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DIAGNOSTIC, ANALYSIS AND MITIGATION OF COASTAL LAND DEGRADATION IN LEBANON*

By

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A. INTRODUCTION

Human interference in Lebanon is contributing significantly to land degradation (Khawlie, 2000; Bou Kheir *et al.*, 2001a; Masri *et al.*, 2001; Darwish et al., 2005). This makes the issue of the assessment of coastal land degradation in the eastern Mediterranean of high interest. The international agencies and local authorities encourage works addressing the improved monitoring of degradation processes, especially through encouraging public participation. It can be supplemented by upgrading the national capacities through using advanced information tools such as remote sensing and GIS for better environmental management and planning of coastal zones. The application of sustainable development principles to fragile ecosystems such as arid and semiarid zones, which are common in Mediterranean areas, must cope with the issues of land degradation and desertification. Preventing land degradation is a less costly measure compared to mitigation and notably to restoration.

The arid and semi-arid zones in the country constitute about 24.1% of the land (Safi, 1999), and are being exposed to a multitude of stresses. These include gullying (Shaban *et al.*, 1999), soil erosion (Bou Kheir *et al.*, 2001b), decreasing land fertility by salinization (Atallah *et al.*, 2000) and an expected deficit of 800 Mm^3 in water availability by the year 2015 (Darwish *et al.*, 1999; Khawlie 2001). The costs of undesirable desertification effects can be summarized in the last fourteen years by 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 damaging and tremendous. They include decline of crop production, sedimentation of eroded soils in undesirable localities, reduction and degradation of arable lands, silting of dams, pollution of watercourses and damage to property by soil-laden runoff.

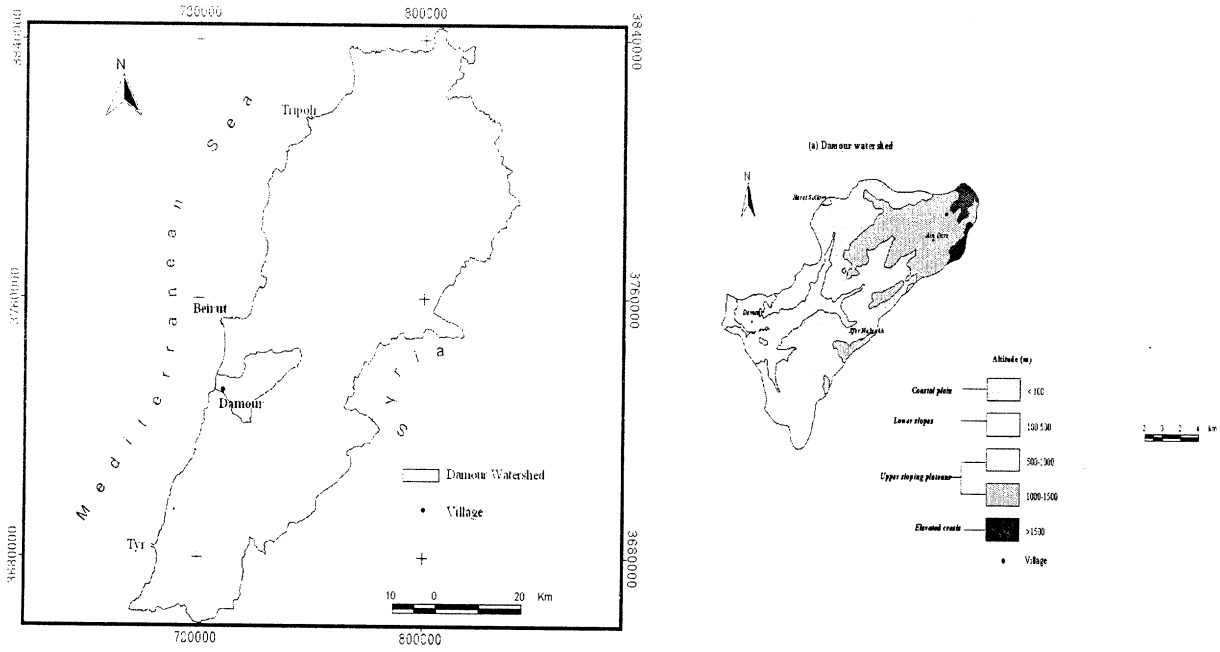
The aim of this work is to analyze the physical factors of land degradation in a representative coastal watershed. It also relates causative agents and mitigation measures with socio-economic aspects to elaborate a management program. The study reveals a prioritization scheme and shows indicators of remediation measures and the role of different stakeholders. A sound knowledge of causes of land degradation and desertification processes is needed in order to select, for each management area, the most appropriate actions for natural resources conservation. Analyzing the physical causes of soil erosion, at the country level, is important for erosion risk mapping and selection of areas for more detailed studies and priority interventions. Because land degradation is of interdisciplinary nature, the concern covers the soil, as one environmental element, and agriculture, forest, water, as well as social and development needs. This allows interplaying of measures to cover actual sites, practices, monitoring and policies.

B. MATERIALS AND METHODS

The area of study is located in Central Lebanon within the Damour watershed, south of Beirut. The Damour watershed is a coastal river basin with permanent watercourse. It extends from higher elevations in the east, i.e. some 1500-2000 m, and goes westward, at a relatively short distance (< 25 km), opening its outlet into the sea (Figure 1). Damour watershed occupies a total area of 333 km^2, and is one of the largest watersheds of the country.

The area characterizes the coastal problem of chaotic urban expansion and diversified land use. The result is a trend of deteriorating water quality and increase in polluted rivers discharge, which also affects agro-products. A dramatic increase in the population rate, notably in the last two decades, multiplied the demands for land. At the same time, improper management of natural resources is rampant which had a noticeable impact on the environment. Sewage water, rather than being used as a valuable additional source of water if treated, is rejected in the river without treatment.

Figure 1. Location and simplified topography of Damour Watershed



The absence of government solutions, in addition to lack of resources, implies the need for the involvement of the local community in the management plans to improve land management, soil conservation and increase efficiency.

1.Geology

The area consists of a few rock formations starting with the Jurassic rocks, which are thick bedded to massive, highly fissured, jointed, well-karstified limestone and dolomitic limestone (Dubertret, 1953). They comprise only 5% of the total area. The Cretaceous rocks comprise the major rock body in this watershed. They occupy 305 km^2 or 91.6% of the total area. Among these, the Cenomanian is the most prevailing rock in the study area. It consists of highly fractured, jointed and well karstified dolomitic limestone, marls and marly limestones. The other major formation is the Senonian marls, chalky marly limestone acting as a barrier along the coastal narrow ribbon.

2. Drainage

Rocks of different lithologies have different effects on surface water flow regime, thus on infiltration rate. Drainage characteristics are indicative of the infiltration rate, recharge rate and run-off (Shaban, 2003). The carbonate rocks such as Jurassic and Cenomanian show a high rate of infiltration (>35%). The increase in the argillaceous content reduces this value such as the case of marly limestone. The sandstone reveals high vulnerability to transport surface water into the subsurface but includes clayey seams that reduce the infiltration and increase run off rate.

3. Landform

In the Damour watershed, the overall area is considered as a sloping terrain, with rugged topography. This makes the terrain prone to superficial movements and effective erosion processes. 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 not large in the watershed (21%), while the areas with a slope gradient between 30-60% are larger (32%). This shows the necessity for soil conservation measures.

4. Climatic pattern

The period of rainfall is relatively short, i.e. about 70-80 days per year (Climatic Atlas of Lebanon, 1982). This creates an intensive rain that leads to torrential flow with a risk of high erosion rate. Precipitation is often from October to March, reaching its climax in January, which may at some extreme instances yield about 160-180 mm/month. The annual precipitation rate over the basin is about 700-1200mm. Snowfall is also included to occupy one-time/5 years on altitudes less than 200 m; 5-10 days/year between 200-1000 m; 30-35 days/year over 1000 m (Sanlaville, 1977; Hakim, 1985).

5. Land cover/land use

Natural vegetation cover occupies the largest portion of the watersheds constituting 55.5%. In Damour watershed, 20.5% of forests are *Pinus* and *Quercus* species among which 7% are very dense; 13% are attributed to shrubs and 22% to herbaceous vegetation. Agricultural lands are less widespread than natural vegetation, covering about 30% in the watershed. Water bodies are present as very small patches occupying 0.3% of the watershed. Human settlements, which constitute one of the major elements influencing water demands and desertification, occupied in 1998 an area of 44 km^2 in Damour watershed, which represent 13% of the area.

6. Soil erosion

The reported study is part of the EC-funded Life project: "Improving Coastal Land Degradation Monitoring in Lebanon and Syria- "abbreviated CoLD" N°: LIFE TCY/00/INT/00069/MED. The project focused on assessing coastal land degradation in Lebanon and Syria. The detailed analysis depended heavily on the methodology developed by PAP/RAC and FAO published as "UNEP/PAP/MAP: Guideline for erosion and desertification control management with particular reference to Mediterranean coastal areas". The outcomes and findings from the fieldwork of the detailed analysis would serve as an input for arriving at a strategy and giving recommendations. The significance of public participation was always given due consideration in the process, especially in view of the requirements of integrated coastal zone management.

7. 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, none-erosion affected areas, i.e. areas with no evidence of any active erosion processes, due to the predominant stabilizing 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.

Within these categories managed and unmanaged areas were distinguished. The unmanaged areas are the stable forestlands, wastelands where no human intervention is observed. The managed areas belong to the lands with agricultural activities, protection or conservation measures.

C. RESULTS AND DISCUSSION

1. Descriptive erosion mapping

The descriptive erosion map for Damour watershed is represented in Figure 2. Damour watershed is characterised by morphological complexity, notably by the alternation of stable and unstable areas in one geomorphological unit (Table 1). For stable areas (73.3 % of the assessed area), both unmanaged and managed areas are found: Only small parts of non-used wasteland of code (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.

- 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 code (01), where natural forest with rare fruit trees and shrubs occupied the land even on steep slopes. These areas are characterized by a low instability risk.

- Stable managed areas cover forestry use code (03) as well as agricultural use code (04) and frequently there is an association of forest and agricultural lands. The forest areas (5.4 % of the assessed area, i.e. 8.07 km^2) are mostly 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.

Figure 2. The descriptive erosion map of Damour watershed.

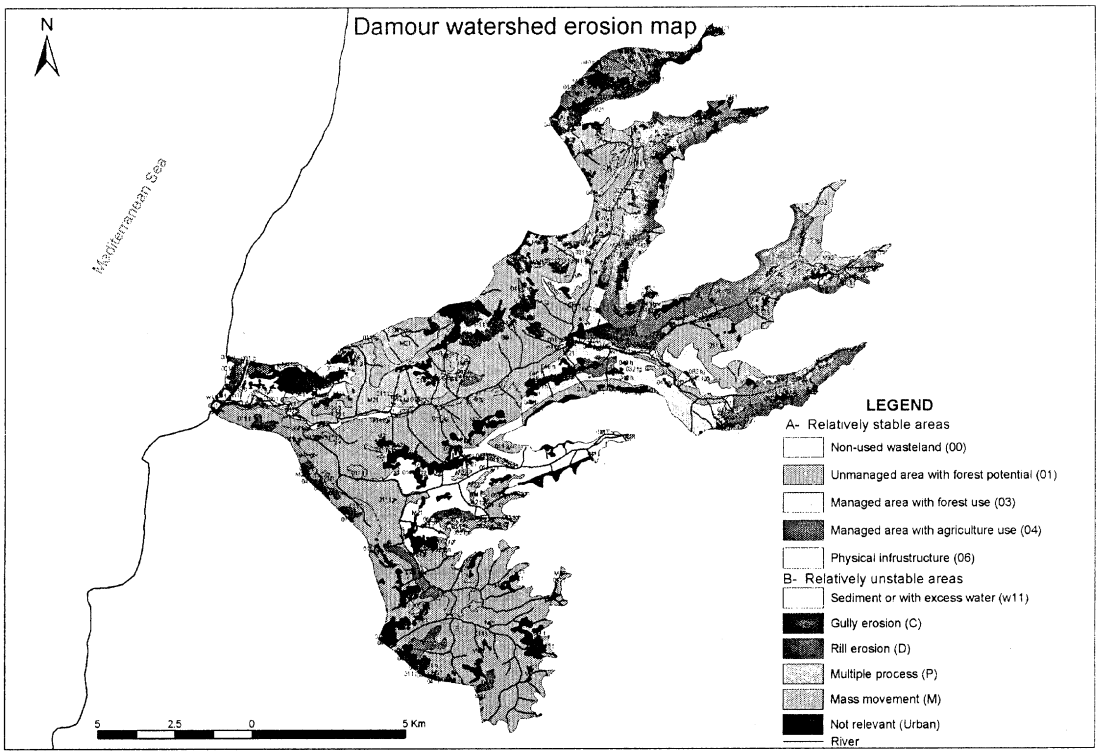

N
Damour watershed erosion map
Mediterranean Sea
5 2.5 0 5 Km
LEGEND
A- Relatively stable areas
Non-used wasteland (00)
Unmanaged area with forest potential (01)
Managed area with forest use (03)
Managed area with agriculture use (04)
Physical infrustructure (06)
B- Relatively unstable areas
Sediment or with excess water (w11)
Gully erosion (C)
Rill erosion (D)
Multiple process (P)
Mass movement (M)
Not relevant (Urban)
River

Table 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
	Localized 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
	Localized 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
	Localized associated processes	Local	P11	2	1,68	1,1
Not relevant				159	15,94	10,8
Total				510	147.73	100

- The Damour watershed consists dominantly of 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 (code 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. 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 low lands' areas with agricultural activities in downstream level Damour plain are classified as managed area with agricultural use (code 04). The coastal lands near the river mouth and on the Damour plain are characterized by dominance of banana production and green housing. This area is of low instability risk. The only risk comes from human activities in the form of urban expansion on the plain and mismanaged cultural practices in greenhouses resulting in soil salinization and possible NO_3 leaching towards the groundwater.

For the 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, 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. Coupled with human mismanagement and poor land cover, the areas represent a highly fragile ecosystem with boulders movement down slope. The negative effect of mass movement is enhanced by inappropriate human intervention in the form of insufficient physical infrastructures (terracing) and absence of water diverging canals and water harvesting practices. In less affected areas, localized landslides characterize 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 localized, intensified and dominant gully erosion and trend to local expansion and widespread intensification characterize these areas. Topography and geology, beside the poor vegetation cover and human interference, are the responsible causative agents.
- 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 characterized 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 characterized by the presence of multiple erosion processes (P), like rill erosion, gully erosion and mass movement with localized 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.

2. Identification and prioritisation of future intervention areas ("hot spots")

Successful land degradation control is based on the efficient use of available resources. This 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 for stable (Table 2) and unstable areas (Table 3). This integrated the results of the physical assessment and related descriptive mapping with the aggravating socio-economic conditions. Actual and potential land use values were considered according to different views, notably the perception of the local population, established national policies and assessment of potential for forestry, agricultural use and other land use forms.

Table 2. Prioritization scheme for some stable areas in Damour watershed

Serial map N°	27	8	10	13	17	3	14
Actual land use*	5	4	4	4	4/5/2	1	2
Code	001tgh	011tg	011gt	012tg	011tgv	041tgh	062tgh
Prioritization criteria (score)**							
Actual degradation risk of the area							
Physical risk (A)	1	1	1	2	1	1	2
Multiplicator for importance of causative agents (D)	1	1	1	1	1	3	1
Influence on adjacent areas (E)	1	1	1	1	2	3	1
Importance of aggravating socio-economic factors							
Overexploitation (F)	1	1	1	1	1	1	1
Rural exodus (G)	2	1	1	1	1	3	3
Land tenure (H)	2	1	1	1	1	1	2
Others (social conflict, market, prices) (I)	-	1	1	1	1	3	3
Total score for actual degradation risk (A * D + E) * F * G * H * I	**8**	**2**	**2**	**3**	**3**	**54**	**54**
Land use value (actual and potential)							
Value of the current land use-local population view (J)	1	3	2	2	2	1	1
Value of the current land use-national policies (K)	1	2	2	1	1	1	1
Potential for forestry (L)	-	3	3	3	3	-	-
Potential for agricultural use (M)	-	-	-	-	-	3	3
Other land use potential (N)	2	2	3	2	2	1	1
Total score for land use value (J + K) * L * M *N	**4**	**30**	**36**	**18**	**18**	**6**	**6**
Total final score [(A * D + E) * F * G * H * I] + [(J + K) * L * M *N]	**12**	**32**	**38**	**21**	**21**	**60**	**60**
Priority for application of preventive measures* **	**1**	**2**	**2**	**2**	**2**	**3**	**3**

* Land use: 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).

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 prioritization results is given in Tables 2 and 3.

Table 3. Prioritization scheme for some unstable areas in Damour watershed

Serial map N°	29	32, 36, 46	33	37, 38	44	42
Actual land use*	6	5	5	6	1/5	5
Code	M32tgh	M21tg	M22tg	C21tg	C32tgv	P11tvh
Prioritization criteria (score)**						
Actual degradation trend of the area						
Extent of area affected (B)	3	2	2	2	3	2
Expansion trend (C)	2	1	2	1	2	1
Multiplicator for importance of degradation process (D)	3	2	2	2	3	2
Influence on adjacent areas (E)	2	2	2	2	1	1
Importance of aggravating socio-economic factors						
Overexploitation (F)	-	-	-	-	-	-
Rural exodus (G)	3	3	1	3	2	1
Land tenure (H)	2	2	1	1	2	1
Others (social conflict, market, prices) (I)	-	-	-	-	-	-
Total score for actual degradation risk (B * C * D + E) * F * G * H * I	**120**	**36**	**10**	**18**	**76**	**5**
Land use value (actual and potential)						
Value of the current land use-local population view (J)	1	1	1	1	1	1
Value of the current land use-national policies (K)	1	1	1	1	1	1
Potential for forestry (L)	3	2	2	3	3	3
Potential for agricultural use (M)	1	2	1	2	1	1
Other land use potential (N)	1	1	1	1	1	1
Total score for land use value (J + K) * L * M *N	**6**	**8**	**4**	**12**	**6**	**6**
Total final score [(B * C * D + E) * F * G * H * I] + [(J + K) * L * M *N]	**126**	**44**	**14**	**30**	**82**	**11**
Priority for application of remedial measures* **	**3**	**2**	**1**	**2**	**3**	**1**

* Land use: 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).

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 rehabilitated areas with physical infrastructures (terraces) and a high instability risk.

But, also some unstable areas (2.2 %, i.e. 3.18 km^2), however, were identified as high priority areas. These areas showed active erosion processes such as: gully networks, dominant mass earth movements with a trend to both local expansion or widespread expansion, and areas periodically flooded and/or sediment buried with a trend to local expansion.

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 comprise mainly unmanaged areas with potential for forestry use only. With regard to unstable areas, 10.3 % (i.e. 15.25 km^2) were identified as medium priority. These areas showed localized gully networks, dominant rill erosion, localized landslides and periodically flooded and/or sediment buried with a trend to widespread expansion.

Stable, non-used wastelands and unmanaged areas with potential for forestry use only 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 localized land slides with a trend to widespread expansion and dominant associated processes with a trend to local expansion, was considered as low priority.

D. REMEDIAL MEASURES

The identification of the currently applied measures was made according to a general distinction between preventive, protective and curative measures. For the environmental concern there are 4 relevant themes: soil, agriculture, forest and surface water. Similarly, for the concern on development, 3 other themes: urban, rural and land use are important. This approach is followed in an attempt to simplify the application of those measures and make them more pragmatic.

Overall, because of low profit from agriculture, lots of practices occur that result in increasing land degradation like excess pumping from wells resulting in seawater intrusion (El Moujabber, 2005). 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 is not sufficient in itself to overcome the problems of induced land degradation. An economic incentive from the government should come to help solving the negative aspects of land abandonment. 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. Local regulations have to be upgraded and their implementation properly executed.

Furthermore, the practice of reclamation of stony hills is not rare in the country. The Green Plan of the Ministry of Agriculture mandate is to subsidize 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 stabilizing the territory and keeping 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 prices lands in the coastal and inner plains and go for the rehabilitation of highly calcareous hills, traditionally unsuitable for agriculture. Land fragmentation is observed in highly populated places. Problems with land tenure must be solved, like the

community property on land and infrastructure. Moreover, it is propagated to make terracing or contour ploughing and strip panting of hills in the mountain chains with dry summer conditions to collect more water on a unit of area and avoid flush flood.

E. PREVENTIVE AND CURATIVE MEASURES

Improving soil structural stability by forestation and maintenance of terraces improves the infiltration rate and accelerates the soil water retention capacity, thus protecting the soil. A possible preventive measure against severe erosion is the building of water diverging canals. This is necessary to mitigate earth movements such as rock falls, which cause severe damage in the urban settlements. For this reason water management issues, including the controlled use of unconventional resources, must be given priority, like water harvesting, diverging and preservation is essential to prevent landslides, 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.

F. DRAFT MANAGEMENT PLANS

To protect arable lands, reforms like introducing mixed plantation with diversified production are needed to face the fluctuating market conditions. With the free trade, a 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 enhancing fertilizer 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 Tables 4 and 5 a project planning approach is given 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 proposed activities cover all requirements of preparatory settings, training, capacity building, socio-economic analysis, modeling, monitoring, and a management-strategy for the decision-maker/ manager/community.

Table 4. Summary of draft management plans for the Damour watershed

Problems & remedial measures			*Institutional/administrative arrangements*	*Monitoring indicators*
Problem	*Priority*	*Remedial measures*		
• unstable areas	3	- stabilize by terraces or forestation & protect	• National level - capacity building - establish databases - enforce regulations - apply land use zoning & protection • Local level -public participation/ NGOs -environmental awareness - agro-cooperatives - enhance agro-sector & socio-economic incentives	- areas are stabilized - forest regenerated - water ways controlled - degraded sites are recovered - terraces maintained & cultivated - agro-sector is recovered - improved living
• burnt forest	3	- rehabilitate		
• torrential water passage	2	- construct protection measures		
• quarried sites	2	- rehabilitate		
• degraded terraces	2	-rehabilitate/cultivate		
• wasteland	1	- cultivate or reforest		

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, and 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 (Table 5). 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 the precious natural resources.

Table 5 Outline of draft management plan for a part of Damour watershed

ID (Serial No.)	Priority	Remedial measures	Institutional / administrative arrangements	Monitoring indicators
040h	High	- Control use of soil cover - Well structured mixed plantation - Balanced development of rural areas - Diversification of production - Warning of epidemic plant diseases - Supporting balance between natural habitats and agricultural areas - Land use based on soil capability and suitability	- MoA + MoW + + DGUP - Municipalities - NGOs - Private sector - Farmers	- pollution (volume) - Abandoned orchards - Stakeholders and participation - Committee operational - rural community welfare - awareness of protected resources
C22tgh	High	- Reduce slope stretch by introducing barriers - Stabilization of soils by contour ploughing and strip planting on slopes - Constructing and rehabilitation of terraces	- MoA - Municipalities - Research and academic organizations - NGOs - Donors and funding institutions - Farmers	- Loss of top soil (cm) - mass wasting (mass) - stakeholders and participation Committee operational - Awareness of protected resources

CONCLUSION

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 remediation measures should be approached accordingly. The emphasis of central and local authorities should be efficiency and reduced cost as the farmers and landowners 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 remediated first. With enough money available, the community can opt for two categories, and choose a spectrum of measures, oriented to the conservation of natural resources and income product generating agricultural and environmental practices.

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