Chapter 5
Desertification and Its Control in Morocco

Y. Hammouzaki

Synopsis This chapter reviews the status of desertification in Morocco. It is divided into three parts. (i) the general context (ii) causes of desertification in Morocco (both proximate and the root causes and (iii) efforts to combat desertification and land degradation (past and planned).

Key Points

- In Morocco, the process of desertification affects large areas. It is more pronounced because the climate is arid and soils are vulnerable to erosion. Also, precariousness of life of the rural populations pushes them to overexploit the natural resources to satisfy their increasing needs, which accentuates the deterioration of surroundings.
- The sectoral approach adopted to attenuate the natural resources deterioration showed its limits because of the increasing amplification of the deterioration. This situation incited the public powers to adopt new orientations of development that result in the strategy of rural development. In this context Morocco finalized a National Action Program (NAP) for Combating Desertification (CD) which constitutes an important stage in the process of its commitments within the UNCCD. The NAP-CD is conceived to promote a strong articulation and a synergism between the sectoral programs through actions of support and accompaniment of the process of combating desertification. Specifically, there is support of actions that promote income-generation, combat the desertification and attenuate the effects of drought, and reinforce the network of monitoring systems. For the implementation of NAP, the institutional mechanism of coordination has been set up) a mechanism for follow-up and assessment of impacts of projects and different ecosystem observations have been initiated. The success of NAP-CD as political engagement and as tool of programming of concrete

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G.A. Heshmati and V.R. Squires (eds.), *Combating Desertification in Asia, Africa and the Middle East: Proven practices*, DOI 10.1007/978-94-007-6652-5_5,

and innovative actions of intervention and implementations will require the mobilization of all available energies.
- Proven practices to arrest and reverse land degradation in all of its forms have been implemented in every region of the country. These include developement of systems of livestock/rangeland integration that provide additional forage and fodder and at the same time increase then cover of plants that can protect the soil, increase carbon sequestration. Several soil conservation technologies have been developed in Morocco and are available for large diffusion but in many cases these technologies have not been permanently adopted. It seems that a large-scale dissemination of these new practices requires some financial incentives that must be sufficiently high to stimulate farmers to adopt the technologies.

Keywords Morocco • Desert control • Afforestation • Deforestation • Clear felling • UNCCD • Atlas mountain • Steppe • Rainfed agriculture • Livestock • Overgrazing • Fuel wood • Barley • Opportunistic cropping • *Atriplex* alley cropping • Algeria • Mauritania • Sahara desert

1 Introduction

In Morocco, the process of desertification affects large areas and over 90 % of the land area is classified as desertified to a greater or lesser extent. It is more pronounced because the climate is dry and highly variable and soils are vulnerable to erosion. The arid and semi-arid high plateau areas of Morocco are fragile environments with weakly structured soils, sporadic and unreliable precipitation, and low productivity. Land degradation is prevalent in the region. Deterioration of rangeland resources and the consequent increase in rural poverty are exacerbated by prolonged and sometimes severe periods of drought. A significant part of the south and southeast is desert extending southward to the northern edge of the Sahara desert.

1.1 General Context

The Kingdom of Morocco is situated in the north west of the continent of Africa, between latitudes 21°–36° N and longitudes 1°–17° W. The country is bordered by the Atlantic Ocean on the West (2,934 km from Cap Spartel in the North to Lagwira in the South), the Mediterranean Sea on the North (512 km from Saidia in the East to Cap Spartel in the West). It is bordered in the East and South by Algeria and Mauritania, respectively (see Fig. 5.1). The total land area is 710,850 km^2 of which arable land is less than 12 % according to the Ministère de l'Agriculture et du Développement Rural.

Fig. 5.1 Map of Morocco showing its location and its neighbors

The country's history is very ancient as attested by numerous prehistoric and historic monuments and artefacts. In historical time, the country has seen a number of invaders and civilizations: Phoenicians, Berber, Carthaginians, Romans, and Vikings. The Arab conquest came in 681. Morocco has existed, as a state, since 788, when the Idris the First was proclaimed king.

1.2 Economy

The population is about 32 million and the growth rate hovers just below 2 % per annum. Agriculture is the backbone of the economy since it contributes 17 % of the Gross Domestic Product (GDP) and provides employment to half of the active labor force. It has benefited as a priority investment sector by the Government during the last four decades. As a result of this policy, 92 large dams have been built with a total capacity of 14 billion m^3. This and other smaller infrastructure, has allowed the irrigation of some 1.2 million hectares (Mha). Major irrigated areas are the Rharb and Loukkos in the NW, the Tadla in the center north of the Atlas, the Haouz in the Marrakech region, the Souss-Massa in the Agadir region, the Ouarzazate and Tafilalet south of the Atlas, and the Low Moulouya in the Northeast. Accelerated land degradation has the potential to increase inflow of sediment to the reservoirs and reduce storage capacity. Soil erosion has serious negative on-site effects, such as a decrease in soil productivity. However, it may also have

off-site effects, such as silting of dams. In Morocco more than 50 million m^3 of sediment are deposited each year in dams' reservoirs. This volume corresponds to a loss equivalent to the volume of water needed to irrigate 5,000 ha (AGR/DAF 2001). To efficiently reduce these offsite effects, adequate government interventions are needed. This may include incentives to implement soil and water conservation practices to farmers (see below).

Fisheries is another important sector as it represents 55 % of agricultural food exports and maintains some 400,000 jobs. Handicrafts contribute 10 % to the GDP and offers jobs to about 1.5 million people.

Tourism is of growing importance to the economy. With 2.5 million tourists in 1999, it contributes 7.8 % to the GDP, and helps maintain about 0.5 million jobs. Desertification and active land degradation threaten tourism.

Mining and energy represent 10 % of the GDP. Morocco has the world's third largest deposits of phosphate, but a stagnant market and lower world prices have reduced the contribution made by this previously important export earner. A small manufacturing sector is growing and bringing export revenues. Consumer goods and semi-finished goods now account for about half of Morocco's export earnings. About 15 % of the labor force works abroad, mainly in European countries such as Belgium and France, and the money these workers send back to Morocco helps to offset the country's large foreign debt.

2 Climate

Morocco is characterized by a Mediterranean climate. Rainfall occurs within the cool season, while the warm season is hot and dry over much of the country. However, owing to its latitudinal location, and as well as the influence of the Atlantic Ocean and the Mediterranean Sea, and that of the powerful Atlas mountain ranges between the southern Saharan and the other zones, the climatic conditions are quite diverse. In fact, this diversity made it ideally suited for the bioclimatic classification of the Mediterranean.

The main bioclimatic subdivisions are:

- *Saharan or desert*, with annual rainfall less than 100 mm and erratic. Winter temperatures are mild along the Atlantic coast, but become cool some 10 km inland and cold further inland;
- *Arid*, with annual rainfall ranging from 100 to 400 mm. This concerns the southern fringe of the Atlas mountains, the Moulouya Valley, the Eastern High Plateaus, the Souss plain and the plains north of the Atlas. Winter temperature subdivisions vary from warm (Atlantic and Eastern Mediterranean coast), to temperate, cool and cold. This latter situation is encountered inland in portions of the Moulouya Valley, and more extensively on the Eastern High Plateaus;
- *Semi-arid*, with annual rainfall ranging from 400 to 600 mm. This concerns the major cereal regions such as the plains of Doukkala, Chaouia, Gharb, Saiss, as well as large portions of the Anti Atlas, High Atlas, Middle Atlas, Central

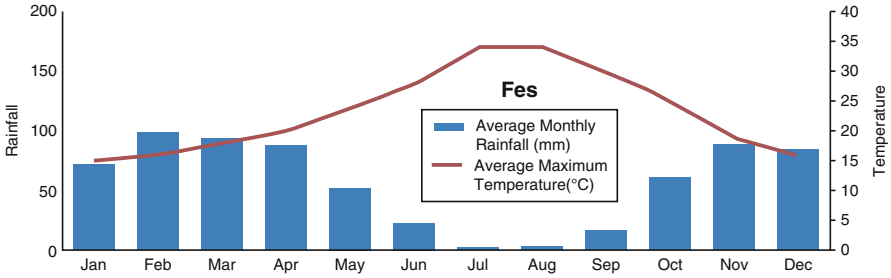

Fig. 5.2 Average monthly rainfall and temperature of Fez (lat. 34° N and long. 5° W)

Plateau, the Prerif zone and the Eastern part of the Rif mountain range. This large spatial extension translates also into a large diversity of winter temperature subtypes;

– *Subhumid*, with annual rainfall ranging from 600 to 800 mm, encountered within the mountain ranges of the Rif, the Middle Atlas, the High Atlas and on localised coastal area (Western Mamora cork oak forest). As in the previous type, the winter subdivisions are also diverse;
– *Humid*, with annual rainfall greater than 800 mm within the Rif and the middle Atlas mountains.

Rainfall is variable within seasons and between years. It occurs mostly in autumn (October–November), winter (December) and spring (March–April) as shown for Fez (Fig. 5.2) Mean annual rainfall (Fig. 5.3) ranges from less than 100 mm (Saharan bioclimate), to 1,200 mm (humid bioclimate).

Extreme temperatures are attenuated in the coastal areas along the Atlantic Ocean and the Mediterranean Sea, translating into bioclimate sub-types of warm and temperate winters. By contrast, in the inland, the temperatures are more extreme and winters can be quite cold (translating into bioclimate sub-types of temperate to cold winters) and the summers very hot. In the mountain ranges temperatures can drop to 0 °F and highest mountain peaks in both the Atlas and Rif mountain ranges are snow capped throughout most of the year.

Drought is the most important and dramatic manifestation of such variability. The country witnessed the longest drought episode in its recent history (1979–1984, most of the 1990s) causing impacts on agricultural production, on farm economics and sustainability, on systems of production (for example, more concentrates are being incorporated into livestock feeding), and on natural resources and environment (acceleration of degradation and resource depletion).

Over the last century there has been a decrease in rainfall throughout the Mediterranean region. In summer, rainfall is now 20 % less than at the end of the nineteenth century. In Tangiers, rainfall has dropped by 100 mm in 40 years and also at Ifrane, in the Moyen-Atlas Mountains. Studies show that a reduction of 100 mm i.e. 1 mm/year has taken place in many countries in the Mediterranean Basin. Since the beginning of the twentieth century, Morocco had balanced phases of rainy and

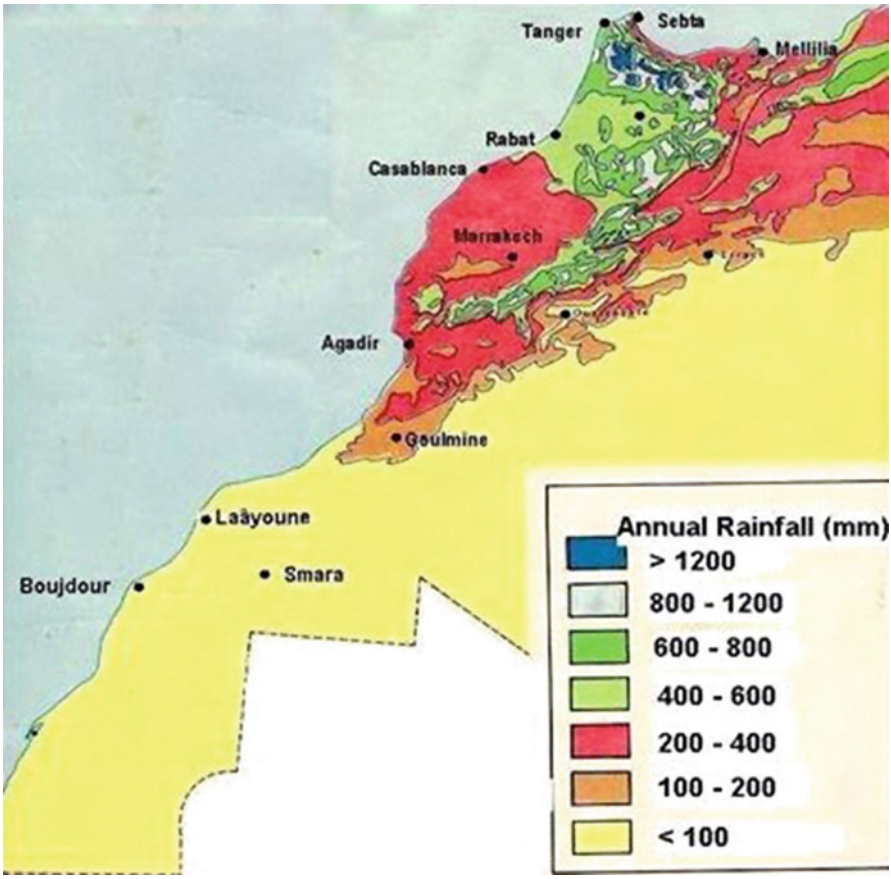

Fig. 5.3 Rainfall map showing that rainfall is low (100 mm p.a.) in most inland of Morocco

drought years. This balance seems to have broken since 1975, as the number of dry years has a tendency to exceed the humid ones. The 1980–1984 drought in Morocco was perhaps the most severe in the country over a period of 1,000 years! (Chbouki et al. 1995). A high mortality of trees was recorded that exacerbated the on-going death of trees brought about from excessive lopping of branches etc. feed livestock and provide fuel wood (see below).

3 Land Area, Arable and Pastoral Areas

Land classification in Morocco shows that 78 % of the area (56 Mha) is in desert and dry zones (annual average precipitation <250 mm/year), 15 % (10 Mha) in the semi arid zone (250–500 mm rainfall per annum) and 7 % in the sub-humid to humid

Table 5.1 Land use in Morocco

Arable and permanent crops	Area (million ha [Mha])
Forests	9.2
Alfa steppe	5.8
Range[a]	3.2
Total	52.885
	71.085

[a]Including low productivity Saharan steppes, rocky sites and areas occupied by infrastructures as they have not been estimated separately

zones (>500 mm rain per year). Arable land and permanent crops represent 12 % (9.2 Mha) of the land area, of which 1.2 Mha are irrigated, 12.5 % (5.8 Mha) is forest, and 52.9 Mha are rangelands and unproductive lands (Table 5.1).

4 Causes of Desertification in Morocco

4.1 Climatic Factors

Like the other countries south of the Mediterranean, Morocco has suffered from a negative trend in rainfall over the last few decades. In 50 years, precipitation has dropped from an annual average of 600 to 300 mm, with more and more successive dry years (1979–1984, 1990–1994, 1998–2001). During these periods, cropping in the rain-fed fields was of low productivity or crops failed and temporary food shortages occurred in the most disadvantaged parts of the country. Arable lands underwent accelerated degradation and destruction as the desertification process in the marginal lands gained momentum. In an effort to save their cattle, livestock producers invaded the forests and cut off the leafy branches to feed their animals. Is this apparent increase in droughts due to global warming or because the anticyclone from the Azores lasts longer and longer in Morocco during the winter, as witnessed in 1999 and 2000? If the tendency for more years to be hot and dry were to continue, it would have a substantial impact on the mountainous environment in Morocco; in particular the snows would melt sooner or winter snows would be replaced by rain. Both scenarios would entail a fundamental change in the regime of the waterways and have serious implications for the irrigation areas.

4.2 Human Factors

Although land degradation in these environments is partly caused by natural factors, the accelerated erosion rates are mostly human induced. Overgrazing is the most

important cause of soil degradation in the eastern regions of Morocco, the Souss, the Pre-Sahara and the Sahara and approximately 8.3 Mha of rangelands are heavily degraded (Ouassou et al. 2006). The land in these regions is collectively used by local tribes and communities. Land use conflicts over access to grazing areas and water are major contributors to continual and often intensive land degradation. In the eastern region, feed subsidies for instance discourage the reduction of livestock pressure on collective rangeland. Higher prices encourage farmers to grow cereals, especially bread wheat, in steeply sloped plots. These government support policies combined to other environmental problems contributed also to soil erosion.

4.2.1 Encroachment of Traditional Rangeland for Crop Production

The disempowerment of traditional institutions has led to the disruption of management of rangelands. Transhumance has practically disappeared. Settling within rangelands has become the rule, and cultivation and privatization of the rangeland is expanding. And what remains of the original rangeland is exposed to fierce overexploitation. Rangeland rehabilitation, therefore, is a high priority for the Moroccan government, which has initiated activities aimed at halting degradation, increasing farmers' income, and stemming the rural exodus. Whilst livestock remains the main source of income, but that the pastoral system has evolved during the last decades a number of other things have occurred:

- The ancestral grazing practices, based on tribal organization and using large areas for grazing, are disappearing and rangeland is degrading at a quicker pace.
- The system is evolving towards an agro-pastoral one, characterized by the intensification of livestock production.
- Pastoral cooperatives are replacing the traditional mode of organization based on tribes.
- There is less transhumance. The best sites are cleared for cultivation.
- Pastoralists with small flocks are more sedentary and, therefore, contribute to rangeland degradation.
- More farmers are raising the Ouled Djellal breed of sheep.
- The contribution of concentrate to livestock feeding is increasing.
- The rural exodus is increasing due to a decline in livestock productivity and the high cost of feed concentrates.

The Moroccan forests are a precious and priceless heritage. They partly cover the Atlantic and Mediterranean slopes of the Moroccan mountain ranges; in the High Atlas, forestlands stretch from the *dir* to the center of the range. This heritage, however, is in great danger. For nearly a century, the forests have been subjected to increasing pressure, first from the forestry services of the French Protectorate, and during the last few decades as a result of the demographic explosion. The causes of this degradation are connected to management errors, uncontrolled exploitation, and the vagaries of the climate.

Soils with relatively low organic matter contents (<2 %) are directly impacted by the serious erosion processes which can exceed 20 tons ha^{-1} $year^{-1}$ (Merzouk 1988; AGR/DAF 2001). It is estimated by World Bank in 2003 that the total annual cost of erosion from agriculture in Morocco was about 0.41 % of its GDP.

4.2.2 Cutting of Forests

Clear cutting was introduced by French foresters during the Protectorate to meet lowland needs, in particular the need for industrial production of charcoal and rail sleepers. This method is still in use today. The government sells concessionary rights to professional coalers who engage in clear cutting, especially of holly oak forests, that usually grow on steep slopes. This method based on a European model is totally unsuitable for the Moroccan mountain forests. The lack of protective foliage exposes the fragile soils to the harsh climate. The ensuing erosion, in turn, inhibits the process of stump shoot regrowth and regeneration of the holly oaks.

For agricultural purposes thousands of ha has being cleared each year in the Rif mountains. The main species cultured is the *Cannabis sativa* L. Increased land pressure combined with a lack of economic development in the region has led to two distinct geographical expansions of cultivation – first, at the expense of forested areas, with thousands of hectares of forest being burned every year to clear new areas for cannabis production; and also in the valley bottoms where better soils and better access to water are available.

Furthermore, this practice deprives the local population of a vital and sizeable amount of dead wood. Since time immemorial, mountain people have taken the wood they needed for their daily lives from the forests. Unauthorized cutting was relatively limited for many centuries, but has increased during the last few decades. All the activities in daily life partly rely on wood and timber: cooking, crafts (making pottery, ironwork, furniture, but also souvenirs for tourists), and construction (roofs, doors, walls).

One custom that greatly damages the forest is cutting branches, especially in the holly oaks, to feed the smaller livestock during the difficult inter-crop season. This gradual, irrecoverable lopping of the leafy branches disturbs the vegetative metabolism of the trees and eventually results in another «dead forest», of which there are so many in the High Atlas. This method also contributes to accelerated soil erosion. The customary collection of dead wood for household use is a good illustration of the scope of the ongoing disaster in the forests. It is usually a chore for women in the Moroccan mountains and, in some places, accounts for up to 50–70 % of their daily activities. As the forests shrink and dead wood becomes scarce, women often have to spend over 10 h a day trekking dozens of kilometers in search of wood. Moreover, they have to «compensate» for the lack of dead wood by uprooting bushes (the thermal value of which is much lower), thereby increasing the risk of accelerated land degradation. In Morocco, 4,500 ha of woodlands are sacrificed to agriculture every year.

An ancient management system allowed a piece of land to be taken from the forest for cultivation, as long as it was subsequently returned to the matorral for at least 10–20 years. However, this forest fallowing phase has been eliminated in view of the need to expand agricultural lands. Furthermore, farmers secretly expand their farmlands by encroaching on the forestlands, tree by tree, which is difficult for the forestry officers to control. Together, all these actions are highly detrimental to the forests and severely diminish the country's forest heritage and its biodiversity. At the politico-economic level, reducing the woodlands jeopardizes their capacity to absorb CO_2 and will, in time, penalize Morocco on the "CO_2 market" provided for in the United Nations Framework Convention on Climate Change (UNFCCC).

4.2.3 Overgrazing

Overgrazing poses another serious problem for the Moroccan environment, e.g. in the Drâa Valley where vegetation is extremely sparse. In the five Drâa Valley palm groves, livestock figures are estimated at 186,000. The large numbers of sheep, goats, and dromedaries are too heavy a burden on a fragile ecosystem, be it the part-time rangelands far from the settlements, or the year-round rearing areas with high stocking rates, located within a radius of about 4–5 km from the douars. Degradation of the plant canopy allows the winds to carry away sand formerly held down by the vegetation, thus accelerating the process of desertification that is already well underway.

5 Efforts to Combat Desertification and Land Degradation in Morocco

5.1 Past and On-going Activities

Morocco ratified the UNCCD in 1996, adopted its National Program to Combat Desertification in June 2001, and established an institutional framework for its implementation. The NAP complements existing sector programs, supports their implementation and promotes an integrated drylands development approach to enhance local livelihoods. Areas of intervention of the NAP include: (1) Promotion of an enabling environment for UNCCD implementation at the policy, legislative and institutional levels; (2) Building the capacity of relevant actors at the national and local levels for drylands development; and (3) Implementation of integrated programs addressing poverty alleviation, local governance and natural resource management. NAP priorities have been effectively integrated into national development planning and budgeting frameworks, leading to their effective implementation.

Morocco finalized a National Action Program (NAP) of Combating Desertification (CD) which constitutes an important stage in the process of its commitments

within the UNCCD but there is still a lack of funding or the necessary capacity in terms of personnel and equipment to fully implement the measures outlined. Government commitment to the incorporation of the NAP into the national development strategy is still some way off. Despite this, Morocco is credited by UNCCD as adopting an "integrated and comprehensive" approach in the fight against desertification and land degradation. With assistance from The Global Mechanism (GM) strengthen the national capacities to establish a development partnership and resource mobilization strategy for the NAP. The strategy focuses on:

- building the resource mobilization capacity of NAP stakeholders;
- strengthening consultations with development partners in financing priority NAP projects.

The strategy, supported by UNDP and Germany through GTZ, has allowed Morocco to integrate the combating of land degradation into national planning and sectoral investment frameworks, as well as into the priorities of several development partners. These partners include Spain that has made combating desertification a priority for its cooperation with Morocco, along with Japan, Belgium, the World Bank, the European Commission and the International Fund for Agricultural Development (IFAD), which have responded positively to the strategy by cooperating in the framework of NAP implementation. Together with IFAD and the United Nations Industrial Development Organization (UNIDO), the GM has facilitated access to Global Environment Facility (GEF) resources by financing the design of a GEF/PDF-B project that raised USD 6 million for Morocco, complementing an integrated development project to combat desertification and reduce poverty in the east of the country totalling USD 18.8 million. Through the HCEFLCD and the Ministry of Agriculture, Morocco allocates 500 million dirham a year to combating desertification and 200 million dirham to rural development, totalling the equivalent of nearly USD 100 million a year. Table 5.2 is a summary of some donor-sponsored programs.

GM-HCEFLCD cooperation has already brought positive results. In recent years, the HCEFLCD and other national stakeholders (in agriculture, water resources and the environment) have designed 53 projects based on the four priority pillars of the NAP:

- Pillar 1: support to combating desertification;
- Pillar 2: support to income-generating initiatives;
- Pillar 3: activities to fight desertification and mitigate the effects of drought; and
- Pillar 4: knowledge building, monitoring and evaluation activities.

At the civil society level, the GM has financed Environment and Development in the Third World (ENDA Maghreb) to design a plan of action to combat desertification for Moroccan non-governmental organizations (NGOs), subsequently integrated into UNCCD/NAP priority projects. Twelve projects based on interlinking and integrating the two themes of desertification and decentralization have been identified and were presented to partners during a national workshop in February 2007. Budget Allocation for follow-up activities has been seriously curtailed and there is more dependence on external (mainly donor) funding.

Table 5.2 Donor-supported projects for combating desertification in Morocco

Title of the Project	Countries	Donor/Program	Comments
Système de gestion d'information scientifique dans la région de Sahel-Doukkala, Maroc	Morocco	LIFE Third Countries	LIFE
Aménagement hydro-agricole du périmètre de Sahla au Nord de la province de Taounate	Morocco	MEDA I Bilateral	EC Delegation
Appui au développement rural intégré	Morocco	MEDA I Bilateral	EC Delegation
Le développement rural participatif dans le Moyen Atlas central	Morocco	MEDA II Bilateral	EC Delegation
Appui à la situation de l'emploi de la femme rurale et gestion durable de l'arganerie	Morocco	MEDA II Bilateral	EC Delegation
Développement participatif des zones forestières de la province de Chefchaouen	Morocco	MEDA I Bilateral	EC Delegation
Forestry Development Project	Morocco		World Bank
Irrigation based Community Development	Morocco	World Bank	World Bank
Emergency Drought Recovery Project	Morocco	World Bank	World Bank
Implementation of pilot systems to monitor the desertification in two countries of the southern coast of the Mediterranean: Tunisia and Morocco	Tunisia, Morocco	LIFE Third Countries	LIFE
Participatory Control of Desertification and Poverty Reduction in the Arid and Semi-Arid High Plateau Ecosystems of Eastern Morocco	Morocco	GEF OP15 Land degradation	IFAD

Overall, negotiations between Morocco and its cooperation partners have generated a total of 1.8 billion dirham (about USD 225 million) to finance integrated projects to combat desertification. Combating desertification is central to not only climate change issues, biodiversity preservation, and water and soil conservation, but also to food security and combating poverty. In Morocco, 93 % of land is affected by desertification processes resulting from unpredictable rainfall, which has tended to decline with unequal and irregular distribution for nearly a century.

The situation is exacerbated by human pressures: an imbalance between the demand for and scarce supply of water; vulnerability and overexploitation of forest ecosystems, rangelands, and already limited soil resources. The per capita useable

agricultural area (UAA) is in continuous decline. The cost of natural resource degradation in the forest, agricultural and rangeland sectors and following the silting up of dams is calculated to be 2.9 billion *dirhams* a year. The NAP must therefore translate into effective measures and actions on the ground. This is the aim of the GM's support to the design of a national resource mobilization strategy based on ensuring coherence between internal and external financing and the integrated application of a range of international instruments for sustainable land management (SLM) and combating desertification.

Even serious matters like deforestation that threatens livelihoods, water storage for irrigation and soil productivity has not been given the support that it requires. In Morocco, reforestation started in 1949 and currently accounts for a total of 767,000 ha of woodlands. The evaluation made at the end of 2000 shows that a net 530,000 ha had actually been reforested, i.e. about 10,000 ha per year. The much higher objective of 22,000 ha per year has only been achieved one single time since 1970. Management and oversight of the precious forests and rangelands is restricted to about 4 Mha of forest land and about 2.3 Mha of rangelands.

Efforts have been made to improve grazing management and apply more scientific principles to rangeland monitoring and condition assessment.

During the period 1980–1990 efforts to were concentrated on:

- the establishment of the rangeland service in the Ministry of Agriculture;
- the training of engineers specialized in range management;
- the delimitation of 11 range improvement areas;
- the organization of the stockbreeders in pastoral co-operatives;
- the launching of the "ley farming" program in the dryland zones (use of annual medics and clovers on traditional fallow "*bour*");
- the planting of fodder shrubs on 17,000 ha; mainly *Atriplex nummularia* and *Opuntia inermis*
- the installation of protected areas on 28,000 ha in the High Atlas and Tafrata zones;
- the establishment of the El Jadida seed production center (Centre de Production des Semences Pastorales);
- the execution of several studies relating to rangeland use;
- the execution of a large program related to the basic infrastructures concerning water, wells, pastoral roads and dipping tanks.

There are opportunities for improvement of fodder resources that can relieve that pressure on the grazing lands and also allow a higher turn-off of livestock for slaughter and at a younger age.

In order to overcome some of the limitations stated above, the Ministry of Agriculture has developed a strategy for range development. The main objectives of this strategy are to:

- create an economical environment compatible with the objective above, allowing the adhesion of the producers and the sustainability of animal production systems;

- satisfy the demand for red meat by the year 2020;
- create a facilitating economic environment for the long term participation of producers and for the sustainability of animal production systems;
- organize stakeholders and facilitate the modernization of pastoral activity;
- conserve natural resources and improve livestock productivity.

The following actions are being taken at different levels in order to achieve the stated objectives:

5.2 Policies and Legislation: Review and Update

- Strengthen management capacity to make better economic use of investments and for the integration of livestock into farming systems. This would be a prerequisite to improving livestock productivity on rangelands;
- Improve marketing channels to benefit herders, particularly the large number of small-scale operators, by providing them access to agricultural credit and markets.

5.2.1 Land Tenure Reform

- Promote community-based organization(s) to ensure active and continued participation of all members of the community in the management of grazing land, to establish and/or clarify by delimitation and registration the status of collective pastoral lands, and especially to put restrictions on land sub-division and shifting agriculture;
- It must be made clear that range management is not simply a technical issue because it also translates land policy into economic use/conservation of basic resources, and the type of development provided to producers without adversely affecting the interest of their heirs or of the nation;
- The selection of interlocutors is crucial to the success of the endeavor, given the nature of the activities to be undertaken. Consequently the beneficiaries must all have similar needs and aspirations in order to minimize conflict. The group leaders must also be clearly identified.

5.2.2 Conservation and Sustainability

One of the main objectives of the strategy for rangeland development relates to the sustainable use of the resources. Protection of the environment is central to this strategy (combating desertification, conservation of biodiversity and agro-biodiversity). Each year, 100 million tons of soil is removed. Several soil conservation technologies have been developed in Morocco and are available for large diffusion but in many cases these technologies have not been permanently adopted.

These technologies deal mainly with soil and water conservation techniques and water harvesting. The Taourirt-Taforalet Rural Development Project (PRDTT) financed by the International Fund for Agricultural Development (IFAD) contributed financially to the introduction of these new practices at some farms in the eastern region in order to encourage large dissemination. However, only a small percentage of farmers (7 %) adopted the new technologies without the project support (Shideed et al. 2005). It seems that a large-scale dissemination of these new practices requires some financial incentives that must be sufficiently high to stimulate farmers to adopt the technologies.

5.2.3 Range Rehabilitation

There is a plan, to be undertaken on 20 Mha over 20 years, to survey the use of pastoral resources. Having these data will strengthen the base for initiating rangeland management initiatives and the registration of communal lands in order to clarify the status of the area to be managed. At the same time, undertaking range improvement and rehabilitation, and taking action, both in time and space, will allow for the generation of credible production and conservation statistics. These actions will involve the rehabilitation of severely degraded rangelands (8.3 Mha over 20 years at a rate of 200,000 ha/year), the improvement of the productivity of rangelands with high potential (50,000 ha/year over 20 years) and the improvement and management of rangelands that are presently still considered to be in satisfactory condition.

5.2.4 Collecting Native Rangeland Species

The rangelands of north-eastern Morocco are home to a diversity of rangeland species. They are an invaluable resource to rehabilitate fragile, dry environments. Due to over-exploitation of these native plants and their habitat, however, many are endangered and some are close to extinction. To this end, ICARDA and national research institutions undertook a mission to assess rangeland biodiversity and collect native rangeland species. The collection covered 43 sites over an area of 2,200 km and rainfall zones of 180–500 mm. Samples were collected at intervals of 10–15 km along the collection route. Over 385 accessions of 60 species were collected. *Stipa* spp. were most frequent (51 accessions of four species). *Artemisia* spp. were also frequent. Other species collected included *Heliantheum* spp., *Herniaria* spp., *Paronychia argentea, Schismus barbatus*, and *Thymus* spp. Vetch (*Vicia*) and medic (*Medicago*) species were found in areas protected from grazing (Fig. 5.4).

Fig. 5.4 Collection of seeds from rangeland plants, including trees and shrubs in Eastern Morocco

5.2.5 Grazing Land Improvement

Results achieved during the phase 1969–1980 made it possible to draw the main lines for rangeland development. These, which are supported by the organization of beneficiaries, the range studies and the rational exploitation of the rangeland, have formed the basis for development of several range projects such the Middle Atlas project, the FAO-UNDP project and the USAID Range improvement project under which capacity building has been reinforced. Activities included characterization and mapping of rangelands; critical appraisal of past and ongoing rangeland development projects; testing methods of rangeland rehabilitation; community-level marginal land rehabilitation; and community seed production of range species.

5.2.6 Monitoring and Assessment of Land Cover Change

The integration of satellite imagery and ancillary data with statistical modelling provides access to updated information for the mapping of rangeland facies, statistical analysis, zoning and identification of vulnerable zones. The building of a database permits the statistical and spatial analysis of data for better under-standing, management and use of rangeland resources.

The Geostat-Maroc project resulted in the building of a rangeland database and a monitoring system based on a GIS. The database can be regularly updated (every 2–5 years for example) according to the degree of environmental pressures on the natural habitat. This methodology can produce a statistical inventory of national rangeland cover with an accuracy as high as 90 %. It can be easily applied in other countries and regions where rangeland resources are important. This project was carried out by the Royal Centre of Spatial Remote Sensing (CRTS), the Department of Livestock and the IAV Hassan II (MAMVA), in collaboration with the National Centre for Spatial Studies (CNES), ENSAT, INSEE and Scot-Conseil of France.

5.2.7 Advocacy, Partnership Building and Resource Mobilization for Climate-Resilient Development in the Oases of Southern Morocco

This program focuses on the drier regions of the south and south-east. Support will be channeled within the framework of the project "Sustainable Territorial Development of Southern Provinces". This project – implemented by "Agence du Sud" in collaboration with regional and local authorities – acts as a framework for regional/local development and a catalyst for investment. The Program will support project efforts to mobilize partners and resources to promote climate resilient development in the southern provinces. Both climate change and accelerated land degradation are major threat to the oases communities There is need to:

- Raise awareness on the impacts of climate change on the oases of Morocco;
- Mobilize partners and resources to promote climate-resilient development in the oases of Morocco.

6 Integration of Forages into Farming Systems

The major challenge to livestock production is the dwindling feed sources. The increase in small ruminant numbers is subjecting the already degraded rangelands to further degradation, and farmers are facing an acute shortage of feed. To support resource-poor farmers, therefore, there is an urgent need to both regenerate the rangelands and provide alternative sources of low-cost feed, such as cactus and feed blocks made from agricultural by-products (Fig. 5.5). Spineless cactus or shrub (*Atriplex halimus*) alone or intercropped with barley, vetch, oats, or other forage crops can improve the supply and quality of feed resources and prevent soil erosion, especially on hillsides outcome of alley cropping was that due to the increase in feed supply, farmers increased flock size. The calculations suggest that alley cropping increased the number of small ruminants by 25 % among technology adopters.

6.1 Integrated Livestock/Rangeland/Crop Production Systems

A range of technologies have been developed to integrate crop-livestock-rangeland production systems. These include:

- Barley production with alley cropping of shrubs such as *Atriplex* spp.
- On-farm feed production
- Feed blocks produced from agro-industrial by-products
- Spineless cactus and fodder shrubs
- Flock management
- Natural pasture enhancement and rangeland management

Fig. 5.5 Planting of long lived drought-resistant hardy perennials into rangeland can provide a valuable protein supplement during the dry season and a drought reserve. *Atriplex* spp. perform well (Photo B.E. Norton)

- Increase animal productivity: animal health and nutrition, better use of genetic resources including wild breeds, and better access to markets and by-products
- Improvement of rangelands: rehabilitate degraded rangelands, improve grazing management.

First, the development of the cactus/*Atriplex* alley cropping in the WANA region has encouraged the governments of Morocco and Tunisia to invest in agriculture in dry areas. By increasing and stabilizing fodder reserves, cactus/*Atriplex* alley cropping can help mitigate drought. The technology is therefore an effective risk-hedging strategy for drylands. The benefits are expected to spur adoption by farmers in similar agro-ecological zones in Morocco, Tunisia and other countries. It is necessary to capture the holistic nature of the problem by integrating economic, environmental and social aspects.

The most important action to integrate forages into the farming systems was the ley farming operation. Other actions include promotion of the new feed production techniques such as fodder conservation, valorization of straw, and utilization of agro-industry by-products.

Development of productive and sustainable production systems based on small ruminants, through the integration of feed and livestock production, both within and across arable and rangeland production systems is a high priority. This would improve the incomes and welfare of farmers and pastoralists in the low-rainfall areas of Morocco, while meeting national demands for small ruminant products and conserving the natural resource base.

Several collaborative research and development projects ('Multipurpose Fodder shrubs and Trees', 'Sustainable Management of the Agro-Pastoral Resource Base in the Oujda Region', the 'Mashreq/Maghreb' project, the 'Taourirt-Tafoghalt' project, and the 'Pastoral and Herding Development' project) are operating in the region. ICARDA and the Moroccan national program are key participants. A common feature of these projects is the use of a participatory approach involving all stakeholders concerned with sustainable development of agropastoral resources. Involvement of pastoral communities within the 'Sustainable Management of the Agro-Pastoral Resource Base in the Oujda Region' project, supported by the Swiss government, is described below to illustrate this participatory approach.

Due to human and animal population growth, cropping has expanded into low rainfall areas and into very fragile environments to the detriment of rangeland, resulting in increased feed deficit and soil erosion. To reverse the situation, ICARDA and its Moroccan partners are testing the suitability of shrubs as an intercrop (alley cropping) with barley and other common crops, such as oats, and mixtures of barley and fodder pea, and barley and vetch.

The ley farming operation was launched in 1986 aiming at the integration of sheep and cereal production by cultivating the 1.6–2.6 Mha that have been in fallow each year. Despite the real advantages that this operation represents in the semi-arid regions of Morocco, the substitution of the rotation cereal-annual medics or cereal-subterranean clover was only done on about 5,200 ha/year. The main reason for the limited adoption of this system is related to the size of the farms. In fact, most of the farms are very small and scattered which makes movement of the herd and grazing difficult.

Alley cropping where an annual crop is planted between rows of the perennial shrub *Atriplex* provide a stable and productive system that benefits the integrated livestock-cropping system.

On-station and on-farm testing suggests that alley cropping with *Atriplex* (salt-bush) could greatly increase crop and animal production, and at the same time help to protect fragile soils from wind and water erosion.

Total biomass and grain yield were higher in alley cropped systems. Energy and crude protein yields also increased by 11–93 % and 16–196 %, respectively. Alley cropping increased land equivalent ratios from 1 (barley or weedy fallow) to 1.20–1.46, suggesting that this technology will be particularly useful in areas where farm size is small. (A land-equivalent ratio of more than one indicates that growing an intercrop gives higher total output per unit area than a single crop). The adoption of this technology is taking off. Indeed, a total of 6,000 ha of alley cropping systems have already been established on private farms within the Taourirt-Tafoghalt project. This was a result of collaboration between different research and development projects, such as the CGIAR System-wide Livestock Program's Multi-purpose Fodder Shrubs and Trees project led by ICARDA, ICARDA's Mashreq Maghreb project, and the Taourirt-Tafoghalt project. A further 8,000 ha are to be alley cropped in the coming years (Fig. 5.6).

Fig. 5.6 A photograph of *Atriplex* in an alley cropping system with barley as the cereal crop (Photo B.E. Norton)

7 Conclusions

Morocco faces many challenges as populations rise, the pressure on land increases and more and more marginal rangeland is converted for cropping (often with disastrous consequences) and the impact of climate change is more severe.

A number of new farming systems have been developed, better remediation measures have been devised and the adoption of new ideas is progressing rapidly, especially for alley cropping.

Acknowledgements A synthesis of this nature necessarily involves drawing upon the plethora of sources some published in less accessible reports that have been prepared under the auspices of the government of Morocco, by the UN system and by the donor community including NGOs. The author is grateful to all those people whose materials formed the fabric of this chapter and the government of China for the opportunity to attend and participate in the Desert technology training course in Wu Wei in 2006. Gratitude is expressed for use of the photographs of Dr. B.E. Norton.

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