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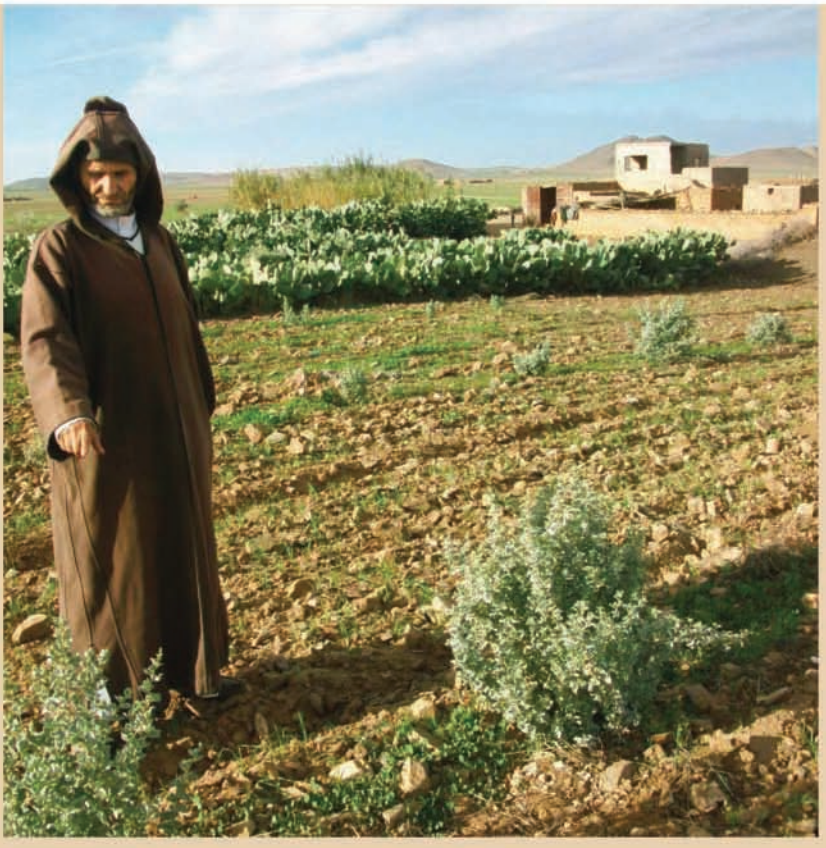

A Review of Available Knowledge on Land Degradation in Morocco

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Oasis — A global agricultural research-for-development partnership against desertification.
Within this partnership, this OASIS project focused on priority land degradation issues that impact on the countries of Jordan, Morocco, Yemen and Pakistan. It was funded by USAID.

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A Review of Available Knowledge on Land Degradation in Morocco
OASIS — Combating Dryland Degradation

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Feedback:
ICARDA welcomes comment and feedback on this publication. Please visit www.icarda.org/ to share your views.

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Key words:
Land, degradation, Morocco, intervention, erosion rate, agricultural policies

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EXECUTIVE SUMMARY

This publication reviews the historical and current literature on land degradation in Morocco and presents the results of a case study in the western part of the country. It is intended as a reflection on the baseline causes for land degradation, so contributing to the development of enabling agricultural policies and the associated institutional dynamics that are needed to overcome degradation problems. Government employees, land care agencies, NGOs, policy makers, farmers and rural communities are the key target audiences.

This report identifies crucial policy inconsistencies and dysfunctions that were, so far, ineffective in overcoming the different forms of land degradation in Morocco. As a result of such deterioration, the capability base of natural resources has been seriously diminished, leading to cuts in productivity in some agricultural systems.

In Morocco, soil erosion is a result of several factors. The most important being increased population pressure over limited natural resources, overexploitation of forestry assets, removal of natural vegetation from the slope lands, overgrazing, cultivation of vulnerable lands in arid and desert regions, and inappropriate general land management (mainly tillage). It is estimated that about 35% of the Moroccan rural population live in areas of serious degradation. The rural poor heavily depend on forest resources, creating extra stress on ecosystems when rangelands and croplands are unable to meet and sustain their livelihoods.

It is estimated that areas in the process of degradation affect the livelihoods and food security of about 1.5 million households in Morocco, who then further extend their agricultural production and livestock systems to other marginal and fragile lands, thus seriously further degrading the natural resource base. An economic analysis has estimated the global cost of lost productivity in Morocco as a result of land degradation at between USD 91 and 178 million per year (cropland and rangeland degradation).

The Moroccan government has devised a National Action Plan that focuses on the ways and means to promote practical tools and to disseminate information on combating desertification. This plan calls for participatory approaches and the implementation of mechanisms for sustainable use of natural resources while introducing monitoring mechanisms on the dynamics of ecosystems. The plan also calls for conserving natural resources through emphasizing control of wind and water erosions and by rehabilitating natural and oasis ecosystems, as well as implementing water resource harvesting and the integrated management of natural resources.

Key words: land degradation, policy, intervention, erosion rate, Morocco.

The project team welcomes discussion and perspectives from interested readers.

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1. Introduction

1.1 DESCRIPTION OF LAND RESOURCE BASE IN THE COUNTRY

Morocco lies at the north-western part of the African continent bordered, to the north, by the Mediterranean Sea, to the west by the Atlantic Ocean, to the east by Algeria, and to the south and south-east by Mauritania. The Gross Domestic Product (GDP) and GDP per capita are, respectively, $121.8 billion and $3,900 (both 2002 est.), which ranks the country to be of Medium Human Development. The Human Development Index (HDI) value for 2001 was 0.606 and it ranked the 126th of 175 countries.

Morocco's rural areas are characterized by poor socioeconomic infrastructure, low levels of education, inadequate support services and an ageing farm population. Farmers are therefore not equipped to face the challenges of an economy that is opening up to free market competition. The major causes of insufficient productivity in the agricultural sector are:

- Degradation of natural resources;
- Rural poverty;
- Insufficient social infrastructure;
- Limited involvement of the rural population, especially women, in the development process;
- Poor use of the Government's human and financial resources;
- Virtual absence of rural financial services for small farmers and the rural poor.

Natural resources are affected by increasing degradation. Apart from the broad alluvial plains, most of Morocco's soils are fragile and subject to erosion. Morocco is a country that has scarce natural resources, especially arable land and water. Intensive agricultural production, large-scale irrigation schemes, industrialization and urbanization have been creating mixed socioeconomic outcomes in the country. Morocco has faced severe problems of air, water and soil pollution, environmental health problems, deforestation and soil erosion and is regarded as very vulnerable to the impacts of climate change. In addition, natural hazards such as floods and droughts occur periodically.

With a total land area of 71.085 million hectares, Morocco's land use can be summarized as 5.8 million hectares of forests (8%[1]), 9.2 million ha of agricultural lands (13%) and 46 million ha of pastures, rangelands and deserts. The plant biodiversity in Morocco registers 4500 species, with 537 endemic species. This means the country lies in second place in terms of diversity in the Mediterranean basin after Turkey (Elyousfi & M'hirit, 1998).

The total area covered by soil survey is estimated to be 15 million ha. It is mostly concentrated in the North and central western part the country, north of the Atlas Mountains, meaning that about 28% of national soil resources are mapped and characterized at different scales. The French soil classification system (CPCS of 1967) is almost the sole legend used. A schematic general soil map of Morocco was prepared at the scale of 1:2,000,000 (MADRPM, 1996; Tables 1 & 2). Irrigated regions are well characterized and soil maps at detailed scales (> 1:20,000) are available in Morocco. However, little information is available in the mountainous and desert regions.

1.2 ECONOMIC SIGNIFICANCE OF LAND DEGRADATION IN THE COUNTRY

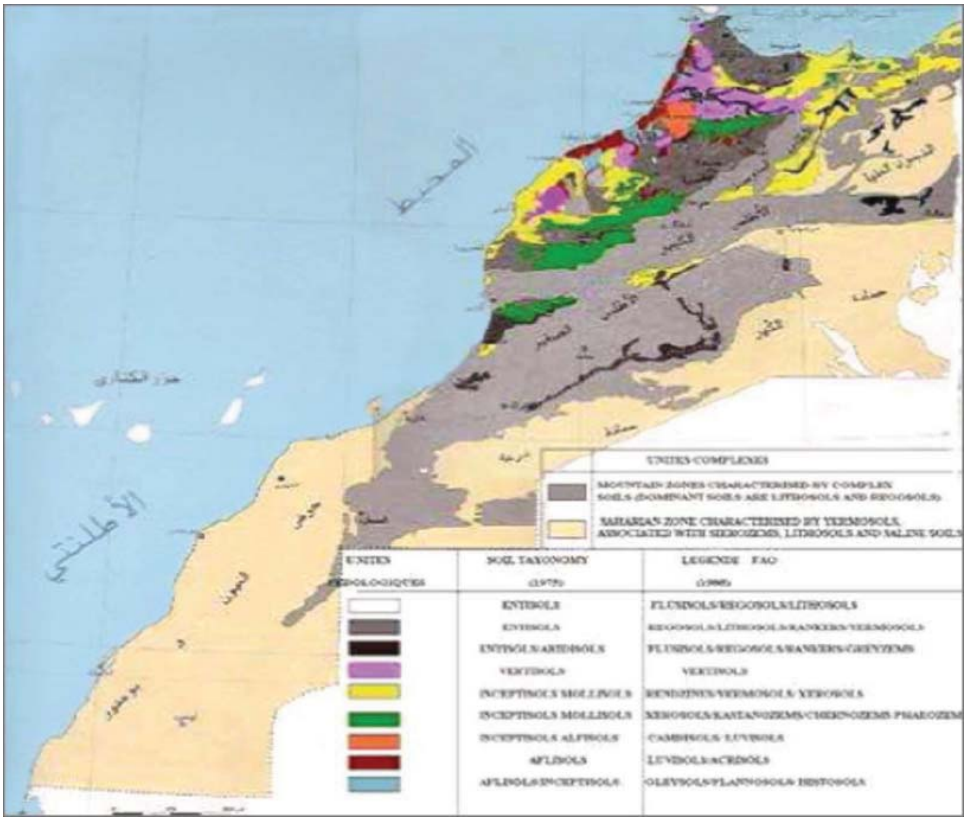
An economic analysis estimated the global costs of lost productivity as a result of land degradation at 91 to 178 Million USD annually (World Bank, 2010). However, there is no commonly accepted calculation method, especially in developing countries where common property is widespread and data is difficult to obtain. In addition to productivity losses, there are parallel impacts of erosion, food

[1]For maintaining equilibrium the norm is 15% to 20%.

Table 1: Major soils types encountered in Morocco

French classification (CPCS, 1967)	Soil Taxonomy	FAO Legend (1989)
Sols minéraux bruts	Entisols	Fluvisols, Regosols, Lithosols
Sols peu évolués d'érosion	Entisols, Aridisols	Regosols, Lithsols, Renkers, Yermosols
Sols peu évolués d'apport	Inceptisols, Mollisols, Ari-disols	Fluvisols, Rankers, Greyzems
Sols calcimagnési-ques	Inceptisols, Mollisols, Ari-disols	Rendzinas, Yer-mosols, Xero-sols
Sols isohumiques	Inceptisols, Mollisols	Xerosols, Kas-tanozems, Cher-nozems, Phaeo-zems
Vertisols	Vertisols	Vertisols
Sols à sesquioxydes de Fer (Fersiallitiques)	Alfisols	Luvisols, Acrisols
Sols brunifiés	Inceptisols, Al-fisols	Cambisols, Lu-visols
Sols sodiques	Soils with saline phase	Solontchaks, Solonetz
Sols Hydromorphes	Soils with aquic moisture regime	Gleysols, Planosols

Source: Badraoui & Stitou, 2002; Ryan et al., 2006



Source: Ministry of Agriculture and Marine Fisheries – MAPM (2000).

Figure 1: Soil map of Morocco

insecurity, poverty and lost environmental services. Very little has been done to assess these costs in space and time. The economic and social consequences of environmental degradation in Morocco are evident: the estimated annual cost of such damage now stands at some 20 billion Moroccan

Dirham (MDH), which represents roughly 8% of the gross national product. Different institutions have estimated cost of land degradation as follows:

- Forest degradation: 154 Million MDH (Dirhams) annually (Morocco's High Commissioner for Water, Forests and the Fight against Desertification - HCEFLD)
- Agricultural land degradation : 940 Million MDH annually (World Bank, 2010)
- Rangelands degradation: 133.6 Million MDH annually (World Bank, 2010)
- Deposition dams: 500 Million MDH annually; it is the cost of building a dam each year (Secretariat of State in charge of Water and Environment)
- Sub-total: 1,728 Billion MDH annually ~ $ 216 Million (1$US=8MDH)
- Ecosystem/ecological cost: Not estimated

Since Morocco has been severely stricken by successive periods of drought and desertification, environmental protection and mitigation measures have been made top priorities for socio-economic development. Morocco, which has understood quite early the significance of the process committed and initiated by the United Nations, has regularly backed these efforts, leading to the design and implementation of the main international conventions (i.e. Biodiversity, Climate Change, Desertification) stemming from the Rio conference.

Table 2: Soil mapping in Morocco

Scale	Area (million hectares)
1/200.000 to 1/500.000	3
1/100.000 to 1/50.000	10
1/20.000 and lower	2
Total	15

Source: Ministry of Agriculture and Marine Fisheries – MAPM (1999).

1.3 DEGRADATION AS A THREAT OR IN THE COUNTRY

In Morocco, land management has always been a sensitive issue. One of the large systems planned for the management of national space and local spaces after Morocco's independence, was designed for two reasons: first, to ensure strong coordination of territorial structure as a basis for development and as a reinforcement of political, economic and social unity; and second to facilitate administration and political and social control based on apportionment, especially promoting the supervision of local officials, resources and populations.

Chronologically, the oldest project whose objectives aim on dealing with desertification problems dates back to the 1960s. This program aimed at contributing to the rural development of Western Rif and controlling erosion risks threatening this region. Actions undertaken within the framework of this project encompassed plantation of fruit trees, land development projects, herd management development, construction of earth roads, rehabilitation of springs and erosion control.

1.4 LAND DEGRADATION: WHO IS AFFECTED THE MOST, HOW AND WHERE?

Land degradation is not just a collection of local problems; it is a global issue responsible for climate change, loss of biodiversity, rural poverty, and the migration of people to cities and across borders. Extreme land degradation and extreme poverty go hand in hand in drylands, where a combination of unsustainable land management and fluctuating weather conditions increase the vulnerability of

the communities. The greatest vulnerability is ascribed to the rural population that represents 46% of total population among which 66% are poor. Moreover, 75% of the poor in rural areas depend on agriculture. It is estimated that 35% of the rural population live in areas of serious degradation, i.e. on rangelands and key ecosystems of the country and the global environment. For instance, the poorest of the poor depend heavily on forests for part of their income and put extra stress on these ecosystems when rangelands and croplands cannot fulfill and sustain their livelihood.

Land degradation affects the livelihoods and food security of about 1.5 million households in Morocco, and is undermining the carrying capacity of the ecosystems of the country. It is forcing farmers to extend production to marginal and fragile lands, thus seriously degrading the natural resource base. At the same time, rangeland quality is being depleted due to increasing herd size and prolonged drought. The majority of Morocco's climatic zones fall under semi-arid and arid ecosystems (93%). These ecosystems, rich with diverse habitats and species heterogeneity, are of high international importance. However, the pervasive poverty and the increasing pressure on the land and its inadequate management are leading to wide scale land degradation, depletion of water resources, loss of wildlife habitat, and increased susceptibility to droughts and climate change.

The use, management and control of degraded common lands are serious issues in Morocco. In the eastern region, about 70% of the land is collectively used by local tribes and communities, and land use conflicts over access to grazing areas and water are regular features, seriously contributing to continual and often intensive degradation of the land. This combination of factors result in a spiral of increasing rural poverty and continual degradation of natural resources, with increasing outward migration of poor people to urban areas and elsewhere. Land degradation is an environmental issue and, at the same time, a development issue. Sustainable land management is essential to both combating degradation of ecosystems and improving human well-being.

1.5 THE OBJECTIVE AND THE IMPORTANCE OF THIS REVIEW

This review falls within the Oasis initiative. This initiative is catalyzed by the CGIAR as a Global Challenge Program to build inter-disciplinary and inter-institutional critical mass and to provide international Research-for-Development forum to confront and overcome desertification through an integrated systems approach.

The USAID-funded project to Combat Dryland Degradation is a part of the Oasis challenge program aiming at bringing together the right mix of inter-disciplinary advanced science with on-the-ground partnerships to make major gains in addressing land degradation. The CGIAR has been urging the centers to 'elevate their game' by aligning their collective work more visibly with such major global and system imperatives, and broadening their partnerships to solve major, difficult research problems. To contribute to the achievement of this goal, the CGIAR has developed an integrated approach to solve complex problems of natural resources management such as land degradation.

The context of this project is within the Oasis as a big challenged program to be led by ICARDA and ICRISAT. Oasis consists of four knowledge streams. This project aims to focus on themes 3 and 4 of the program portfolio through the following objectives:

1. Contribute to the development of enabling environment that overcomes the policy, market and institutional dynamics that aggravate land degradation.
2. Motivate dryland users to choose land rehabilitation over land degradation by identifying development pathways and livelihood options that lead to more sustainable, diverse, remunerative, and resilient dryland management
3. Translate successful changes at local levels to larger areas benefiting large numbers of rural poor.

This review aims then at reviewing existing and potential national/sector policy quantitative and qualitative assessment and its impact on land degradation: with discussion with policy makers,

scientists, extension, land users (focus groups) including the ability to change policy. This review attempts to examine available knowledge related to:

- Secondary information related to land degradation issues, causes;
- Existing policies and institutions and their impact; and policy environment;
- Effort to document the relationship between land degradation and policy;
- Cost of land degradation;
- Previous and existing projects.

2. Characterization of Land Degradation in Relationship to Agriculture

2.1 AGRO-ECOLOGICAL ZONING (OR TYPES OF FARMING SYSTEMS IN THE COUNTRY)

Morocco is located in the northwest corner of Africa, bordered by the Mediterranean Sea and the Atlantic Ocean on the north and west, by Algeria on the east, and by Mauritania on the south. Its total land area is 710850 km^2 and includes several zones, among which are agricultural plains and river valleys, plateaus, and mountain chains (Anon., 2004). Most of lands are arid to semi-arid from which 75% are rangelands, 13% forests and 8% are cultivated (Figure 2). Morocco has a Mediterranean climate characterized by a dry and hot summer (4 to 6 months) and a short and cold winter in elevations. The Mediterranean climate prevails over much of northern and central Morocco, and is moderated by the Oceanic influence. Moving southward, the climate becomes increasingly hot and arid with important temperature differences. Over two-thirds of Morocco can be classified as arid and semiarid, with low and variable rainfalls and frequent droughts.

The Moroccan climate varies from sub-humid in the north, semi-arid to arid in the center, to Saharan in the South. The rainfall rate is irregular in time and space. The average annual rainfalls reaches more than 1000 mm in mountainous areas of the north (Rif and Tangiers basin and West Mediterranean Coast) and less than 300 mm in the Moulouya, Tensift, and Souss-Massa basins, south-atlas areas and the Saharan area (Table 3).

Table 3: Climatic zones of Morocco

Climatic zone	Area (ha)	Percentage	Rainfall range
Extremely arid	440440	61.6	< 100
Arid	117260	16.4	100-250
Semiarid	106535	14.9	250-500
Subhumid to humid	50765	7.1	> 500
Total	711000	100	

Source: Ministry of Agriculture and Marine Fisheries – MAPM (1999); Laouina, 2007.

The North Atlantic Oscillation (NAO) is the main general circulation feature associated with the rainfall variability and the concurrent state of NAO is inversely related to precipitations. The relationship is in fact due to the major role played by the AZORES high pressure. Four mountain chains (High Atlas, Anti-Atlas, Middle Atlas and Rif) represent 15% of total country area and 70% of water surface flow generated by precipitations (Anon., 1999). More than 50% of the precipitations are concentrated over only 15% of the country area. In addition, spatial and temporal rainfall variability is considerable. Eighteen years of rainfall data (1988 till 2005) from 35 provinces showed an average annual rainfall for Morocco of 344 mm (Balaghi, 2006). This average may be misleading since provinces were given the same weight while they differ largely in size and geography. It also hides large variation among provinces, varying from 32 mm for the far South Saharan province of Dakhla to 866 mm for the mountainous region of Ifrane, a 27-fold difference in rainfall. There is a clear gradient of moisture from South to North. Six distinct classes of rainfall could be identified, labeled as Saharan, Pre Saharan, Arid, Semi-arid, Sub humid, and Humid, similar to agro-ecological classification.

Comparison with long term averages indicated that changes have occurred during the last 18 years, toward a decrease in rainfall, as reported by Balaghi (2006). Provinces belonging to the extreme classes usually maintained their dry/wet positions, but some of the intermediate provinces have slipped down to the drier classes, due to the overall decrease in rainfall. As an example, before the eighties the provinces of Kenitra used to be classified as humid, Meknès and Fès as sub-humid, and Settat as semi-arid. They are now classified as sub-humid, semi-arid and arid, respectively.

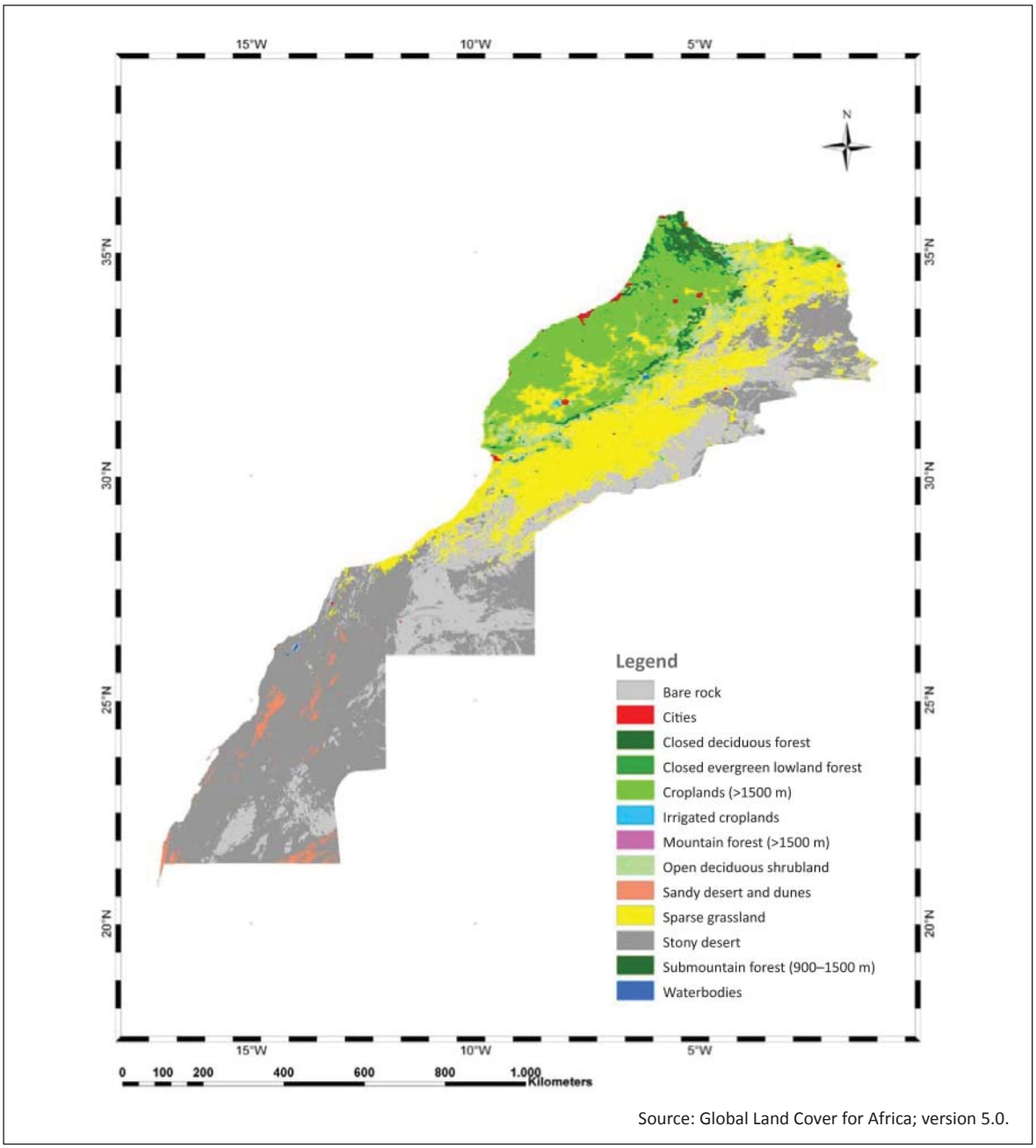


Figure 2: Land cover map of Morocco

Year-to-year variation of annual rainfall within each region is rather high in Morocco, ranging from a minimum of 23% (Oujda, in the northeast) up to 113% (Dakhla, in the south). Seasonal monthly rainfall appears to be concentrated in the period of September-May, with the months of November and December being the wettest, followed by October and January, and then February. There is practically no rain during the summer season. This pattern is encountered in all kind of seasons, whether the cropping season is dry, intermediate or wet. A similar pattern of monthly rainfall distribution is observed across all regions, with November and December being the wettest months followed by October and January. Differences between regions or seasons come from differences in the key months of November, December, followed by October and January.

Moroccan agriculture is mostly rainfed. It operates through a mixed and integrated crop/livestock system, representing the main source of income for the majority of rural households. Most arable land and rangeland in Morocco are located in areas receiving less than 400 mm of rainfall, where cereals and small ruminants mainly sheep are integral components of an extensive dryland production system.

In the framework of the land resources conservation orientation plan in rain-fed agricultural zones, an agro-ecological zoning was proposed (ISCRAL, 1994). The project was based on the analysis of soil constraints with respect to intensive agricultural development in non-irrigated areas. Homogeneous eco-logical zones were defined and delineated by overlaying 5 digital sheets of information at 1:2,000,000 scale: the structural map, the satellite image, the bio-climatic map, the soil resources map, and the pastoral ecosystems map. A total of 263 agro-ecological zones were defined automatically. These units were grouped into 44 principal zones. At another scale, these principal zones were grouped again into 7 major categories. Dixon et al. (2001) provide the most comprehensive description of the numerous farming systems currently in use throughout the world. They identify and broadly delimit these systems based on criteria that include:

- The natural-resource base;
- Dominant livelihoods (main staple and cash income sources as well as the balance between crops, livestock, fishing, forestry, and off-farm activities);
- The degree of crop-livestock integration;
- The scale of operation.

Table 4: Major farming systems

Farming Systems	Principal Livelihoods	Major features
Irrigated	Fruits, vegetables, cash crops	The system contains both large and small-scale irrigation schemes.
Highland Mixed	Cereals, legumes, sheep, off-farm work	There are two subsystems; (a) rainfed cereal and legumes plus tree crops (fruits and olives) on terraces, (b) livestock (mostly sheep) on communally managed lands. Poverty is extensive, as markets are often distant, infrastructure is poorly developed and the degradation of natural resources is a serious problem.
Rainfed Mixed	Tree crops, cereals, legumes, off-farm work	Supplementary winter irrigation is used for wheat and on summer cash crops.
Dryland Mixed	Cereals, sheep, off-farm work	The risk of drought is high and considerable food insecurity exists. Livestock, including cattle and small ruminants, interact strongly with the cropping and fodder system. Poverty is extensive among small farmers.
Pastoral	Sheep, goats, barley, off-farm work	
Sparse (Arid)	Camels, sheep, off-farm work	

Source: ISCRA, 1994.

Moroccan farmers pursue a wide range of crop and livestock enterprises that vary not only within but also across the major agro-ecological zones. The interaction of natural resources, climate and population determines the physical basis for farming systems (Table 4). As croplands, pastures and forests come under greater pressure, productivity and biodiversity are threatened and there may be growing tension between development and conservation goals.

Agriculture in Morocco is characterized by a dichotomy between the traditional and commercial sectors. The traditional sector consists of small farms in rain-fed areas involved predominantly in cereal, legume, and livestock production. The commercial sector operates mainly in irrigated areas. Farm surveys indicate that about 70 percent of farms are small in size (under 5 hectares) and account for 23 percent of total land under cultivation. Farms less than 20 hectares in size represent 96 percent of the number of farms in operation. The average size of a farm in Morocco is 5.7 ha.

2.2 FORMS AND TYPES OF LAND DEGRADATION:

The problems of environmental degradation are closely bound up with the development of populations and civilizations. Without some sense of how fast soils are being lost, it will be difficult to mobilize the resources to save them. The apparent increase in soil erosion over the past generation is not only the result of a decline in the skills of farmers but also of the pressures on farmers to produce more.

Soil erosion is a consequence of increased population pressure and overexploitation of forestry resources. Moroccan soils face high erosion rates which exceed international standards. Removal of natural vegetation from the slope lands and their conversion for cultivation exposed many extensive areas of the mountains regions and plateaus to soil erosion. This is particularly the case of the Rif Mountain, which is characterized by steep and long slopes, soft geologic material (marl and shale), and severe climatic conditions. Erosion rate in the Rif Mountain is one of the most severe ones in the world (30 to 70 t/ha/year; MADRPM, 1991). Also, overgrazing and cultivation of vulnerable land in arid and desert regions have induced severe wind erosion. Soil degradation is enhanced by inappropriate land management, mainly tillage. Tillage is one of the main degradation factors in the Mediterranean basin. Tilling up and down slope also produced a net soil transport in the direction of tillage and leads to soil degradation.

Soil erosion is a major environmental and economic problem that threatens the sustainability of dam reservoirs and agricultural lands in the Rif Mountains. A large effort is being made to limit soil erosion up stream of the dams (National Plan for Watershed Management). Erosion factors are of four types:

1. Water erosion;
2. Wind erosion;
3. Chemical erosion;
4. Physical degradation (Griesbach, 1993; Merzouk, 1985; Halitin, 1988; Karmouni, 1988; Lal, 1988 and 1995a; Mrabet et *al.*, 1993; Barbier, 2000; Hoegmood et al., 2000).

Almost all Moroccan lands face water erosion and more than 2 million hectares of agricultural lands are water eroded. Average soil degradation varies from 2.1 to 20 t/ha/year, but exceeds these rates in northern and north-western basins. In the pre-Rif hills, measured erosion in small basins is about 5.8 t/ha/year for a forested watershed, 18.4 t/ha/year for a mixed-use basin (cleared and cultivated), and over 90 t/ha/year in fully cultivated basins. Until year 1988, 700 million m^3 storage capacity was lost, and it is appraised that the actual annual loss of 50 million m^3 capacity will rise to 150 million m^3 in about year 2030, if siltation is not confined (Anon., 1995). As a comparison, the storage capacity loss is evaluated at 0.5 to 1% per year in the Mediterranean circumference, whereas it is 2% in Morocco.

Water erosion, considered as a natural process accelerated by man, is the main cause of the degradation of agro-pedological heritage as well as the deterioration of water quality that it entails. Soil erosion is the most important soil degradation process in Morocco, which affects up to 40% of its territory according to FAO (1990). The total annual soil loss is evaluated at 100 million tons which correspond to 50 million m^3 annual reduction in the storage capacity of the dams. A large effort is being made to limit soil erosion up stream of the dams through the National Plan for Watershed Management (Ouassou et al., 2006).

According to figures released on the occasion of the celebration, on June 17, of the World Day to Combat Desertification, the total cost of land degradation in Morocco amounts to around 7 Billion dirham, which is 1.7% of the GDP. Figures of the High Commissioner for Water and Forests also suggest that some 93% of Morocco's dry-weather (arid to sub-humid) areas are vulnerable to desertification due to overexploitation of natural resources. Anthropogenic deforestation and forest fires accounts for an annual loss of 30000 of forest land. In mountainous country, when plant cover is destroyed, gullying, torrents and landslides carry away much solid matter, causing widespread damage. In the plains, the most frequent problems are siltation of canals, rivers and ports, flooding of major riverbeds, muddy

Table 5: Soil degradation (in percent national area)

TYPE OF DEGRADATION		Spain	Morocco	Italy	Tunisia	Turkey
Water erosion	Extreme (a)	3.0	6.0	0.5		30.0
	Strong (b)	49.0	12.2	35.0	37.0	67.5
	Moderate (c)	12.5	25.7	47.5		
	Slight (d)	25.5	9.0			
Wind erosion	(a)					
	(b)		1.0		35.0	
	(c)		16.0			
	(d)					
Physical degradation	(a)					
	(b)			14.0		2.0
	(c)					
	(d)					
Chemical degradation	(a)					
	(b)	6.0			3.0	
	(c)		12.4	3.0		
	(d)	1.0	13.5			
Naturally sandy environments		3.0				
Lakes						0.5
Sebkhas[2]					6.0	
Dunes / deserts			4.2		19.0	

Source: PNUE-ISRIC, 1992.

colluvial deposits in residential areas. The overall environmental degradation represents a cost of 13 billion dirham (3.7% of GPD). The same estimates were given by (MAPM 1989).

Depletion of soil fertility is a major biophysical cause of low per-capita food production. Over decades, small-scale farming operations have removed large quantities of nutrients from the local soils without applying sufficient quantities of manure or fertilizer to replenish them. Wind erosion is damaging most agricultural lands. As an example: It is estimated that 300000 ha are subject to sand dunes in the regions of Ouarzazate, Zagora and Errachidia. There is a loss of 500 ha/year.

a. Relevant indicators of land degradation types

The indicators of natural resources have been examined for each of the major ecosystems, whether natural or managed, prevailing in Morocco (MADRPM, 2001). With regard to land degradation in the natural ecosystems, it is worthwhile noting the overuse of natural resources and the worrying pace at which erosion is spreading. Out of the 20 million ha of watersheds located upstream of existing or future dams, approximately five million ha face significant risks of water erosion. With an average soil loss of over 2000 tons/km2/year in the Rif region, Morocco belongs to the group of countries exhibiting the highest erosion rate.

On the other hand, the diagnosis of Moroccan forests shows quite a worrying degradation, resulting from the combination of excessive wood harvest, forest fires, crop encroachment and excessive harvest

[2]Sebkhas is a transliteration of the Arabic word for a salt flat. Sebkhas are temporary lacustrine systems.

of fuel wood. Thus, forest decline is estimated at approximately 31.000 ha each year, the breakdown of which is as follows : 22.000 ha corresponding to fuel wood harvest, at a level far beyond the productive capacity of the forest, 4.500 ha resulting from land clearance, 3.000 ha lost to fire, and 1.000 ha to urbanization and other domestic uses.

Similarly, rangelands are subject to impoverishment of their vegetation cover. In this regard, approximately 8.3 million ha of rangelands are heavily degraded. They are located mainly in the eastern regions of Morocco (the Oriental), the Souss, the Pre-Sahara and the Sahara. Furthermore, land clearing affects more than 65.000 ha, taken from the best grazing lands of the country. Managed ecosystem's degradation occurs in both rainfed agricultural lands and in irrigated areas:

- Rainfed agricultural lands are constantly exposed to numerous forms of water and wind erosion, leading to loss in soil fertility and arable land. A comprehensive study conducted in 1973 concluded that out of 7,7 million ha of agricultural lands, which were concerned by the survey, 5,5 million ha were subjected to intense erosion
- Various forms of degradation including overexploitation of the water table also threaten irrigated lands and water pollution resulting from untreated domestic and industrial waste waters. Salinity is, however, the most visible expression of irrigated land degradation. It occurs in most Moroccan irrigated systems. Available data on salinity indicates that approximately 500.000 ha located mainly in the command areas are threatened by salinity
- The oasis is also threatened by salinity and sanding. A study, conducted in 1982 on 21.000 ha, revealed that 35 % of the Tafilalet palm grove soils were salty (4 to 6 g/l), and 18 % very salty (> 16 g/l). In addition, sand movement continuously threatens houses, agricultural lands, irrigation canals and roads. Affected areas are estimated at 30.000 ha in the Ouarzazate province and 250.000 ha in the Errachidia province.

According to (WB, 2003), the Environmental Sustainability Index (and ranking) for Morocco in 2002 were 49.1 (73rd). Soil erosion and salinization emerged very early in Morocco along with the introduction of agriculture and irrigation. The other forms of degradation are not documented and their severity and risks have not been yet assessed. The state of the art inventory suggests that soil degradation is very swift.

Topographical and climatological factors associated with high population growth make Morocco a favorable area for erosion. Erosion processes remove the fertile part of the soils and thus reduce the effective depth to be exploited by roots. Calcium carbonate accumulation at shallow depth as caliche or soft deposits limits soil depth and thus the amount of available water to plants. This is a major constraint limiting the agricultural arable land in Morocco.

There are also a number of causes of soil degradation: salinization, water logging, compaction through mechanization, mineralization of organic matter, and skeletonization through selective erosion. Many studies conducted in the irrigated perimeters have shown that irrigation leads generally to soil and water quality deterioration. The major types of degradation are: secondary salinization, surface sealing, ground water recharge by drainage water, rising of saline groundwater, reduction of soil drain-age, soil compaction, and loss of organic matter.

Most of the post management studies done in the irrigated zones of Morocco demonstrated that many soils, initially non-saline, became saline, after a number of years of irrigation. At present, the surface area of saline soils is estimated by about 350,000 ha (Badraoui, 1998). Most of this area is located in the Tafilalet, Ouarzazate, Bahira, Tes-saout Aval, Moulouya, Tadla, Doukkala, and Gharb perimeters (Table 6).

Table 6: Land Salinization by basin

Irrigated basin	Area affected by salinization (x 1000 ha)	%
Gharb	15	12.5
Basse Moulouya	30.2	27.7
Haouz	24.6	29.9
Tafilalelt	20.9	70.4
Ouarzazate	14.5	65.9
Tadla	19.3	24.5
Doukkala	0.6	1
Sous Massa	9.8	28.8
Loukkos	2.8	14.5
Bahira	21	22.8
Total	158.7	

Source: Badraoui, 1998.

The principal causes for secondary salinization are:

- Drainage systems do not exist or not functioning properly;
- Saline groundwater rising and high evaporation;
- Using irrigation water with high content of salts and/or sodication hazards;
- Absence of natural outlet for drainage water.

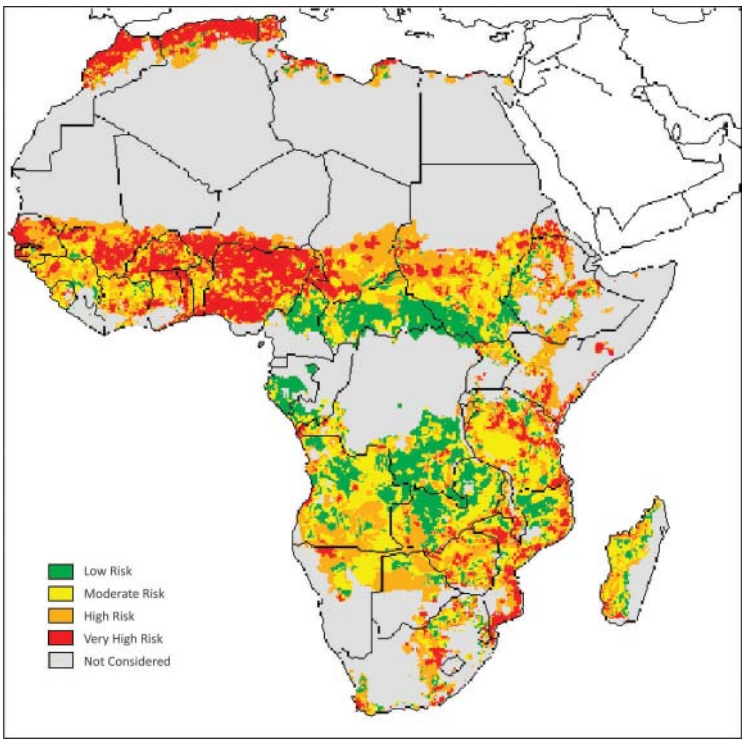
Loss of organic matter is also one of the major consequences of intensive cropping under irrigation. Irrigated soils in Mediterranean regions can be considered as incubators providing optimal conditions (humidity and temperature) for microbial activity and thus a rapid degradation of organic carbon. A mean annual variation rate of organic matter of - 0.09 % per year during the last 10 years was established in Doukkala region (Badraoui, 1998). This decrease of organic matter is attributed to the non-incorporation of crop residues into the soils. Crop residues contribute to about 30% the total forage consumption in Morocco.

Inappropriate water management under conditions of irrigated lands lead to soil salinity, sodicity and water-logging. Vast areas of irrigated lands suffer from pollution, including overuse of chemical fertilizers, pesticides and herbicides, industrial wastes and inappropriate soil amendments. Overexploitation of irrigated arid lands beyond the low capacities and the fragile qualities of arid soils with low resilience, especially at the early stages of reclamation, aggravates the problem even further.

Continued deforestation for different reasons including deforestation to convert to cultivated lands, fires leading to destruction of thousands of hectares every year, cutting trees and shrubs for fuel. Mismanagement of forestlands is leading to decline of their goods and services. Such land-use changes induce changes in surface runoff, erosion and groundwater. More generally, as a result of climatic and anthropogenic shifts, hydrological fluxes and physical characteristics evolve in the sense of desertification.

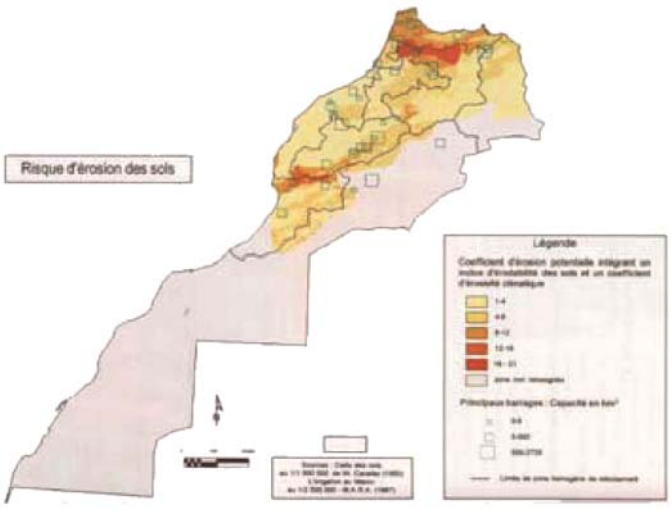
b. Effort to document land degradation

Geographical prevalence and estimated area affected, GIS mapping, soil surveys. Any estimate of Morocco's soil losses depends on fragments of data that exist for various parts of the country, as well as assumptions to fill in the gaps in the global data fabric (Figures 3 & 4). According to an FAO study



Source: Reich et al. (2001).

Figure 3: Risk of human-induced desertification



Source: Ghanem, 2005.

Figure 4: Erosion map of Morocco

(FAO 1990), 40 % of agricultural lands are under water erosion risks. The most important data on erosion by water can be summarized as follow (Benbrahim et al., 2004):

- For a total land area of 22 700 000 hectares, 12 500 000 hectares of agricultural and pasture lands are eroded by water (MAMVA, 1995);
- In a report, from 7 500 000 hectares of agricultural lands, 5 500 000 hectares are highly eroded (MAPM, 2001);
- From 20 million hectares of watersheds, 5 millions are already eroded, 11 millions are highly eroded and 3 million hectares need urgent soil erosion control (MAPM, 2001).

Indirect sources of evidence include hydrological studies of river silt loads, rates of reservoir sedimentation and personal experiences of soil scientists and government officials. 74% of the 22 watershed basins of Morocco are under menace of water erosion. In fact, a total of 100 million tons of soil losses and a reduction of 50 million m^3 of dams' storing capacity are registered.

The soil's chemical, physical and biological properties undergo important changes which play an essential role in causing vulnerability to desertification due to human activities. This phenomenon prevents the reconstitution of the vegetal cover and can be considered as the ultimate form of soil degradation.

Most research studies show the overall important part of anthropic actions on land degradation in Morocco, and evaluates the level of water erosion in Northern Morocco (Rif and pre-Rif areas), wind erosion in Southeastern Morocco (Drâa and Ziz valleys), overgrazing in Eastern Morocco, salinity in Southwestern Morocco, and deforestation in general. Wind erosion is poorly studied in Morocco. It is however suggested that in some situations the thresholds of irreversibility have already been reached or even exceeded (Zobisch, 1998). GIS and remote sensing coupled with erosion modeling are principal tools used for analyzing spatial extent of soil erosion in Morocco, basically at watershed levels (Bou khier et al., 2001).

c. Causes and consequences

The climate is the first determinant of land degradation. Its major characteristics are extreme variability, low rainfall, an average duration from 4 to 6 months, and the wintertime cold, which in altitudes over 1500 m, is a real constraint for plant growth and development. Scarcity and fragility of water and arable land resources contribute to their degradation through deepening the chronic unbalance between increasing population and available natural resources. In 1990, water availability per capita/per year was 1,151 m^3. It is predicted that this quantity will drop to only 689 m^3/per capita/per year, in 2025. Similarly, arable lands will undergo the same constraints already affecting the water resources.

Natural resource degradation in Morocco is partially linked to the strong population explosion. In the rural world, the current population trend encourages the proliferation of unsustainable production patterns based on land use which is incompatible with its production capacity. In order to overcome the natural hazards and meet their basic needs, populations continue to substantially depend on natural resources. They often resort to irrational practices, such as deforestation and overexploitation of lands and pastures which are, in many ways, contrary to the vision of distinctive sustainable development.

d. Anthropogenic Factors

Morocco's increasing population pressure and the accelerating loss of topsoil seem to go hand in hand. Overgrazing is the most important cause of soil degradation, accounting for 49 percent of the area, followed by agricultural activities (24 percent), deforestation (14 percent), and overexploitation of vegetative cover (13 percent). All these types of degradation cause a decline in the productive

capacity of the land, reducing potential yields (Lamar & Ruellen, 2007). Removal of natural vegetation from the slope lands and their conversion for cultivation has exposed many extensive areas of the mountains regions and plateaus to soil erosion. This is particularly the case of the Rif Mountain, which is characterized by steep and long slopes, soft geologic material (marl and shale), and severe climatic conditions. Erosion rate in the Rif Mountain is one of the highest in the world, 30 to 70 t/ha/year (MADRPM, 1991). Over-grazing and cultivation of vulnerable land in arid and desert region have also induced severe wind erosion.

Mechanization of agricultural systems has been accompanied by damaging effects and pressure on the environment. These negative effects on the environment have created an increasing awareness of the need for an economically and environmentally sustainable agriculture and consequently a review of much of the soil management practices. The need for tillage has been questioned, in the last decades, partly because of the excessive erosion from farmlands (Mrabet, 2008). Intensive land cultivation methods using tractors and plows are a major cause of severe soil loss and land degradation. Especially in warmer areas, where the topsoil layer is thin, conventional tillage contributes to soil loss. However, most farmers, researchers and extension agents still believe that loosening the soil with tillage implements increased rainwater infiltration. Some of the adopted management practices include extensive tillage with heavy machinery, lack of proper crop rotations and integrated farming systems, cultivation of exotic crops that need elaborate efforts and excessive nutrients and water.

e. Forest Degradation

Desertification threatens 90 percent of land in Morocco where forests cover only 8 percent of the national territory. Degradation of plant and forest cover call for enhanced soil erosion processes that bring about adverse environmental impacts, a decline of palatable species and domination of non-palatable and invasive species. Cultivation of marginal lands and forest clearing to increase the cereal production have led to destruction of plant cover and loss of valuable biodiversity for the sake of achieving marginal productivity. At present, reforestation efforts are unable to come even close to offsetting the loss of natural forests.

f. Climate change

Morocco receives most of its precipitation during the northern hemisphere winter semester (October-March), when the most significant climatic feature is rainfall (Lamb and Peppler, 1988). Precipitation is inversely related to the concurrent state of the North Atlantic Oscillation (NOA). This inverse relationship between Moroccan precipitation and the NOA is stronger around the Atlantic coast. Approximately 95 to 98 percent of rainfall occurs in the country during the period from October to May and this coincides with cereal production cycle.

Morocco is particularly vulnerable to the impacts of climate change because of widespread poverty, inequitable land distribution, and overdependence on rainfed agriculture. Most models predict more frequent and severe extreme-weather events, including both drought and flooding. Since 1980, however, droughts in Morocco have been very severe with a decrease in precipitation of about 25 percent, compared to the long-term average. Climate change exacerbates soil degradation in the dry areas (pastoral, agro-pastoral, and sparse 'arid' systems). Prolonged drought has already led to adverse ecological consequences, including loss of plant cover in some areas, elimination of bushes, the lowering of groundwater tables - especially near wells and watering holes, an increase in shifting sands and greater wind erosion of fine soil components.

Widespread land degradation processes are conducive to serious foregone economic returns, reduction in returns from capital investments, lower income of rural households, spread of poverty and increased rural to urban migration.

Variability in rainfall, as well as variability in flow of major rivers, conveyance and on-farm losses of water resources, inadequate water harvesting and spreading techniques, as well as, under exploitation

of vast groundwater and non-traditional water resources contribute to deficiency and inefficiency of water resources supply and utilization.

g. Institutional and public policies

Other institutional and governance factors compound natural resources degradation at varying levels. The complexity of the land use patterns in Morocco is also compounded by the difficulties linked to the multiple age-old land tenure systems. These attributes are often perceived, and sometimes wrongly, for being responsible for the constraints tied to the land tenure system, often resulting in a feeling of insecurity yielded by some Moroccan land ownership systems and a user-resource relationship dominated by behavioral patterns, having something in common with short-term overexploitation and abuse.

On the institutional and public policies levels, some incoherencies and dysfunctions are noted in the arsenal of incentive measures implemented so far. Uniform implementation of the provisions of the Agricultural Bank and the Agricultural Development Fund loan schemes (subsidies and loans, price support) throughout the country without proper consideration of ecosystem specificities have resulted in inadequate resource allocations. This has also generated some distortions in the production systems, promoting crop expansion at the expense of forest and rangelands, unsuitable for agricultural activities.

a. Changes in land using patterns

The studies on erosion in Mountain regions are numerous, mainly in the Rif (Benbrahim et al., 2007). According (Naimi et al. 2005), in Nakhla watershed (northern Morocco), the interpretation of aerial photographs along with field work, shows that slightly eroded zones represent 46% of the total area of the watershed, whereas sheet and rill erosion represent respectively 40% and 1.7%. Gully soil sliding erosion and badlands extend on 9.65% and 0.97% of the overall area, respectively. Land slide erosion represents 0.64% of the watershed. The distribution of erosion forms inside the watershed shows that bulk erosion and sheet erosion zones are located on all lithological facies and on all slope classes. All forms of gullies expand mainly on marls and on slopes ranging between 10% and 30%. Badlands extend on moderately hard flyschs with slopes exceeding 50%. Landslides and caving-ins develop on flyschs and locally on marls with slopes of 10% to 50%, while bank sappings are spread out on soft alluvium of lower slopes.

b. Impacts on land productivity

One of the most difficult challenges facing nations attempting to implement the desertification Convention is the integration of productivity considerations into national development programs. Productivity increases have been significant and consistent over the last five decades in the irrigated farming systems. Over 50 percent of the areas currently under irrigation need to be rehabilitated due to soil quality decline and salinization, if they are to achieve their sustainable potential.

Morocco has experienced a drought in one year out of every three years over the past few decades, (UNEP 2002). Serious problems of land degradation, desertification, declining soil quality, reduced soil fertility and low agricultural production levels may be irreversible if appropriate measures are not taken soon (Mrabet, 2008).

2.3. ESTIMATED COST OF DEALING WITH LAND DEGRADATION

The degradation cost of agricultural land can be assessed by the value of lost agriculture production due to a decrease in land productivity. This study supposes that the majority of agricultural land is planted with cereals. Therefore, the cost of degraded agricultural land corresponds to the value of

lost cereal production. The cost of rangeland degradation is estimated through the value of lost forage production.

a. Method for estimating land degradation

The methodology adopted to estimate the share of degraded agricultural land is that developed by (FAO, 2000). According to FAO, degradation is expressed by a temporary or permanent decrease in land productivity due to human activity. FAO distinguished four degrees of land degradation in terms of land productivity reduction, (Table 7):

Furthermore, FAO distinguishes five geographic range intervals for degradation, which represent the share of degraded land in one mapping unit. This share ranges from 0 to 5 percent; 5 to 10 percent; 10 to 25 percent; 25 to 50 percent and 50 to 100 percent. By combining degrees and geographic or spatial ranges of erosion, FAO obtains four ranks of degradation severity (slight, moderate, severe, and very severe) and consequently twenty combinations of degree-range highlighted in (Table 8):

Table 8 suggests that 10 to 25 percent of land is subject to extreme degradation, 25 to 50 percent of land is subject to strong degradation, or 50 to 100 percent of land is subject to moderate degradation. Also it suggests that 10 to 25 percent of land is subject to heavy degradation, or that 25 to 50 percent of land is subject to moderate degradation or that 50 to 100 percent is subject to slight degradation.

Table 7: Degradation land degree

Degree of degradation	Effect
Slight	Low reduction in productivity
Moderate	Considerable reduction in productivity
Strong	Biological functions of soil are considerably destroyed;
	no potential for rehabilitation and use
Extreme	Biological functions of soil are considerably destroyed; non recoverable.

Source: FAO, 2000

Table 8: Degrees, ranges and ranks of degradation according to FAO

	Degradation Range (percentage)				
Degree of degradation	0-5	5-10	10-25	25-50	50-100
Slight					
Moderate					
Heavy					
Extreme					

Source: FAO, year 200.

Severity ranks

Slight Moderate Severe Very severe

Application to the case of Morocco:

Table 9 shows land degradation over all Moroccan territory (excluding the Saharan provinces). It shows that 19 percent of land (or 8.7 million hectares) is subject to severe degradation:

b. Degradation of agricultural land

Agricultural activities and cultivation cause land degradation. FAO (2000) notes that land degradation also results from deforestation, overgrazing, overexploitation of biomass, and industrial activities. The contribution of each to total degradation was not calculated, however, it was possible to estimate degraded land due to agricultural activities.

"Agricultural activities" signify the impact of agricultural activities on land degradation. Degraded land could be as much as 8.7 million hectares (Table 10), representing 19 % 36 of total area (excluding the Saharan provinces). This corresponds to 100 percent of severely degraded land.

Table 9: Land degradation in Morocco

Degradation rank	Area (thousands of hectares)	Percent (%)
None	2,000	4%
Slight	4,200	9%
Moderate	29,700	67%
Severe	6,300	14%
Very severe	2,400	5%
Total	44,700	

Source: FAO, 2000

Table 10: Land degradation in Morocco due to agricultural activities

Degradation rank	Morocco
Total area (000 ha)	44,700
Land degradation	
Severe degradation (000ha)	6,300
Very severe degradation (000ha)	2,300
Total degradation (000ha)	8,700
Percent of total degraded area	19%
Land degradation due to agricultural activities	
Severe degradation (000ha)	8,700
Very severe degradation (000ha)	
Total degradation (000ha)	8,700
Percent of degraded area due to agricultural activities	100%
Percent of total degraded area due to agricultural activities	19%

Source: FAO, 2000

According to (Table 10), the degradation of 8.7 million hectares is classified as "severe". According to (Table 8), "severe" corresponds to several degree combinations and degradation ranges. The following scenarios are thus possible:

- 10 to 25 percent of the land is severely degraded;
- 25 to 50 percent of the land is moderately degraded;
- 50 to 100 percent of the land is lightly degraded.

Of all surveys conducted on land degradation in Morocco, none shows severe land degradation (or a non-recoverable loss of the soil's biological function). Thus, only scenarios for moderate and light degradation are used in this analysis. As an example, an FAO study of Morocco showed that since 1975, of 22.7 million hectares of side basins, only 8.2 million hectares have been suitable for cultivation of which 50 percent require urgent soil conservation measures. In reality, that leaves 4.1 million hectares suitable for cultivation. The remaining 14.5 million hectares should not be cultivated at all.

Another survey conducted by the Ministry of Agriculture and Agricultural Development (MAMVA, 1996) found that 2.1 million hectares of agricultural land suffer from water erosion. This area is believed to be underestimated; however, since the report's authors only studied priority sites requiring urgent intervention, the actual number of affected hectares is likely to be far greater than 2.1 million hectares. We can therefore consider that these hectares face "severe" to "very severe" degradation.

c. Assessing the cost of degraded agricultural land

To estimate the cost of degradation, this study used the average of the lower bound of moderate and slight erosion and the average of the upper bound of moderate and slight erosion. According to (Table 11), the cost of degradation ranges from 842 million to 1,683 million Dh, averaging 1,263 million Dh (or 0.36 percent of GDP).

Table 11: Cost estimate of degraded cultivated land

	Lower limit	**Higher limit**
Moderate erosion	25%	50%
Degraded agricultural land (000 ha)	2,175	4 ,350
Level of decrease	20%	20%
Decrease in yield (qx/ha)	2	2
Lost production (000 qx)	4,350	8,700
Lost value (million dirhams)	1,122	2,244
Slight erosion	50%	100%
Degraded agricultural land	4,350	8,700
(000 ha)		
Level of decrease	5%	5%
Decrease in yield (qx/ha)	0,5	0,5
Lost production (000qx)	2,175	4,350
Lost value (million dirhams)	561	1,122
Average (million dirhams)	842	1,683

Source: MAMVA, 1996

d. Rangeland degradation

Morocco's 65 million hectares of pastureland are the primary source of animal feed, providing 30 percent of overall requirements. However, pastureland is under pressure from climatic factors (erosion, drought) as well as animal (overgrazing) and human factors (land clearing for cultivation, removal of woods). (Table 12) provides the distribution of pasture land nationwide (as described in the REEM, 2001).

Degraded pasture land.

The share of degraded pastureland will only be calculated for the area with dominant steppe and forest covers (excluding the Saharan region). These pasture lands cover an area of 12 million (58 minus 46) and 5.1 million hectares (according to table 6). The percent of degraded rangeland is 46 percent and 19 percent respectively. This is an average calculated based on data from MADREF and stated in (REEM 2001).

Table 12: Distribution of pastureland (millions of hectares)

Area		Forests	Steppe
Dominance steppe	58	0.64	57.4
Saharian	46	0	46
Presaharian	5.7	0.06	5.6
Oriental	5	0.3	4.7
North Atlas	1.3	0.29	1.01
Arganeraie	1.5	0.7	0.8
Dominance forest	5.1	4.7	0.4
Middle Atlas	1.2	1.0	0.2
High Atlas	2.2	2.0	0.2
Rif	0.9	0.9	0
Mamora, centr. plateau	0.8	0.8	0
Dominance cereal	0.1	0	0.1
(sahel pasture)			
Coastal Meseta	0.1	0	0.1
Total	64.7	6.1	58.1

Source: REEM, 2001

e. Loss of productivity due to rangeland degradation

The "National Plan for Watershed Management" adopted two levels of loss: six percent and ten percent. Based on these levels, the total loss in fodder production ranges between 26 to 44 million units in regions with steppe dominance and 32 to 54 million units regions with forest dominance (Table 13).

Table 13: Loss in fodder production

	Dom. steppe	Dom. Forest	Total
10 percent loss			
Pasture area (000 ha)	12,000	5,100	17,100
Percent of degraded area	46%	19%	
Forage production unit/ha/yr	79	558	
Loss in yield	0.1	0.1	
Loss (000 units)	44,096	54,070	98,166
6 percent loss			
Pasture area (000 ha)	12,000	5,100	17,100
Percent of degraded area	46%	19%	
Forage production unit/ha/yr	79	558	
Loss in yield	0.06	0.06	
Loss (000 units)	26,458	32,442	58,900

f. Total cost of land degradation

The total estimate for land degradation cost ranges from Dh 975 to 1,900 million, or an average of Dh 1,440 million (0.41 percent of GDP). It is important to note that this analysis is limited to degradation of cultivated land and does not include the impact of salinity on irrigated soil. Therefore estimates provided above are likely to underestimates the total impact of land degradation.

Table 14: Damage cost of rangeland degradation in 2000

Nature of rangeland	Dom. steppe	Dom. forest	Total
Degraded pastures (thousands of hectares)	5,520	969	6,489
Damage cost (million Dh) loss of 10%	100	123	223
Damage cost (million Dh) loss of 6%	60	74	134
Damage cost (million Dh) average	80	98	178

Source: REEM, 2001

3. Dealing with land degradation

3.1 POLICY ENVIRONMENT IN THE COUNTRY

The policy for erosion control dates back to 1951 with the launching of the soil restoration law. The law for forest conservation and use is as old as 1917. The national forest plan was re-instigated in 1970 and reformulated in 1998 to protect forest and water bodies. The national plan on watershed management was accepted in 1996 in order to rehabilitate 75.000 hectares per year up to 2016. In 1970s, the government developed a national plan for pasture and rangelands. The sectorial approaches adopted to attenuate the natural resources deterioration showed their limits because the increasing amplification of the deterioration (Mrabet, 2001). In this context Morocco finalized in 2001 a National Action Program (NAP) of Combating Desertification (CD) which constitutes an important stage in the process of its commitments within the united nation convention for combating desertification (MAPM, 2003). In fact the government of Morocco signed the international convention for combating desertification in 1994 and ratified it in 1996.

a. Priority status of dealing with land degradation in the National Development Plan

Morocco realized scattered activities in the seventies and eighties to combat degradation in one or more of the land use categories. The activities were based on sectoral approach through governmental institutions and public authorities. Activities included surveys, studies, formulation of pilot programs, and execution of limited projects. These activities were of limited duration and discontinued nature.

Morocco's approach to sustainable development is mainly environmental. The two main strategic documents are the National Strategy for the Protection of the Environment and Sustainable Development (with French acronym, SNPEDD) from 1995 and the National Plan of Action for the Environment (with French acronym, PANE) of 1998.

The Kingdom of Morocco ratified a desertification National Action Program (NAP) in 2001. In light of this development, various partners have supported the country financially and have provided intensive back-up through consultation. The Moroccan Action Program links efforts to combat desertification with poverty reduction and rural development.

Morocco's policy for environmental management and combating desertification is developed as an integral part of the National Action Plan for combating Desertification (NAPCCD), and the National Action Plan for the Environment (NEAP). These are strategic documents for sustainable development, approved and enforced by acts of parliament. The Government of Morocco's agricultural and rural development strategy for 2020, along with the National Initiative for Human Development, is a large-scale poverty reduction program designed to:

1. Alleviate poverty, vulnerability, marginalization and social exclusion by improving the incomes and the living conditions of vulnerable people;
2. The establishment of a sustainable dynamics in favour of human development, the prosperity and wellbeing of all the people of Morocco.

b. Institutions dealing with land degradation (government agencies), their responsibilities and capacity

A more general concern about environmental problems was growing in Morocco when the Rio Conference took place in 1992 and the country reacted actively by creating its Ministry of the Environment (Département de l'Environnément or DoE) just after this summit, and also by paving the way for creating the National Strategy for the Environment and Sustainable Development.

The other step in that direction was taken in 1995, when the government initiated the dynamization of the National Council of the Environment (CNE) which created in 1980 as consultative and coordination body for stakeholders (ministries mainly). Apart from the Rio Summit, another strong factor urged the principles of Sustainable Development to take into account the liberalization of the economy, principally through the cooperation with the US, as well as the European Union in 2010.

The development of dynamic and durable farming systems requires a conducive policy environment. A myriad of agencies and institutions are responsible for the protection of the environment and combating land degradation in Morocco. At national level, they are shared by more than six main ministries:

- Land use management;
- Water and Environment;
- Equipment and Transport (National Directorate for Meteorology);
- Agriculture and Maritime Fisheries;
- Energy;
- Habitat and Urban Planning.

Alongside the traditional administrations and other sectoral institutions whose activities can cause environmental damage, Morocco also has several councils related to general environmental conservation activities such as the Superior Council for Water and Climate. The major institutions that are specifically concerned with land degradation, however, include the Ministry of Agriculture and Fishery, the High Commission for Forest and Desertification and the Department of Environment. It is noteworthy that despite all these important government structures and programs, the public spending for the environment in Morocco has not exceeded an estimated 4.320 billion Dirham, i.e. 0.007% of the GDP. There has been a gradual acceptance of the need to re-orientate development towards the elimination of poverty, based upon sustainable resource use. Five broad strategic initiatives were proposed:

- *Sustainable resource management*. Natural resources need to be conserved, through improved watershed management in hill and mountain areas, soil conservation in sloping lands and improved range management in pastoral areas. Components include: strengthening local resource-user groups; better management practices; and improved long-term policies.
- *Improved irrigation management*. Increased efficiency in irrigation water management is essential to support the intensification and diversification of production and to reduce resource depletion. Components include: schemes based on both surface and underground water technology; and adjustments to water charges and other regulatory measures.
- *Re-oriented agricultural services*. The re-orientation of agricultural research systems to fully involve farmers will underpin intensification in the irrigated and rainfed mixed systems and enterprise diversification in all systems. Components include: extension services based on a variety of public and private service providers; and greater support for rural agribusinesses to create off-farm employment for farmers.
- *Revitalized agricultural education systems*. New approaches to science and higher education learning systems are particularly important in the training of agriculturalists who will work in both public and private sectors. Components include: the adoption of the significant advances in interdisciplinary learning and systemic thinking which have played such an important role in agricultural education elsewhere in the world.
- *Rationalized agricultural policies*. The challenge to Moroccan agriculture is not only to enhance production to meet the increased food demands of the expanding population, but also the judicious use of soils so that their productivity is sustained in the foreseeable future. This is the main objective of the new strategy of Morocco's Green Plan.

c. Existing policies

The adoption of the United Nations' Convention on Desertification Control (UNCDC) in June 1994 and its entry into force in December 1996 represents an important landmark in the process initiated by the international community to attempt facing up to the challenges posed by desertification and drought control. This convention recognizes the importance of putting populations at the forefront of any activity whose purpose is to redress the land degradation trends in the areas that are hard hit by desertification. It also underscores the importance of adopting a participatory approach in addressing these issues. In this regard, concerned parties are urged to design national action plans to combat desertification and to ensure that the whole process of design and implementation of desertification control activities truly involves grass root populations.

The National Action Plan to combat desertification and drought effects (henceforth the NAP) is the outcome of a long process followed through by all the stakeholders. The concepts of concertation and participation were fully put into practice through organizing meetings, workshops and seminars and also through field visits. In addition, consultations initiated with the interested local populations allowed us to have a better grasp of their perceptions of land degradation, their expectations as well as the core actions they deem fit.

From a conceptual perspective, the NAP provides both a general guidance framework and ways to schedule actions, as it is not the only ongoing planning framework existing in Morocco. The NAP fits within a broader scope integrating all activities and initiatives aiming to achieve the goal of sustainable development.

These frameworks overlap and have common relations that lack the synergy and complementarity needed to create the appropriate conditions that would help attain sustainable development in Morocco. Finally, since the NAP is more a participatory planning process than a mere document, it is vital that a consensus and collaboration between all involved actors is maintained throughout the implementation phase, just as it was throughout the preparation phase. In line with this logic, and in compliance with the spirit and provisions of the UNCCD, the setting of an appropriate institutional mechanism and an operational system for monitoring and evaluation are criterial for a flexible and dynamic implementation of the NAP.

The National Action Plan to combat desertification represents a basic tool for implementing the international convention on combating desertification in Morocco. Recognizing the importance of this facility and its determining role in the success of the implementation of the convention, the design of the NAP-Morocco was planned methodically and according to a carefully put time schedule that sets the success conditions for its implementation as a priority. The important stages covered by the National Coordination Body and the Steering Committee for the NAP are designed as follows:

- an initial long stage of raising awareness and disseminating information and relevant documentation on desertification (a stage initiated in 1994, even before effective entry of the convention)
- a stage, especially allocated for analyzing the status quo, of desertification control
- a local and regional concertation stage that builds the NAP on negotiated results with the concerned parties in different areas
- a stage to perform the basic focus studies, including harmonizing existing plans and funding mechanisms
- a stage for a joint formulation of the NAP, its validation by a national Forum and its adoption by the government.

The government's adoption of the NAP is being supported by concrete provisions related to its implementation. The re-attachment of the NAP's steering structures to the Permanent Inter-Ministerial Council for Rural Development, presided over by the Prime Minister, is an evident act of support, conceived as a conceptual framework for the operational implementation of Strategy 2000 for rural development.

The financing of the NAP in the next economic and social development plan has been provided for and an agreement over the Rural Development Fund as a financing framework has been reached while waiting for the implementation of a more specific and more appropriate mechanism. The expansion of the National Coordination Body (NCB) to external multilateral and bilateral partners, represented by two leading agencies, has also been considered.

d. Social development, the National Initiative for Human Development (INDH)

Launched by his Majesty, King Mohamed VI, on May 18, 2005, this initiative is an innovative step towards a comprehensive development of the country. It is a five-year plan for sustainable socio-economic and political development through different development projects, which aim at building infrastructure and providing employment and social services, particularly in rural areas (403 rural communities characterized by high rate of poverty >30%). The 2020 Strategy of Rural Development and the plan of action for its implementation are integrated within the framework of the orientations and principles of the INDH. The long term goal is to promote a pattern of development which fulfills the needs of the population while ensuring that the environmental resource base is maintained for future generations.

In order to achieve this goal, a comprehensive approach integrating rural development and environmental protection is adopted. This implies working with local communities, building capacities, launching model projects and influencing the policy frameworks operating in the region. Such an approach requires working from the local, through the regional and up to the national level.

e. Agricultural policies influencing land use and patterns

Seeking to revive the agricultural sector in the face of an exacerbating global food crisis, the Moroccan government has decided to opt for a new strategy. This new, ten-year-long strategy will focus on improving the situation of farmers and creating employment and wealth. This plan aims at boosting the Moroccan economy as well as elevating the standard of living of Moroccans. The new strategy will provide farmers with technical and financial assistance to increase their production.

The plan invests 11 billion Dirhams in creating a national agricultural fund as well as developing over 1500 new projects, including the development of rural farming. It considers sustainable development of farmers' working conditions, subsidies for irrigation and other farming equipment, the establishment of storage and marketing units for farm produce, and the intensification of livestock operations.

To help the process, there are calls for a new "one-stop shop" to help improve the Moroccan farming sector by accelerating formal procedures. It is estimated that the current legislated average, for example, means waiting for 13 months before obtaining the necessary financial aid; a reasonable target is considered to be 40 days. The new farming policy aims at promoting and guiding private investment through targeted subsidies and focusing on activities which would make better use of the country's agricultural potential.

Ten regional funds, as well as, the national fund that allows farmers to increase their production, are also about to be launched; a new strategy that has been applauded by Moroccan farmers. Accordingly, the state must take a mediator's role between the sector and investors to speed up change. Given the realities of the sector, the current situation of farmers calls for a redefinition of the state's role in the form of new relationships between the producers and industry players. The state must orchestrate programs that facilitate innovation, financing and access to markets.

Such active state support of the agriculture sector is of little value, given the lack of rainfall in 2007. Directly or indirectly responsible for the livelihoods of roughly half of the country's population, agriculture represents a source of both concern and potential for the Moroccan economy. The agriculture sector's most immediate need concerns the country's significant dry spell. The government

has already begun to address this particular issue by organizing an array of subsidies to subsidize purchasing state-of-the-art equipment that reduce water loss in irrigation systems.

In addition to addressing water-related issues, the ministry's new strategy must also address another major hurdle; inheritance practices. These practices in rural Morocco dictate that the land is transferred to successive generations and split into equal shares. This traditional practice has been responsible for the decreasing size of the average plot of farmed land. According to government statistics, roughly 69% of Moroccan farms consist of plots of less than 5 ha. Only 11,000 farms currently operate on lands in excess of 50 ha.

While small and medium-sized farming operations limit productivity levels, subsidies do not provide long-term, viable solutions. As Morocco gradually integrates into the global market, its farmers will further fall behind more efficient and modernized foreign competitors, unless reforms are implemented. Moreover, the World Trade Organization and the Free Trade Agreement guidelines will apply greater pressure if the country fails to overhaul the sector.

To begin the restructuring process, the Moroccan government has pursued a strategy of leasing state-farms previously under the management of Société de Développement Agricole (SODEA). The undemanding bidding procedures for leasing government lands have thus been far more successful in attracting new sources of foreign direct investment (FDI) and skilled management to the sector.

In 2004, 41,837 ha of agricultural leases were issued, generating 4.7 billion dirhams ($610m) in revenue for the state coffers. According to government statistics, foreign holders of these leases injected 25.3m Dirhams ($3.28m) into the sector in 2006. A similar tender involving an additional 38,731 ha of state farmland was concluded in 2007.

Despite the success of the state-land lease program, the government's new agriculture strategy must address the critical issue of agricultural land segmentation and the lack of economic cooperation among the country's 850,000 small-plot farmers who currently represent the backbone of the sector. Implementing further reforms regarding these issues will enable economies of scale and attract greater interest from foreign investors.

f. Regulations for the protection of the natural resource base

Moroccan legislators have developed a solid array of legal devices that oversee natural resources use and regulate the forms and the scope of government interventions. Nevertheless, the laws governing natural resources remain generally inefficient because of their repressive character. These laws are sometimes too advanced to be feasibly applicable, and they are often found incompatible with the less developed reality they are set to address.

Despite the wealth of legal texts, decision makers are incapable of coping with some key issues such as water costs, forestry and pastoral resources, land tenure reform, the nature of the desired liberalization and the type of production system to be promoted, in other words, the issues that affect the citizens' daily lives and help maintain appropriate conditions for combating substantial land degradation.

g. Previous and existing projects dealing with land degradation

Numerous plans, strategies and programs have been designed recently for combating land degradation. Although some of these strategies and plans have not yet been translated into concrete actions, the process of their preparation has provided an opportunity for carrying out an in-depth and holistic reflection on establishing a diagnosis of the current situation, identifying constraints and defining new courses of action for development.

Most of these designed plans, strategies and programs have a clearly defined, sector-based dimension. Few are mandated with a horizontal mission aiming at ensuring an integrated type of development. A third category consists of a new generation of cross-sectional programs focusing on reducing the deficit accumulated by Morocco in terms of social infrastructure in rural areas. They fit within the objectives of giving substance to the policies related to poverty alleviation.

Integrated plans and programs

Chronologically, the oldest projects whose objectives aim at dealing with desertification problems are:

- The DERRO (Economic and Rural Development Project of the Occidental Rif) program that was launched in 1965 and adjusted in 1968: aims at contributing to the rural development of Western Rif and controlling erosion risks threatening this region. Actions undertaken within the framework of this project encompassed plantation of fruit trees, land development projects, herd management development, construction of earth roads, rehabilitation of springs and erosion control.
- The Integrated Development Projects (IDP) : consist of a project package prompted by the World Bank at the end of the 1970s.The IDP covered almost one million hectares, primarily in grain- cropped areas, and in places where extensive livestock production systems play an important role in the economy of existing farmsteads.
- The national plan to combat desertification: was developed in 1986, in compliance with the recommendations of the International Conference on Desertification held in Nairobi in 1977. The plan focused on two priorities: rangeland management and supply of fuel wood. Specific projects were then suggested for each of these sectors and homogeneous zones were identified for project implementation.

Sectoral land use plans and programs

In rainfed areas: The design process of the master plan for management and conservation of dry lands (i.e. bour) has particularly contributed to the enactment of Law number 33/94, which has become a basic policy instrument underlying public intervention outside irrigated schemes.

In irrigated areas: The National Irrigation Program (NIP) encompasses all the policy elements for state intervention in the irrigated schemes between 1993 and 2000. Re-appraisal of irrigated areas management seeks to achieve three basic goals: (i) expanding land under irrigation, (ii) water saving, and (iii) initiating partnership schemes. The NIP grants a particular importance to small and medium-scale hydraulics.

In the forestry sector: The National Forest Colloquium held in Ifrane in 1996 was instrumental in developing sector-based strategies seeking to achieve a partnership-based sustainable development of the Moroccan forest. This strategy is built around five major axes: (i) patrimonial management of the forest; (ii) a long-term vision of forestry development; (iii) development of the peri-forestry areas; (iv) development of partnership schemes; and (v) revamping the financing system of the sector.

The national plan for watershed management was finalized in 1996. Its preliminary conclusions mainly concerns classifying watersheds on the basis of the degree of their erosion severity and defining appropriate approaches for watershed management. The plan also provides insights into the cost of inaction and its impacts on agricultural productivity, on dams' lifespan, and more generally on the country's social and economic development

The plan for protected areas was developed in 1994. This plan identifies three priority categories in terms of planning the process of granting the label "protected area" to inventoried sites. Thus, the first group, consisting of 51 Sites of Biological and Ecological Interest (SIBE), will be labeled in the protected areas within five years from implementation of the status. The two other deadlines were set at eight and 14 years for 44 and 59 sites (SIBE), respectively. The plan integrates in its approach the

expectations and concerns of populations, which are either riparian to or operators of the protected areas.

The reforestation plan was finalized in 1997, in conformity with the recommendations of the strategy for forestry development. Inspired by a long-term vision, this plan aims to meet in a sustainable way the core needs of forestry products of Morocco. Implementation of this ambitious objective will be achieved through developing partnership schemes involving the maximum of private and public operators with a view to speeding up the reforestation process and promoting participation to local programs on the basis of a participatory approach.

The strategy for rangelands development: The conclusions yielded by the studies, carried out on rangelands, highlight the fact that any rangeland development strategy should be the expression of a strong political will, providing concrete options to the sensitive issues of land tenure status, conditions of affordability with regard to the resource base and the production systems offered to pastoralists. This strategy challenges the principle of free-of-charge access to rangelands and to drinking water for animals. It also provides a contingency plan to facilitate implementation of an appropriate policy for adequately pricing access to rangeland resources.

The Oasis space: The National Plan for Restructuring and Development of Palm Groves was launched in 1987, updated and prorogated in 1998 for nine additional years to run until 2007. The plan proposes to reverse the trends of regression of the Moroccan palm groves and to upgrade this sector through introducing bayoud resistant varieties, management development of date palm cultivation techniques and marketing of products.

Millennium Challenge Account (MCA)-Morocco program (2008-2013): Several erosion control measures are anticipated to be installed during the *MCA-Morocco Fruit Tree Productivity Project (the Project)*. These include dense plantings of fruit trees with cuvettes along the contour, installation of graded terraces on slopes between 5 and 30% steepness, and cover or perennial intercropping on slopes steeper than 30%. In addition, farmers who intercrop small grains and legumes on slopes flatter than 30% will be encouraged to plow along the contour and to install contour filter strips of grass or perennial legume crops along the tree rows. These measures are predicted (using the Universal Soil Loss Equation – USLE) to reduce soil loss by 83-93%.

The Rural Development Strategy to 2020 Horizon (initiated in 1999): was initiated to overcome disparities and improve livelihoods of rural populations through a series of measures to halt human-induced land degradation process through the implementation of territorial participatory and integrated projects.

Lessons learned:

- The solutions suggested to control natural resources degradation, often inspired by government services, did not lead to the expected results. Incoherencies and constraints identified can be grouped into three main categories: (i) the legal and organizational frameworks, (ii) programs scope and procedures for their design and implementation, (iii) staffing and funding mechanisms.
- *The organizational framework:* The Moroccan institutional system is characterized by an overabundance of administrative actors where too many agencies and authorities are involved, directly or indirectly, in reforming natural resource management.

The management approach:

- Autonomist attitudes of government agencies are a major obstacle to their collaboration, coordination and integration. Little synergy is indeed perceptible between the different actors. For example, some discrepancies have been recorded between the management approaches of natural ecosystems promoted by the livestock department, the forest and water service and the department of land development.

- Excessive centralization of the decision-making process is often identified as a major institutional constraint. In addition, the design procedures of programs on natural resources development have, so far, followed a top down and hierarchical approach with little or no involvement of civil society. This has created an environment of suspicion and resistance on the part of beneficiaries as to programs' implementation, as well as serious problems of coordination between the various stakeholders or project partners.

The legal framework:

- Enacted bills do not, in some instances, meet the requirements of ensuring continuity and accountability, and rarely mention population participation in the decision-making process.
- Analysis of the Moroccan legal arsenal relative to natural resources management reveals a scarcity of incentive measures.. While repressive measures are plethoric, incentives destined to boost natural resources conservation are clearly lacking. This is particularly common in cases of forestry and rangeland use and soil conservation.

The scale of intervention: Government structures do not have both the capacity and the flexibility to operate at the lowest scale levels. The existing administrative and accounting procedures are more suitable for large-scale operations designed at the national level or at least at a scale of a significant size. Yet, it was clearly demonstrated that smaller scale projects are always better focused and more successful. The corollary of this approach is that most projects do not meet the requirements in terms of flexibility and therefore ignore grass root needs. The inability of government services to integrate population needs at the lowest local level tremendously limits the scope of their programs and the equitable distribution of their benefits among all users.

The funding mechanisms: are systematically identified as a major constraint to successful implementation of projects dealing with natural resources development and conservation. This constraint reflects at least five limitations:

- irrelevance of the loan system;
- inadequate public funding;
- absence of mechanisms for fund raising;
- funding discontinuity;
- lack of stability and rigidity of encumbrance of funds.

The management and supervisory staff: In general, natural resources management remains understaffed. These shortcomings are illustrated clearly when comparing the extent of areas covered by projects dealing with natural resources and the human resources allocated to oversee them. In addition, the few available technicians are not fully optimized due to the absence of a clear definition of their mandates and fair compensation for their efforts. Another sign of understaffing problems relates to insufficient knowledge of the resource base and unavailability of adapted technological packages. This leads to a tendency of standardization of available techniques.

Available technologies to deal with land degradation

"Combating desertification includes activities which are part of the integrated development of land in arid, semi-arid and dry sub-humid areas for sustainable development..." (UNCCD, Article 1). Several technologies dealing with land degradation were developed and are available either for testing or diffusion. These technologies deal mainly with:

- *Soil and water conservation techniques:* With regard to the extent of diffusion and causes of failure and the extent of policy and institutional influence on diffusion, this part is treated in the section on the lessons learnt from previous projects (section above).

- *Water harvesting:* Water has always been an important component of societal development. Many of the powerful and sustainable civilizations of the past were developed in the areas where just enough water was available. These civilizations developed irrigation schemes that lead to agricultural production, which was the main source of income. In dry areas, where water was scarce and drought prevailed, people developed techniques for collecting and storing rainwater for domestic uses, watering livestock and irrigating crops. Such water harvesting schemes, not only help people survive drought, but also insure their well-being.

  Rainwater harvesting locally collects and stores rainfall through different technologies, for future use to meet the demands of human consumption and human activities. The art of rainwater harvesting has been practiced since the first human settlements. It has been a key entry point in local water management ever since, buffering supplies of rainfall to service the human demand of freshwater.

  As it involves the alteration of natural landscape water flows, rainwater harvesting requires water managers to carefully consider the tradeoffs; however, it can stil create multiple benefits, offering synergies between different demands and uses at a specific location (Agarwal and Narain, 2005; Malesu et al., 2005). To many water managers, rainwater harvesting is a technique to collect drinking water from rooftops, or to collect irrigation water in rural water tanks. However, rainwater harvesting has much wider perspectives, especially if it is considered in relation to its role in supporting ecosystem goods and services. Future pressure from climate change, growing population, rapid land-use changes and already degraded water resources quality, may intensify water shortages in specific communities and exacerbate existing environmental and economic concerns.

3.2 Rainwater harvesting typology

Rainwater harvesting technologies can be divided into two main areas depending on source of water collected; namely the in situ and the ex situ types (Barron, 2009). In essence, in situ rainwater harvesting technologies are soil management strategies that enhance rainfall infiltration and reduce surface runoff. The in situ systems have a relatively small rainwater harvesting catchment typically not greater that 5-10 m from point of water infiltration in the soil. The rainwater capture area is within the field where the crop is grown (or point of water infiltration).

In situ systems are also characterized by the soil being the storage medium of the water. This has two principal effects. Firstly, it is difficult to control long-term water outtake. The soil moisture storage for crop uptake depends on vegetation type, root depth, storage capacity of the soil and air and the climatic demand. Secondly, the outtake in space is determined by the soil medium characteristics, including slope. Due to gradients and sub-surface conditions, the harvested water can act as recharge for more distant water sources in the landscape, including groundwater, natural water ways and wetlands, and shallow wells. The in situ rainwater harvesting systems are often identical to a range of soil conservation measures, such as terracing, pitting, conservation tillage practices, commonly implemented to counter soil erosion. Thus, harvesting rainwater by increasing soil infiltration using in situ technologies also counteracts soil loss from the farmed fields or forested areas. In situ rainwater harvesting often serves primarily to recharge soil water for crop and other vegetation growth in the landscape. The water can also be used for other purposes, including livestock and domestic supplies if it serves to recharge shallow groundwater aquifers and/or supply other water flows in the landscape.

The ex situ systems are defined as systems which have rainwater harvesting capture areas external to the point of water storage. The rainwater capture area varies from being a natural soil surface with a limited infiltration capacity, to an artificial surface with low or no infiltration capacity. Commonly used impermeable surfaces are rooftops, roads and pavements, which can generate substantial amounts of runoff water that can be collected and stored for different uses. The storage systems in the ex situ harvesting are often wells, dams, ponds and cisterns from where water can be extracted for multiple uses.

3.3 Rainwater harvesting in rainfed agriculture

In arid zones where rainfall is low (<300 mm/year), water scarcity is the major limiting factor in water provision. But in semi-arid and dry sub-humid tropical regions, total seasonal rainfall is generally adequate to meet needs and also to significantly improve agricultural water productivity, if it were evenly distributed. However, dry spells with little or no rainfall occur in most cropping seasons during critical stages of plant growth. Soil moisture reaches critical limits and causes crop damage and even failure. Most rural poor areas experience water scarcity for agriculture, and consequently poor yields and compromised livelihoods. This is usually due to the lack of public, private and individual investment in the provision of even small scale water infrastructure. Therefore, adaptation to rainfall variability is the greatest water challenge (Barron, 2009).

Local harvesting of small portion of the rainwater in wet periods and utilizing it for supplemental irrigation during devastating dry spells, offers a promising solution in the fragile, rainfed regions of the world. As total rainfall is spread over a few rain events of high intensity in most regions in Asia and Africa, much is lost through runoff and evapotranspiration. It is important to capture and convert a part of this lost resource into more productive use. The storm runoff can either be converted directly and spread on the fields, or collected in inexpensive water storage systems for later use.

Water harvesting techniques may be catchment systems, collecting runoff from a large area. They include runoff farming, which involves collecting runoff from the hillsides and diverting it into plain areas, and floodwater harvesting within a streambed using barriers (check dams) to divert stream flow onto the soil. Micro-catchment water harvesting methods are those in which the catchment area and the cropped area are distinct, but adjacent to each other. Establishing catchment systems often necessitates ecosystem rehabilitation and conservation, in order to secure the runoff.

Introducing rainwater harvesting to improve soil ecosystem productivity in rainfed agriculture promises large social, economic, and environmental paybacks, particularly where poverty reduction and economic development are concerned. Rainwater harvesting presents a low-cost approach for mediating dry spell impacts in rainfed agriculture. Remarkable successes have been witnessed in poverty-stricken and drought prone areas of India and Africa. In several countries of West Asia and North Africa, rainwater harvesting is a traditional practice in certain regions.

The M&M project, in its third phase, has been aimed at developing productive and sustainable agropastoral systems that conserve the resource base and support rural livelihoods in the dry areas of the WANA region. The intended program has been scaled out to cover a wider geographic area and a larger number of communities. It could cover a governorate or district according to the system followed in each country. This will provide a more comprehensive approach that allows for the integration and interaction of institutions, policies and best options and provide a realistic base for larger potential investment programs by donors. The program will be continued to take a regional approach working through the multidisciplinary teams that have been implementing the Mashreq/ Maghreb project. However, not all activities have been implemented in all countries. Implementation of the various elements of the program was determined by the comparative advantages of each country and team, with the regional structure of the project facilitating the exchange of information and transfer of proven options between the contributing countries.

The program had several complementary components where targeted adaptive research to introduce new options generated elsewhere from ongoing or new research, have been largely considered. These included:

- *Water harvesting:* Emphasis has been put on the use and dissemination of appropriate water harvesting techniques including micro-catchments, contour ridges, collection and storage of rainfall water in cisterns, pits or earth dams. The new tools developed by ICARDA to assess the potential for water harvesting on a larger scale, using remote sensing and GIS applications, were applied.
- *Alternative cropping systems*: Alternative cropping systems for better soil and water use efficiency were tested including drought tolerant trees (shrubs, olive, almond, fig, and others) and native plants with medicinal, social and economic value that could play a major role in the diversification of production systems and income generation.

4. Conclusions

4.1 CRITICAL KNOWLEDGE GAP

An analysis of current systems of natural resources use reveals immense difficulties in securing renewal and sustainability. It also identifies crucial policy inconsistencies and dysfunctions, developed over many years which have resulted in the degradation of the productive base of natural resources. Under certain conditions, they have resulted in diminished productivity of some agricultural systems, leading to a drop in rural populations' incomes, aggravated by an ever-increasing pressure on natural resources.

The major concern of the National Action Plan focuses mainly on ways and means to promote the dissemination and sharing of information on combating desertification. There is also a crucial need for a referral system on participatory approaches and more generally on the terms of implementation for a sustainable participatory approach, on baseline knowledge and on monitoring the dynamics of ecosystems.

The implementation of the NAP-Morocco will help tremendously in enriching the technical resources available, relating to understanding desertification processes and natural resource management.

While aware of the various programs and sector-based plans underway, and the existing links between poverty alleviation and desertification control, the deliberate option adopted by the NAP is the promotion of measures likely to further follow-up existing programs. It also aims to inject fresh blood into their implementation and to promote rural development dynamics.

The criteria adopted for identifying the NAP actions express the willingness to consolidate the plans and programs being implemented and also to enhance capacity building and take into account the needs and priorities expressed by the grass root populations. These criteria also express the concern to prioritize combating desertification (LCD) preventive actions, to perpetuate the spillover effects of the programs underway on the LCD, and to work towards their long-term appropriation by the recipients.

Thus, four categories of follow-up actions are emphasized by the NAP.

- The first category includes support and accommodating actions to the implementation process of the existing LCD programs, seeking to achieve a dual objective: (i) strengthen institutions and capacity building, (ii) compile the necessary elements of a technical and procedural referential, a prerequisite for an enlightened type of decision-making.
- The second category consists of promoting activities seeking to diversify income generating sources and the welfare of the rural communities.
- The third brings together actions likely to contribute directly or indirectly to the development of water and soil resources and biodiversity, in so far as they receive a scant coverage from the existing plans and programs.
- The fourth category mainly concerns upgrading basic knowledge and the development of natural resources monitoring systems.

Taking into account the nature of the foreseen activities and the strategic character of the NAP, perceived as tool to reinforce and catalyze the sector-based programs for desertification control; the NAP is globally seen as a core program.

On the other hand, initiating the NAP implementation under the best possible conditions requires the following:

- Organizing an awareness building and extension campaigns in the framework of a communication strategy involving all stakeholders, who will follow the NAP in its various implementation stages.

- Translating the NAP into final projects based on a territorial-based approach and give core priority to the following themes :
  - in-depth knowledge of natural resources and desertification typology
  - water resources harvesting and their integrated management, particularly in the south and the east of Morocco
  - conserving natural resources through emphasizing control of wind and water erosions and through rehabilitating natural and oasis ecosystems
  - ensuring local development through integrating actions likely to promote diversification of income generating sources, in a participatory and partnership- based framework
  - upgrading the skills and competencies of the different agents through community-based training and outreach programs, NGOs and grass root populations in general
  - conserving and upgrading the value of fauna and flora biodiversity in order to better take advantage of the adaptation capacities to desertification and drought condition
  - strengthening national research capacities on desertification control through creating a network of research institutions
  - reinforcing the information dissemination system through involving other partners
  - adapting and relaxing legal and regulatory procedures as well as funding mechanisms so that they are compatible with participatory and partnership-based approaches and proximity actions as advocated by the NAP.

4.2 RESEARCH IMPLICATIONS

Production of technical packages suited to arid, semi-arid and dry sub-humid areas provide support to research and development programs to rationalize natural resources management. This aid will be in the form of contract-based programs concluded with the relevant research institutions and the structure entrusted with the responsibility to implement the NAP.

The NAP will make allowance for some actions likely to encourage the support of technology transfer operations, whose terms of reference will be agreed upon in a concerted framework, involving producers' representatives, outreach structures and research institutions.

The vast and varied core research fields focus on the following areas:

- investigate the resilience capacity of plant communities to recurrent droughts
- establish maps on agricultural land suitability and identify the degree of their soil erosion vulnerability
- tap into new crops with high added value likely to diversify rural activities and to generate job opportunities for young project developers
- identify and develop plant and animal genetic material tolerant to water stress
- develop ecosystems monitoring tools, a sort of long-term watch, leading to the setting up of observatories
- adapt and establish new water saving techniques and rehabilitate those techniques engineered by populations themselves
- deepen knowledge relating to the economic and social coverage of desertification
- identify appropriate means for bayoud-palm tree disease control.

Promotion of rainwater harvesting:

- The scarcity of water in arid areas seriously impedes the welfare of the rural populations. Implementation of projects to harvest water resources will prioritize indigenous approaches

and will contribute to mitigate the harmful effects of drought, and more generally alleviate the constraints linked to water deficits in arid regions. More particularly, local programs will harvest rainwater through retention dams or other forms of reservoirs offering real possibilities to compensate, even if partially, for the water deficit issue that is becoming acute in Morocco.

- Technical choices should be adapted to the regional specificities, and efforts should be geared to upgrading conventional technologies used in many areas in the country.
- Consolidation of agricultural and rangeland sustainable development
- Strengthening of baseline knowledge and development of natural resources monitoring systems through:
  - Inventory of soil and vegetation resources
  - Monitoring and evaluation system for ecological, economic and social impacts of the drought
  - Strengthening the network for ecological monitoring
  - Monitoring and evaluating the impacts of desertification control programs.

4.3 DEVELOPMENT IMPLICATIONS

Achieving success of the NAP in its twin dimensions of political commitment and planning as well as an implementation tool of concrete and advanced actions to combat desertification will require tapping into all available resources.

The NAP's implementation should be backed by an awareness building campaign targeting politicians and locally, regionally and nationally elected councils and civil servants. This drive should remove any ambiguity in connection with the significance and the stakes of desertification, which needs to be dissociated from drought and sand encroachments, its most widely known manifestations. There is also a need to rethink the procedures for managing public funds or, at least, making them more flexible.

The different public and private operators should translate, through their behaviour, the values conveyed by the NAP. The operationalization of the principles of integration, decentralization and participation should be integrated into the daily behaviour of these operators.

The NAP's spirit cannot accommodate the rigidity of the current procedures pertaining to decision-making that constitutes a serious obstacle to its implementation. In this regard, it is imperative that administrations are reengineered in the sense of better communication, more effective delegation of some prerogatives and more flexibility in the rules governing spending, execution and control.

The main provisions, which are key for creating an enabling environment for implementing the NAP-Morocco under the best possible circumstances, as reported (MADRPM, 2001) are:

1. Formal adoption of the NAP by the government as a conceptual and strategic framework for implementing the international convention for desertification control and alleviation of drought effects in Morocco.
2. Institutional tying up of the NAP to the standing inter-ministerial council of rural development and the NAP's adoption by the council as a preferred framework for operationalizing the 2020 rural development strategy.
3. Establishment of a limited transitional steering committee resulting from the National Coordination Body and made up of ministerial departments and institution managers concerned by rural development. This committee will be entrusted with the responsibility of preparing the final institutional anchoring to ensure articulation between the different development programs and to schedule urgent actions for the NAP's take off.

4. Putting in place - as soon as possible - relays and local and regional coordination mechanisms, which are operational and empowered with decision making power to facilitate coordination of intervention by the various state departments and to give an impetus to effective participation by other concerned parties.
5. Solemn adoption of the participatory approach and its integration as a preferred course of action for the NAP's implementation, whose underlying principle is based on promoting decentralization, deconcentration and consolidation of the associative fabric.
6. The socio-economic development plans, should take into account, and integrate the NAP, specifying the component accruing to every concerned department and partner.
7. In the initial stage and while awaiting the design of a specific and fine-tuned funding mechanism, budget support of state funded operations will be shouldered by the Rural Development Fund (FDR).
8. Fund channeling to local and regional areas, as well as involving NGOs and other stakeholders are envisaged on contract and conventional bases, in such a way as to guarantee appropriate conditions of monitoring/evaluation and transparency.
9. Translate the NAP into implementable actions and projects based on territorial approach and granting priority to the following themes:
    - stock take of inventories and development of an in-depth knowledge of the state of natural resources
    - carry out follow-up and performance-oriented actions related to desertification control programs underway
    - initiate project and pilot actions for activity diversification and income improvement in the rural world
    - promote advanced desertification control projects. These projects should focus on areas that have not been currently explored or exploited substantially
    - carry out programs to upgrade the skills of stakeholders through training/information programs for the benefit of the different categories of intervention.
10. The NAP implementation should be supported by awareness and outreach campaigns designed within the framework of a global communication strategy, which should involve the entire stakeholders and partners in the NAP's implementation.
11. Widen the NCB to involve bilateral and multilateral lead agencies as an important provision that will give further impetus to cooperation and promote greater commitment from development partners for raising additional funds to control desertification.
12. Give top priority to the study of various possible cooperation and follow up forms grouping the different programs related to the United Nations conventions and linked to sustainable development (NAP, biological diversity, climate change, wetlands) and to the national programs and initiatives to eradicate poverty and to combat desertification and drought effects.
13. Capacity building of national research on desertification control through creation of a cooperation network, linking competent institutions in the field.
14. Design a monitoring/evaluation system for desertification and drought control and another to assess the impacts of various control programs. In addition, there is a need for creating a network of observatories and sites in the different natural and managed ecosystems.

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About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa (CWANA) region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.

The Consultative Group on International Agricultural Research (CGIAR) is a strategic alliance of countries, international and regional organizations, and private foundations supporting 15 international agricultural Centers that work with national agricultural research systems and civil society organizations including the private sector. The alliance mobilizes agricultural science to reduce poverty, foster human well being, promote agricultural growth and protect the environment. The CGIAR generates global public goods that are available to all.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR with a System Office in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.