beirut:	39.8%
Beirut suburbs:	36.5%
Rest of Mount Lebanon:	37.0%
North Lebanon:	30.7%
South Lebanon:	31.9%
Nabatieh:	30.1%
Bekaa:	30.8%

Distribution of active population by economic sectors and Mohafazats
Source: CAS 1998

Mohafazat	Agriculture	Industry	Housing	Trade	Services	Total
Beirut	0.2%	12.4%	7.0%	26.6%	53.8%	100%
Beirut suburbs	0.6%	20.8%	9.9%	25.4%	43.3%	100%
Rest of Mount Lebanon	5.3%	14.1%	15.2%	21.4%	44.0%	100%
North Lebanon	14.9%	14.9%	10.6%	21.3%	38.3%	100%
South Lebanon	16.8%	12.2%	14.9%	24.1%	32.0%	100%
Nabatieh	17.6%	12.3%	17.3%	22.3%	30.5%	100%
Bekaa	20.7%	12.5%	9.7%	20.6%	36.5%	100%
Total	**9.3%**	**15.1%**	**11.6%**	**23.3%**	**40.8%**	**100%**

National population density 1997: 400 persons/km^2

Coastal zone population

The coastal zone shelters about 67% of the total population, with an average density of 1,395 persons/km^2 (compared to a national average of 400 persons/km^2).

Coastal Central Lebanon comprises 63 percent of the population of the coastal zone, North Lebanon 23 percent, and South Lebanon 14 percent. Close to half of the coastal population is concentrated in the Greater Beirut Area (GBA). The rest of the coastal population is distributed between two regional poles, Tripoli and Sidon (17.6% together), a

group of subdistrict centres (Batroun, Byblos, Jounieh, Jdeideh, and Tyre), and other fishing, agricultural, and industrial small settlements such as Qalamoun, Amsheet, Enfe and Chekka.

Before the war, urban structure was organised around four poles of regional growth: Beirut, Tripoli, Sidon and Zahlé. Three of those four poles are located along the coast, with the remaining pole in the Bekaa valley (Zahle). The capital city and its suburbs exhibited a high rate of primacy (2.8), exceeding four times the sum of the population of the remaining regional poles in the country. It also accounted for over two thirds of the economic activities, two thirds of the overall employment, the entire state administration, all the country's higher education, ninety-five percent of the banking activity.

The unintended beneficial impact of the war was the redistribution of economic and residential activities among main, secondary and tertiary centres (both coastal and in-land) and within the Beirut Greater Area. This decentralisation and regional growth were characterised by chaotic urban growth and the spread of uncontrolled and illegal development, due to a total disregard for building regulations and controls. Unregulated ribbon development expanded along coastal access roads, linear urbanisation was further reinforced by privatisation of the coastline and suburban sprawl encroached on agriculture land near coastal cities.

Economic data
GDP 2001 around US$ 16.5 billion US$ 4100/inhabitant Source: CDR – IAURIF SDATL, September 2002: 34

Composition of GDP by different years
Source: CDR – IAURIF SDATL, September 2002: 34

Sector	**1968**	**1972**	**1994**	**1995**
Agriculture	10.2%	9.9%	12.0%	12.4%
Energy, water and industry	2.3%	2.0%	17.7%	17.3%
Construction	12.9%	13.9%	9.4%	9.2%
Transport & communications	4.5%	4.6%	2.8%	2.8%
Trade	8.9%	7.5%	28.7%	30.1%
Housing	7.8%	8.8%	4.5%	4.2%
Other services	13.1%	14.3%	16.7%	16.4%
Public administration	31.8%	31.5%	8.3%	7.4%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**

About 73% of Lebanon's 1995 GDP (-$10 billion in 1995) was produced in the coastal zone. Compared to the country, the economic output of the coastal zone is characterised by lower contribution from agriculture (5.3% of coastal GDP, compared to 9% overall), compensated by higher contribution from industry (23.1% of coastal GDP, compared to 19% overall). Other sectors contribute approximately the same proportions of coastal and national GDP.

Tertiary activity
Source: CDR-IAURIF, SDATL, September, 2002: 41
The commercial sector is characterised by its important part of the GDP which has barely changed between 1970 (32% of the GDP) and 1995 (30% of the GDP).
Decrease in transit trade: transit movement represents only 1% to 2% of importations for around 35% in 1973.

Number of commercial establishments 1977 in Lebanon is 106 633 (53.7% of total enterprises of Lebanon). 71.7% of them are for trade retail, 21.8 for trade and

maintenance of vehicles and 6.5% for wholesale business. 94% of these enterprises are small (less than 5 employees).

Tourism sector's share of the Lebanon's GDP for the last 10 years was estimated to be lower to the half of 1970 (14% to 18%).
Number of enterprises: 10 366 in 1997.
Number of tourists:

- 1.4 million in 1974
- 396 000 in 1996
- 837 000 in 2001

40% of these visitors during June, July and August.

Industry

Number and Distribution of Industries According to MoI and CAS
Source: MoI, 2000 (based on data compiled in 1998-99) & CAS Studies, 1996-98

Mohafaza	Number of Industries According to		Divergence (%)
	MoI (1998-99)	CAS (1996-97)	
Beirut	2,547	2,931	+15.1
Mount Lebanon	11,011	12,696	+15.3
North	3,865	6,231	+61.2
South	1,641	2,804	+70.9
Nabatiyeh	712	1,517	+113.1
Bekaa	2,250	3,103	+37.9
Total	**22,026**	**29,282**	**+32.9**

Distribution of Eight Largest Industrial Branches Across Mohafaza Source: MoI, 2000

Industrial Branch	Beirut	Mount Lebanon	North	South	Bekaa	Nabatiyeh	Total
Food products and beverages	720	1,615	1,020	385	580	160	**4,480**
Leather and leather products	143	969	117	15	21	25	**1,290**
Textiles	76	500	115	38	56	19	**804**
Clothes & dyeing fur	534	1,302	286	18	95	28	**2,263**
Wood products	208	1,188	151	309	310	83	**2,249**
Non-metallic mineral products	20	1,132	551	238	458	131	**2,530**
Fabricated metal products	286	1,946	477	274	371	199	**3,553**
Furniture & other manufactured goods	185	1,018	770	236	104	39	**2,352**

Source: Lebanese economy 1998 Marwan Iskandar

The industrial sector – mainly the production of cement, furniture, paper, detergent, cosmetics, pharmaceuticals, batteries, garments and processed foods – has been estimated to contribute about 15 percent of GDP and to provide more than 80 percent of Lebanon's exports in 1998.

Quarrying: There are 710 quarries in Lebanon employing around 14 000 workers producing mainly aggregate and stone. Environmental concerns have resulted in new regulations to control damages caused by these operations. Accordingly, a master plan regulating the quarry industry was issued in 1997, allowing quarrying only on eighteen sites under very strict regulations.

Coastal zone

About 85 percent of the industrial units are located in the coastal zone and employ about 89 percent of the total industrial workforce. Industries are concentrated in Central Lebanon (Greater Beirut Area and Mount Lebanon), which comprises 67% of industrial units and 79% of the industrial workforce in the coastal zone.

Total industrial output in 1994 was estimated at $3.72 billion, with an added value of $1.83 billion or about 20 percent of GNP for 1994. Assuming contribution to industrial GDP is proportional to employment, coastal industrial GDP can be estimated at US$1.63 billion in 1994 (89 percent of US1.83 billion) and $1.69 billion in 1995.

There are three cement plants in Lebanon: Two Portland cement plants in Chekka, 15 km south of Tripoli and one white cement plant in Sibline, 10 km north east of Saida

Agriculture

Land use Lebanon (in thousands of hectares)
Source: Lebanese economy 2000 Marwan Iskandar

	1967	**1980**	**1999**
Farmed land	216	215	248
Fallow land	114	60	53
Forests	55	50	21
Non-agricultural land	632	692	698
Total	**1,017**	**1,017**	**1,020**

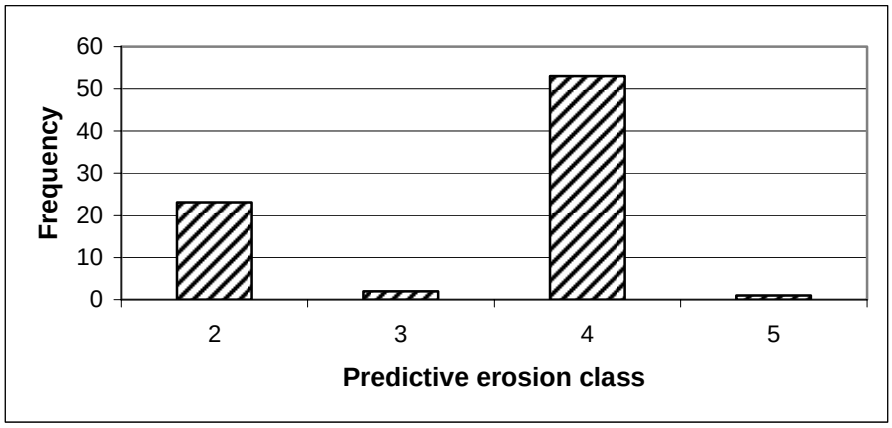
The share of agriculture in GDP in 2000 was estimated at less than 12 percent, compared with 12-14 percent in previous years (related activities, such as storage, refrigeration, and food processing represent a further 5 percent of GDP). Lebanon imports around 75 percent of its food needs, which amounted to around US $1.2 billion in 2000 Source: Lebanese economy 2000 Marwan Iskandar.

Lebanon produces crops in five major categories: cereals, fruits (not including olives), olives, industrial crops (e.g., sugar beet, tobacco), and vegetables. Fruit and olive trees occupy 45 percent of the total cultivated area, and have increased by about 230,000 dunums in the past 10 years. The area covered by greenhouse production has also significantly increased over the past years, from 6,700 dunums in the late 1980s to almost 50,000 dunums in 1999. Agricultural production in greenhouses is more intensive than in open fields and requires more agro-chemicals (pesticides and fertilisers).

Agricultural production is concentrated in the Bekaa, which accounts for 42 percent of total cultivated land. The Bekaa hosts 62 percent of the total area used for industrial crops (including sugar beet, tobacco, and vineyards) and 57 percent of the total area used for cereal production. The North (Akkar and Koura regions) host 40 percent the area used for olive production in the country. Fruit trees cover 24 percent of the total cultivated area.

ANNEX II: COMPARISON OF PREDICTIVE AND DESCRIPTIVE EROSION MAPPING – THE EXAMPLE OF THE DAMOUR WATERSHED

As intermediate step between modelling and describing soil erosion, two predictive erosion maps have been produced. After consulting the first map and reconsidering two main factors of soil erosion, like land cover/use and slope gradient, a second "preliminary" semi-descriptive erosion map was produced. In this version, the level areas with agricultural activities are classified into very low erosion risk. With increasing slope gradient and dominance of shrubs and herbaceous species, the area was subdivided into three major units with increasing erosion risks, i.e. the steep bare lands are placed on the top of unstable areas. Despite the fact that in the second mapping process, a higher score was given to the forest cover, the expected erosion status of forest lands located on steep slopes, in both cases, did not match the filed observation and description. But it was clear from the prediction and fieldwork that the stable managed area with agricultural production on sloping lands is threatened mainly by human mismanagement, i.e. bad agro-practices. However, in the first predictive erosion map this area, as well as the forest area on steep slopes, was mainly classified as highly susceptible to erosion (Figure 1), due to the high score given to the slope. This implies that a higher influence must be attributed to land cover-use, notably under forest systems even on steep slopes.

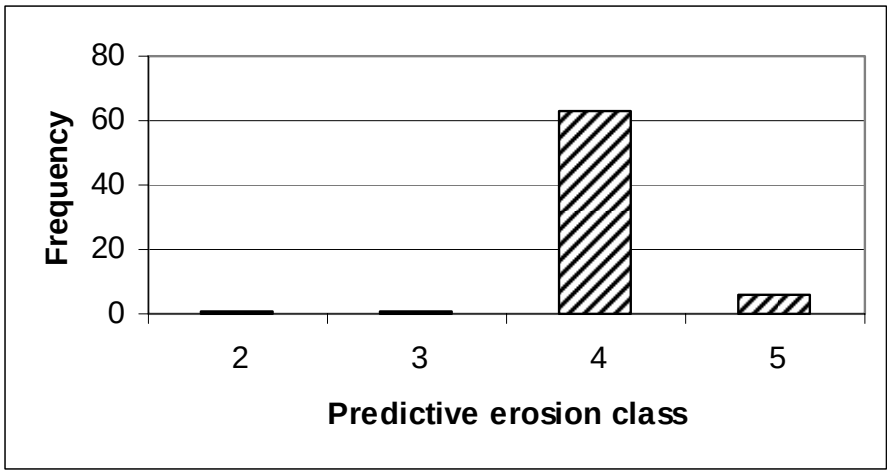


1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4- Highly susceptible to erosion
5- Very highly susceptible to erosion

Figure 1. Frequency of 040h occurrence in the Damour Watershed

Indeed, attributing a score of 16 for the sloping lands with a gradient between 14 and 20%, and a score of 24 for lands with a slope gradient >20%, means overestimating the effect of sloping lands and underestimating the effect of steep lands and closed forest cover. Matching between the expected erosion risk and actual situation in the field occurred mainly in bare lands prone to mass movement that had been classified as medium and high erosion risks. In the field, the team was faced with the complex morphology and land fragmentation resulting in a wide variety of erosion types and association of stable and unstable areas. In many instances, some locations were unreachable, thus a binocular was used for the description.

Based on the followed models to predict soil erosion, the sloping lands were mainly classified as highly susceptible to erosion (Figure 2). Such prediction did not consider the presence of old traditional terracing in the east Mediterranean which can be identified using remotely sensed data.



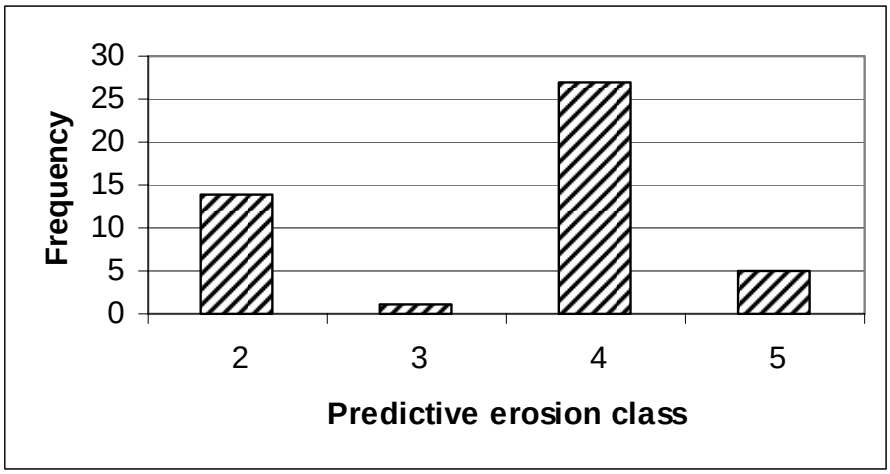
1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4- Highly susceptible to erosion
5- Very highly susceptible to erosion

Figure 2. Frequency of 062tgh occurrence in the Damour Watershed

Terraces on sloping lands in Damour watershed are constructed, as usual, to protect the soil against erosion. Terracing converts the sloping land into levelled land, or mini catchments. Therefore, the soil is not only protected against erosion, but it is gaining an improved drainage condition and higher infiltration rate in comparison with the bare, unrehabilitated soil. This is due mainly to the fact that the soil is gravely and stony. Abundant surface stoniness protects the soil particles from the impact of raindrops. On the other hand, soil deepening on the terraces improves groundwater recharge and allows for water storage in the subsoil where moisture is used by the rainfed olive crop. However, this makes the system more vulnerable to any source of contamination. Moreover, a high instability risk for the rehabilitated spots was observed due to the slope, type of geology and human interference. This implies improving the socio-economic conditions of olive production and oil market to create motivation for land maintenance and reduce rural exodus.

In Lebanon 90% of the area of sloping lands occupied by olive is maintained by terraces. The nature of the narrow coastal strip characterising the coastal Lebanese area and hill slopes to the east made local farmers divide the lands into small terraces without stonewalls for the cultivation of rainfed wheat. Even some forested areas were provided with primitive terraces. Olive has always been occupying marginal lands with higher degree of erosion, thus the retaining stones were necessary, notably on hard limestone areas, where they are available. Only the areas with soft marls are observed to have terracing without contour stones, probably because of the transportation problem. Those unmanaged terraces on badlands were observed to return into initial form with the sedimentation and colonisation of natural herbaceous and partly shrub vegetation.

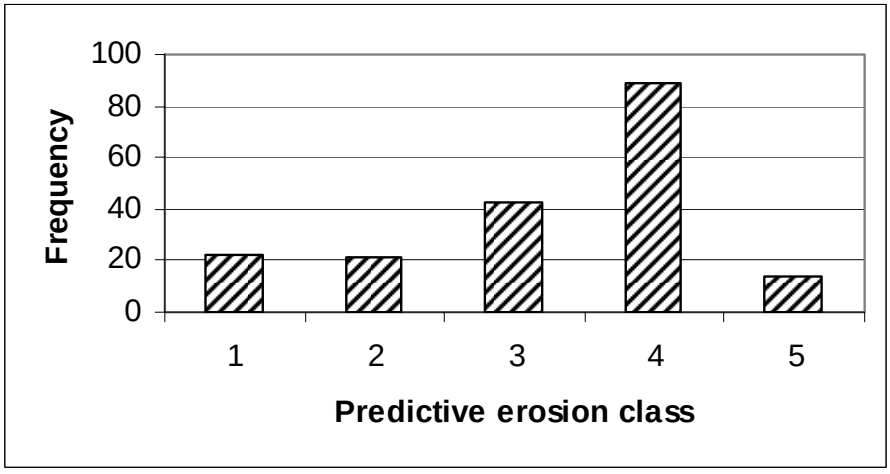
Level lands in the watershed, especially the low lands, are occupied by more intensive cropping systems, like irrigated vegetable, fruit trees and plastic houses. These have received a low score of erosion risk according to the team expectation (predictive erosion map 2). However, the same map produced by the German experts showed discrepancy regarding these stable units too (Figure 3). However, a risk of inundation was observed during the field work that implies protection measures from seasonal water and or sediment excess.



1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4- Highly susceptible to erosion
5- Very highly susceptible to erosion

Figure 3. Frequency of 041w1 occurrence in the Damour Watershed

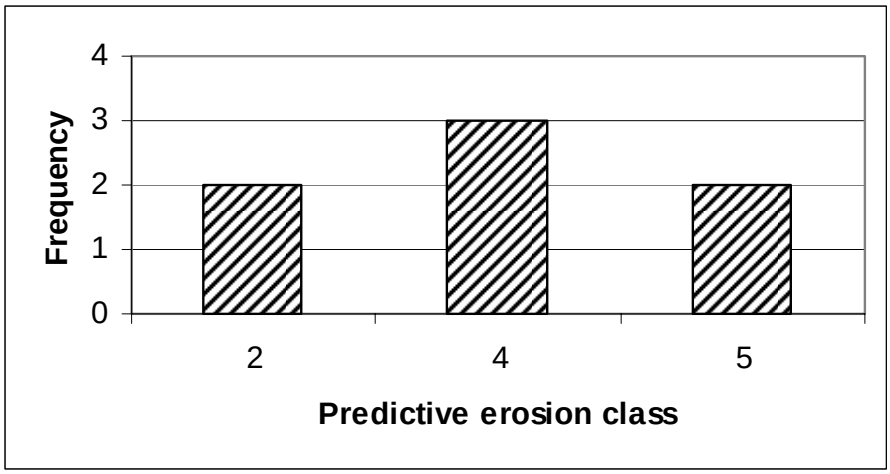
The protective role of forest stands in the Lebanese mountains is clear from field observation where even steep lands are covered by dense forest. The adequate microclimate created by the river and exposure create the conditions for trees growth and development even during the long dry season. An example of the effect of forest on soil protection against erosion can be seen in Figure 4 which demonstrates that only in 41 observed polygons (less than 20% of the mapping unit) prediction matched with reality.



1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4- Highly susceptible to erosion
5- Very highly susceptible to erosion

Figure 4. Frequency of 011t occurrence in the Damour Watershed

This can be explained by the fact that the average slope gradient in this unit was 12.85% with several polygons having the gradient below 6%. The same considerations apply to the stable managed areas with forestry use only, associated with the stable unmanaged areas with potential for forestry use only (Figure 5) which, however, cover part (60%) of the predictive classes (Classes 2, 4 and 5).

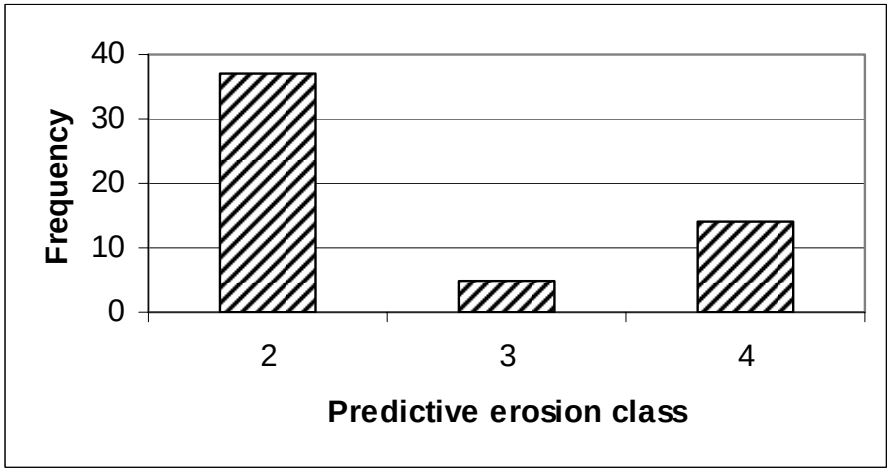


1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4. Highly susceptible to erosion
5. Very highly susceptible to erosion

Figure 5. Frequency of 032tgv occurrence in the Damour Watershed

This indicates the abundance of natural forests in the area and could be less important reforestation efforts, despite the instability risk due to the effect of topography, geology and less dense vegetation cover (open forest and closed herbaceous).

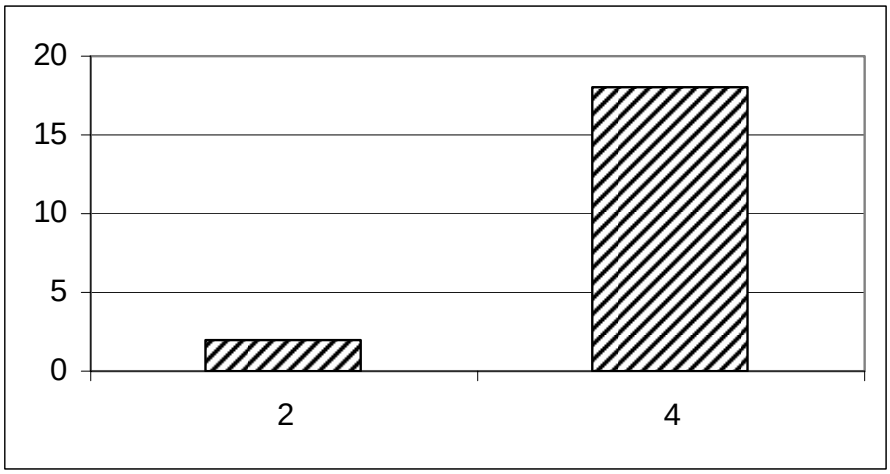
For the case of slight slope gradient and medium soil depth, more than 70% of wasteland matched with the predictive erosion map (Figure 6).



1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4- Highly susceptible to erosion
5- Very highly susceptible to erosion

Figure 6. Frequency of 001g occurrence in the Damour Watershed

The matching between the expected and real erosion status of the unstable areas showed less difference in the assessment of the role of each factor in enhancing soil erosion. More than 80% of observed cases with gully erosion matched the predictive erosion map (Figure 7).

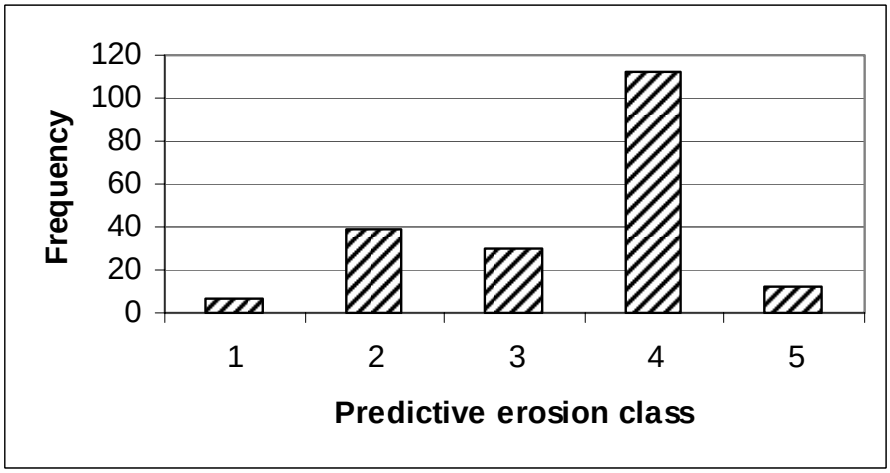


1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4- Highly susceptible to erosion
5- Very highly susceptible to erosion

Figure 7. Frequency of C31 tgv occurrence in the Damour Watershed

An explanation of this output could be the dominance of herbaceous and shrubs cover and combined effect with the relatively high slope gradient. Two polygons covered by fruit trees on sloping lands and described as affected by rill erosion (D2gt and D1tvh) completely matched with the predictive map.

The highest matching is noticed in mass movement (Figure 8). Different types of land use characterise these areas including closed and open forest, shrubs, herbaceous, urban, olive and fruit trees. The main cause of matching is the slope gradient. A possible speculation indicates that slope gradient must be given high score in the units with secondary vegetation cover. In case of forest cover, this factor must be underestimated for the high protection role of the forest on soil conservation.



1- Not susceptible to erosion
2- Slightly susceptible to erosion,
3- Moderately susceptible to erosion
4- Highly susceptible to erosion
5- Very highly susceptible to erosion

Figure 8. Frequency of M21 tg occurrence in the Damour Watershed

Equally, all areas classified as affected by multiple processes were considered in the predictive map as highly susceptible to erosion.

ANNEX III: EROSION MAPPING LEGEND

The erosion mapping legend, presented below, provides a methodological basis for erosion/desertification mapping, as described in detail in the PAP/RAC Guidelines for Mapping of Rainfall-Induced Erosion Processes in the Mediterranean Coastal Areas, 1997 and the UNEP/MAP/PAP Guidelines for Erosion and Desertification Control Management with Particular Reference to Mediterranean Coastal Areas, 2000.

A. PREDICTIVE MAPPING: INFERRED GLOBAL EROSION HAZARDS

Symbols

(0)	**none** (Equivalent to **stable non-used wasteland** in **descriptive mapping: 010**)
(1)	**very slight**
(2)	**slight**
(3)	**moderate**
(4)	**severe**
(5)	**very severe**

B. SITE-DESCRIPTIVE MAPPING: GRADE OF STABILITY/EROSION PROCESSES

I. Stable, non-erosion-affected areas (*)

00	**stable, non-used wasteland** (rock outcrops, cliffs, stony or sandy areas)
01	**stable, unmanaged areas with potential for forestry use only**
02	**stable, unmanaged areas with agricultural potential** (crops and pasture)
03	**stable, managed areas with forestry use only**
04	**stable, managed areas with agricutural use** (crops and pasture)

- **Rehabilitated areas by means of:**

05	**natural or artificial re-vegetation**
06	**physical infrastructures** (terraces, check dams, etc.)

*__Grade of instability risk__

Assessment of **instability risk** for all **stable** environments (00 to 04) and of risk for **rehabilitated** environments, i.e. 05+06 (i.e. a risk in the first years of rehabilitation;) to be expressed by a complementary digit (0 to 3) to the original **stable units'** code:

4: No risk (= highest grade of **stability**)
5: Low to moderate
6: High
7: Areas in hazardous/precarious/critical state (Stability threshold = highest grade of **instability risk**)

Example : 03 = **stable** managed areas with forestry use only
: 032 = **stable** managed areas with forestry use only with a high **erosion risk**

*__Identification of main causative agents__

Instability risk assessment may be reinforced by the identification of its most probable/ prevailing **causative agents** inherent in the **landscapes'** main basic components, i.e.:

t: Topography
g: Geology
v: Vegetation
h: Human activities
a: Animal activities (trampling, terracing, etc.)

Extra codes might be freely added according to local specific contexts and situations.

Example: 023 **g** = stable unmanaged areas with agricultural potential with erosion risk mainly due to geologic factors.

II. Unstable areas (**)

- ***Splash erosion***

A1	**localised** (<30% of the area is affected)
A2	**dominant** (30-60%)
A3	**generalised** (>60%)

- ***Sheet erosion***

L1	**localised**
L2	**dominant**
L3	**generalised with soil profile removal**
Lx	**= unreclaimable areas due to total soil removal**

- ***Rill erosion***

D1	**localised**
D2	**dominant**
D3	**generalised**

- ***Gully erosion***

C1	**individual gullies**
C2	**localised gully networks**
C3	**dominant**
C4	**generalised**
Cx	**= unreclaimable areas due to generalised bad lands**

- ***Wind erosion***

E1	**localised loss of topsoil/overblowing/deflection**
E2	**dominant**
E3	**generalised**
Ex	**= unreclaimable areas due to total sand or sediment burying or topsoil removal**

- ***Mass earth movements***

M1	**local gravitational soil creep/solifluction**
M2	**localised land slides/mudflows**
M3	**dominant**
M4	**generalised**
MX	**= unreclaimable areas due to total slope slides**

Symbols

- ***Water or sediment excess***

W1	**areas periodically flooded and/or sediment buried**
W2	a**reas permanently flooded and/or sediment buried/waterlogged areas**

- ***Degradation induced by land management***

S1	**soil compacting**
K1	**soil crusting**
Z1	**cattle trampling/terraceting**
H1	**salinisation**

- ***Associated processes***

See “Note” in para (**)

Multiple processes

P1 P2 P3 etc.(for description of different closely interacting erosion processes)

****Erosion expansion trend (rate)**

Assessment of erosion rate/trend for all **unstable** erosion-affected areas to be expressed by a complementary digit (0 to 3) to the original **unstable units'** code:

4: Trend to **stabilisation, recession** or limitation of spatial **expansion**

5: Trend to local **expansion** or **intensification**

6: Trend to widespread **expansion** or **intensification**

7 **:** Trend to increase **generalised degradation** towards an **irreversible state**

Example:

L2 = dominant sheet erosion

L23 = dominant sheet erosion with a trend towards generalisation and an irreversible state (Lx type units)

Note: All multiple or mixed but clearly identifiable erosion processes can be mapped by associating or combining the corresponding codes (the sequence of the codes should be established according to the relative importance of the processes: first code = the most important process):

Example: L_{11}/C_{12} = Localised sheet erosion combined with dominant gully networks with a trend to widespread expansion or intensification.

- ***Point/line erosion data (Individual erosion processes)***

	**rocky canyon**
	**individual gully and/or gully head**
	**individual landslide/mudflow**
	**gravitational stone fan**
	**waterways bank erosion**
	**coastal erosion line**

Improving Coastal Land Degradation Monitoring (CoLD)
Field Observation Format: Description of current erosion processes

Observation serial No	Predictive erosion class identity	Photo No	Stable areas			Unstable areas			
			Type	Grade of instability risk	Main causative agent	Type	Extent	Trend/intensity	Special causative agent

Improving Coastal Land Degradation Monitoring (CoLD)
Field Observation Format: Aggravating socio-economic factors

Observation serial No	Actual land use/cover	Noticed remedial measures	Proposed remedial measures	Influence on surrounding*	Overexploitation*	Land abandonment*	Land tenure	Land use value*			Comments
								Value of current LU		Potential for forestry/ agriculture/ other LU	1. For stable areas: Land fragmentation, Market conditions.. 2. For unstable areas: Expansion trend, special prone areas.
								Stakeholders*	Policies*		

*. 1. Low to moderate; 2. Increased; 3. High or critical

ANNEX IV: PHOTOS FROM THE STUDY AREAS

Photo 1: Terraced land within forest area in Damour watershed (Beit Eddine-Deir Kamar area)

Photo 2: Mass movement is frequent on colluvial deposits in Damour watershed (Upper and middle left)

Photo 3: Signs of rill and gully erosion on bare lands separated by terraced area (middle part) and forest (lower and upper parts) in Damour watershed

Photo 4: Widespread sheet erosion accompanying rill erosion on deforested hill slopes of Damour watershed

Photo 5: Rock falls is observed on colluvial slopes soon after the removal of protecting cover (Wadi El Set, Damour watershed)

Photo 6: The absence of water harvesting practices promotes gully erosion (Deir Qamar area, Damour watershed)

Photo 7: Modern terrace construction beside the old terraces interact with forest in Damour watershed

Photo 8: Typical mass movement area with rock falls near Ghaboun-Chartoun (Damour watershed)

Photo 9: Gully erosion in Damour hills

Photo 10: Mismanagement results in great damage of houses spread on colluvial areas and prone to mass movement in Kfarhim (Damour watershed)

Photo 11: A non-used wasteland that can be rehabilitated into forest or terraced agriculture (Jarjou, Zahtani watershed)

Photo 12: Gully erosion development after forest fire near Tassi source (Zahrani watershed)

Photo 13: The non-used wastelands are not completely unproductive. Due to limited soil resources in Lebanon they can be involved in the environmental balance or production system (Houmin area – Zahrani watershed)

Photo 14: Rill erosion near Houmin Faouka (Zahrani watershed)

Photo 15: Terracing of wastelands near Arab Salim-Jarjou (Zahrani watershed)

Photo 16: Urban expansion occurs on the expense of fertile lands in the plains. But, in the mountainous areas it is sometimes accompanied by terracing and agricultural activities (Zahrani watershed)

Photo 17: Foreground: Dominant mass movement caused by geology and topography despite the terraced agriculture in Khasfeh area near Jarjou (Zahrani watershed). Backgound: Mass movement associated with rill erosion.

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