Drylands of the Mediterranean Basin: Challenges, Problems and Prospects

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11.1 Introduction: Overview and Context

The lands around the Mediterranean Sea (the Mediterranean Basin) form the largest of the five world regions subjected to a Mediterranean climate – long warm to hot dry summers and mild to cool, wet winters (Figs. 11.1 and 11.2). According to Gintzburger et al. (2006), the region considered stretches from the Turkish Anatolian plateau to the Red Sea in Southern Jordan over 1,200 km and from the Lebanese coastal zone through Syria and Iraq to the Iranian border. This is the cradle of ancient civilizations where pastoralism continues to be an essential agricultural activity (30% of agricultural income) supplying the local population with indispensable red meat and milk products.

Bioclimatically, the Mediterranean Basin (Le Houerou 2004) comprises a transition between southern desert (Saharan-Arabian deserts) and northern nondesert (European woodlands). Using UNEP's aridity classification, the political boundaries of all Mediterranean countries (Fig. 11.2) include the whole range of dryland types: from south to north, southern Mediterranean countries, which are closer to the Saharan-Arabian deserts than the northern Mediterranean countries, have hyperarid drylands (true deserts), semiarid drylands and dry subhumid drylands. Northern Mediterranean countries have semiarid drylands, dry subhumid drylands and nondryland regions – humid areas.

The UNCCD does not regard hyperarid drylands as prone to desertification; hence, all Mediterranean countries have within their boundaries areas prone to desertification and areas not prone to desertification; in southern Mediterranean

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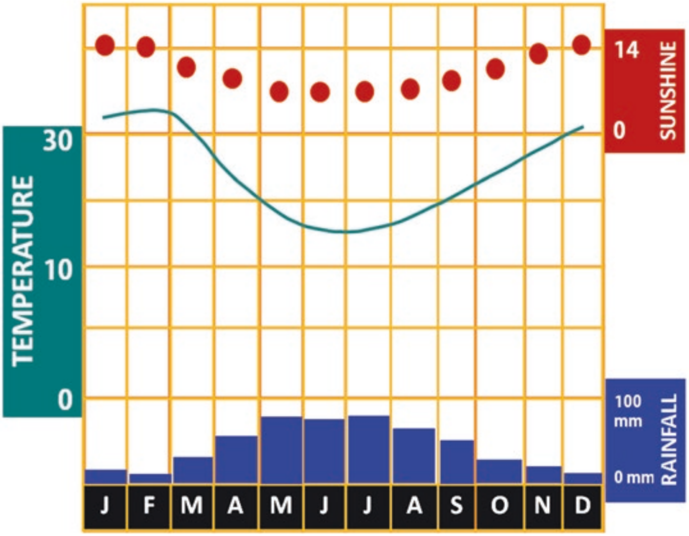

Fig. 11.1 A typical climatograph for a site within the Mediterranean Basin

Fig. 11.2 There are numerous countries in the Mediterranean Basin. The drier areas are shaded in darker colours

countries, areas not prone to desertification are the southernmost and driest regions, and in the northern Mediterranean countries, these are the northernmost and least dry regions. The European and/or the northern parts of the Mediterranean Basin do not have arid and hyperarid drylands. In the south-eastern parts of the basin, these dryland subtypes do appear and become widespread with increasing distance from the coast (the transition between semiarid and arid drylands occurs between 260 and 720 km due south of the Mediterranean coasts of North Africa whereas in the south-eastern Mediterranean arid drylands often appears close to the coastline).

The eastern Mediterranean countries – Israel, Lebanon and Syria combined – present the full gradient (southern-northern) of the global drylands. Thus, most drylands of the Mediterranean Basin are semiarid and dry subhumid drylands. Namely, drylands that are at least part of their extent are characterized by a degree of aridity that is most prone to desertification. Using UNEP's classification, the political boundaries of all Mediterranean countries include the whole range of dryland categories: from south to north, southern Mediterranean countries which are closer to the Saharan-Arabian deserts than the northern Mediterranean countries, have hyperarid drylands (true deserts), semiarid drylands and dry-subhumid drylands; northern Mediterranean countries have semiarid drylands, dry subhumid drylands and non-dryland regions – humid areas. These climatic conditions make the Mediterranean vegetation (woodlands, scrubs, steppes and grasslands) well adapted to survive dry conditions and to recover from droughts, floods and fires. Yet, land degradation and desertification do occur in croplands, rangelands and woodlands in the Mediterranean Basin. They have led to economic and social impacts such as land abandonment, migration to urban areas and reduction of the economic value and social function of the land. Population growth in both rural and urban areas increases food demand and leads to intensive cultivation which often exacerbates land degradation and desertification and causes declining productivity and poverty.

Desertification is the result of two factors operating either singly or in combination in arid Mediterranean zones. These are (1) periods of prolonged drought and (2) human exploitation of arid lands (Le Houerou 2005). The resulting degraded conditions threaten the long-term future of lands in the Mediterranean Basin. For the past century, conditions have deteriorated due to agricultural policies, such as governments providing subsidies on the costs of imported feed, and range mismanagement, such as overgrazing, risky rainfed cropping, fuel wood collection and increasing watering places by installing new boreholes combined with escalating use of trucks and tractors to cart livestock, feed and water to remote rangeland areas. Deteriorating conditions have a clear bearing on the lives of herders and nomads and may have future global impacts as impoverished rangeland populations leave the rangelands (see Sect. 11.2.1 below) (Table 11.1).

In Algeria, for example, rangelands are mostly located within a belt between 100 and 600 mm isohyets and cover 39% of the country. Rangelands support 38% of the country's human population and nearly 48% of the sheep units (SU). Livestock utilizing the rangelands contribute about half of the GDP of the country.

Many areas of the Mediterranean Basin are classified as drylands and hence are prone to desertification, but there are differences between the southern and the northern parts of the basin. In the southern part, most dryland areas are classified as arid and hyperarid, while in the northern parts, only few arid areas, but many dry subhumid and semiarid drylands, are found. The semiarid areas are currently the most affected by desertification, but the concern for dry subhumid areas is increasing.

Drylands that, for at least part of their areal extent, are characterized by a degree of aridity that is most prone to desertification, on account of both its moderate vulnerability impacted by moderate human population pressure. Indeed, the Mediterranean Basin has experienced desertification during its lengthy history of extensive and intensive land use (IDCC 2008, 2010, 2013). Experiences

Table 11.1 Economic indicators of North African rangelands

Economic indicators	Morocco	Algeria	Tunisia	Libya	Egypt
Contribution of livestock as proportion of agricultural GDP	260.	480.	0.30	(~0.15)[a]	
Rangelands as proportion of total area	420.	390.	250.	(~0.02)	010.
Human population on rangelands and desert areas as proportion of total population	380.	380.	280.	(~0.10)	
Rangeland contribution to yearly feed calendar	0.30	0.10	0.10	(~0.05)	0.05
Small ruminants (sheep equivalent[b]) as proportion of livestock in pastoral areas	0.75	0.48	0.20	(~0.90)	0.27

Adapted from Nefzaoui and El Mourid (2008)

[a]In brackets: estimate for Libya for 2011

[b]One sheep equivalent = one dry ewe (DE = 45 kg liveweight); one goat = 0.7 DE; one local cow = 5 DE; one dromedary = 7 DE

accumulated during the millennia of combating desertification and more recent advances in agricultural research have been and still are counterbalanced by population growth, though there are some very recent positive trends.

11.2 Land Degradation as a Response to Dryland Development

The notion that the very factor that has been urged upon developing countries now for about a century might be the principal root cause of dryland degradation will come as shock to many. Whole UN agencies (United Nations Development Programme, UNDP; International Fund for Agricultural Development, IFAD) have been set up to assist dryland countries (in particular) to develop. Bilateral donors such as the UK Department for International Development Agency (DFID), Canadian International Development Agency (CIDA) and Swedish International Development Cooperation Agency (SIDA) and the World Bank, Asian Development Bank, African Development Bank and Islamic Development Bank provide funds and technical assistance.

Land degradation in drylands (desertification) can be thought of as a response of dryland ecosystems to pressure of dryland development and is therefore what Safriel (2006) describes as a "manifestation of non-sustainable development". The pressure constitutes an attempt to overexploit the ecosystem service of biological productivity for generating subsistence crops or livestock. The pressure increases with reduced aridity of the drylands, whereas the vulnerability to desertification increases with aridity. These contrasting trends across the global aridity gradient place drylands of intermediate aridity, like those common within the Mediterranean Basin under the greatest risk of desertification.

11.2.1 The Interlinkages Between Development and Desertification

There is accumulating evidence that supports the description of *desertification* as a reaction of dryland *environment* (or ecosystem) to *development* (Kreutzmann 2012). Vulnerability and resilience to accelerated land degradation are both affected by development initiatives which created both the economic conditions for anthropogenic impacts on land and water resources (including climate change) and the social conditions that limit resilience capacity. This environmental response is driven by people striving to produce *essentials* for human livelihoods – food, fibres and forage – by exploiting a major service of dryland natural ecosystems, that is, land or biological productivity (Millennium Ecosystem Assessment 2003). Dryland development is characterized by the intensification of this exploitation, forcing the ecosystem to *increase* the provision of the service of biological productivity beyond its natural provision rate. However, this attempt often achieves in drylands the opposite result – the provision of biological productivity not only increases, but it *declines* to a level below that prevailing prior to the onset of development. This man-induced time-lagged reduced provision of the service of biological productivity, its causes and its repercussions jointly constitute the phenomenon of desertification. Thus, the first signs of desertification serve as an indicator that the threshold between sustainable and non-sustainable dryland development has been crossed (Safriel and Adeel 2008). Once their land becomes desertified, people abandon the land and migrate to new areas. As shown in Fig. 11.3, migration (*sens lat.*) can be at different scales (within boundary) and cross boundary of events that had led to the desertification of the land of their first choice. Only this time the downward spiral to desertification is much faster than the one experienced by the already desertified land. This is because the land of second choice is of biological productivity inherently lower than the one of first choice and hence more vulnerable. Thus, sooner than later, the people take a more dramatic, *cross-boundary* migration. Here, the term is used in its broadest sense too: migration through rural-urban boundary, through socio-economic boundaries and finally through ethnic, national and political boundaries. These cross-boundary migrations driven by the decline in provision of the dryland ecosystems' service of biological productivity make desertification to snowball from an environmental biophysical phenomenon to a societal security issue. These are often expressed in social, ethnic and political strife that further increase the demand for biological productivity (Fig. 11.3).

While there are development projects and practises that do not generate desertification (IDDC 2008, 2010, 2013) most desertification cases are tightly interlinked with dryland development – for example, exploiting fossil water to grow alfalfa in the deserts of Saudi Arabia or sedentarization of pastoralists, e.g. Bedouin in North Africa and the Gulf States or *Kuchi* in Afghanistan/Iran. In recent years, a renaissance of modernization theory-led development activities can be observed. Higher inputs from external funding, fencing of pastures and settlement of pastoralists in new townships are the vivid expression of "modern" pastoralism in urban contexts. The new modernization program incorporates resettlement and transformation of

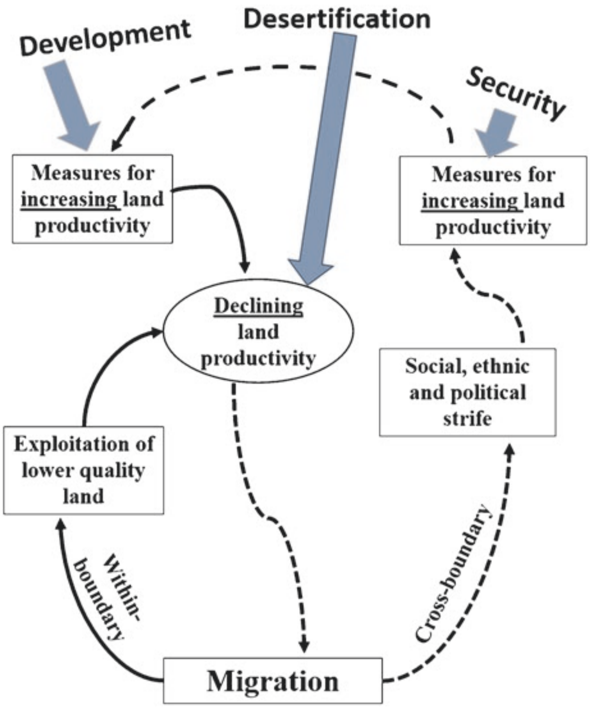

Fig. 11.3 The desertification vortex: development (*left-hand boxes*) driving desertification (*solid arrows*, *central circle*), which generates security issues (*dotted arrows*, *right-hand boxes*), which drive intensified development (*broken arrow*) and further desertification

lifestyles as to be justified by environmental pressure in order to reduce degradation in the age of climate change (Feng and Squires, 2017).

According to Kreutzmann (2012):

> In conventional views, pastoralism was classified as a stage of civilization that needed to be abolished and transcended in order to reach a higher level of development. In this context, global approaches to modernize a rural society have been ubiquitous phenomena independent of ideological contexts. The 20th century experienced a variety of concepts to settle mobile groups and to transfer their lifestyles to modern perceptions. Permanent settlements are the vivid expression of an ideology-driven approach. Modernization theory captured all walks of life and tried to optimize breeding techniques, pasture utilization, transport and processing concepts.

11.3 Climate Change and Its Implications

Data from many sites throughout the Mediterranean Basin show that warming and drying are widespread. The observed drying trend since 1950 was predominantly due to winter drying, with very little contribution from the summer. The historical region of Fertile Crescent (FC) was recently hit by an intense and prolonged drought episode during the two hydrological years 2007 and 2008. The impact of the 2007–2009 drought in vegetation was evaluated with normalized difference vegetation index (NDVI) obtained from VEGETATION instrument. It is shown that large sectors of south-eastern Turkey, Eastern Syria, Northern Iraq and Western Iran present up to 6 months of persistently stressed vegetation (negative NDVI anomalies) between January and June 2008. During the following dry years (2008–2009), dry areas are restricted to Northern Iraq with up to 5 months of stressed vegetation. The impacts on cereal production (wheat and barley) were severe in the major grain-growing countries in the area. Syria, Iraq and Iran were significantly affected by this drought, particularly in 2008. The economic impact was mostly due to the steep decline in agricultural productivity in the highly populated areas of the Euphrates and Tigris river basins.

The drought-affected region is located at the eastern end of the Mediterranean Basin, a region characterized by decreasing precipitation and river flow in the last few decades. The strong dependence of vegetation dynamics on water availability has been for long recognized throughout the Mediterranean Basin and especially in semiarid regions in North Africa (once a major source of cereal grains). In this environment, natural vegetation and nonirrigated crops are crucially dependent on soil moisture provided by seasonal rains or springtime snowmelt. This dependence leads to quite different vegetation activity levels on seasonal and inter-annual timescales. Consequently, opportunistic annual species may appear rapidly in response to humid condition of the soil, and their greenness is mainly related to recent precipitation (Zaitchik et al. 2005). On the other hand, winter crops and persistent vegetation are dependent on deeper reserves of soil moisture, and their vegetative cycle is the result of the combined effect of precipitation (over weeks and months), evaporation and, in some regions, of temperature. The vast majority of crops in these regions are nonirrigated and thus dependent on winter precipitation. Dry conditions during the planting period cause crop failure due to lack of water during the germination of the seeds. A combined effect of lack of precipitation over a certain period with other climatic anomalies, such as high temperature, high wind and low relative humidity over a particular area, may result in reduced green vegetation cover. When drought conditions end, recovery of vegetation may follow (Nicholson et al. 1998), but such recovery process may last for longer periods of time.

11.3.1 Drought Impact on Vegetation

The combined effects of this future precipitation decrease and the widely accepted future increment in the surface temperature on the Mediterranean (Christensen et al. 2007) will bear important changes in the region's hydrological water cycle. The strong seasonal and inter-annual variability of vegetation in most semiarid regions is a subject of particular interest due to the ecological and economic impacts. In particular, the high sensitivity of vegetation to climate forcing may result in rapid land use changes and high vulnerability to land degradation, as a result of human action. The changing land cover pattern reflects the precipitation regime in the area.

Over longer periods, changes may have a considerable impact on the viability of agricultural and pastoral systems.

Greenhouse gas emissions are rising throughout the basin. No climate model predicts that rising GHGs will cause the Mediterranean region to get wetter as a consequence of rising GHGs, so, instead of waiting for yet more model confirmation of what we already know, the time is ripe for Mediterranean countries to plan for the drier times ahead (e.g. Iglesias et al. 2007). Droughts are likely to be more frequent (Hoerling et al. 2012).

11.3.2 The Causes of Increasing Aridity

According to Seager et al. (2014), the hydroclimate consequences of warming and the associated thermodynamical adjustments of the hydrological cycle are well understood. The dynamical mechanisms for hydro-climate change – why the atmospheric mean and transient circulations change in the way they do – are not so well understood. It has been known for a while that the mid-latitude jets and storm tracks shift polewards under global warming, and the Hadley cell expands, causing expansion of subtropical dry zones. Wu et al. (2012, 2013) provide a review of proposed mechanisms for this and advance the case that this is a tropospheric response to stratospheric circulation adjustment with the signal propagating downwards via linear wave refraction.

11.4 Poverty, Land Degradation and Ecological Migration

Desertification and poverty are interlinked, culminating in land abandonment and trans-boundary, mostly South-North, migration. The current flow of immigration within the Mediterranean Basin is unidirectional – the geographical South-North migration from North Africa to Europe, as well as from the "socio-economic south" to Western Europe. At least in part, a substantial segment of this immigration is driven by loss of food and environmental security linked to desertification. This immigration then drives apparent or even tangible "soft" security concerns in the target countries, some of which are themselves desertification-affected countries. Attaining sustainability of dryland development, through relieving much of the pressure on the service of biological productivity of dryland ecosystems by replacing them with alternative dryland livelihoods, will reduce immigration and increase security within the Mediterranean Basin. The desertification-driven unidirectional migration will be replaced by mutual exchanges. Safriel (2006) suggests several South-North flows that can be envisaged. One is that of cash crops produced by intensive but low-impact agriculture (e.g. Egypt and Jordan export fresh fruit (grapes and melons) to Spain and other countries). Dryland aquaculture has considerable potential too. Dryland aquaculture is inherently advantageous on dryland agriculture. This is, paradoxically, due to the water scarcity or, more precisely, to the high evaporative losses that make an area a dryland. Although aquatic organisms live in water, they do not transpire water; hence, water losses from aquaculture can be analogous to evaporation, rather than to evapotranspiration. Furthermore, many more aquatic than terrestrial crop species are tolerant to salinity in water and even benefit from it. Thus, dryland aquaculture can thrive on fossil aquifers; though quite common in drylands, their salinity greatly curtails their usability by dryland agriculture. Both freshwater fish and species adapted to saline water (brine shrimp, etc.) can be used. Water that is no longer suitable for fish can be used to irrigate hardy species such as olive or grape. Another possible South-North flow is that of transported solar or wind energy generated in southern Mediterranean arid drylands that may provide a tangible segment of the North's energy demand. Wind power and solar energy "farms" generally require much land. Most drylands are sparsely populated and land is not scarce.

Generally, creation of better urban livelihoods can be based on the tourist and solar energy industries and better organized ways to capitalize on drylands' scenic and cultural attractions (eco-tourism and cultural tourism) and climatic attributes (abundant sunshine, mild winters, etc.). A combination of these developments has the potential to arrest the North-South Mediterranean migration and replace it with a northbound movement of cash crops and solar power and a southbound movement of tourists as well as finances linked to carbon trading, under the auspices of the Kyoto Protocol and the 2015 Paris Climate accord. Although "dryland development" and "rural development" are often synonymously used terms, dryland cities as an alternative to dryland villages may prove to be a sustainable option for settling more people in drylands[1] (Safriel 2006). Dryland urbanization may be advantageous, both over other land uses in drylands and over urbanization in the non-drylands. This is because dryland cities consume and hence impact fewer land resource than the drylands' farming and pastoral livelihoods and have a lower environmental impact than non-dryland cities. The prevailing notion of drylands is that of harsh climate and meagre livelihood opportunities; hence, the success of dryland cities depends on their ability to provide livelihoods as well as living conditions that are as advantageous as those provided by non-dryland cities.

Addressing land degradation, desertification and drought in the Mediterranean Basin includes policy reforms and enforcement, as well as research and extension that promote sustainable land use and restoration of already degraded lands. Reynolds et al. (2007) explain that the sustainable development for dryland ecological environment requires land user participation, and humans must be considered as part of the natural system. Sustainable development of agriculture *sens lat*. in the arid region must ensure the livelihoods of farmers, agro-pastoralists and herders in order to effectively implement sustainable development of the agro-ecological system. Climate change affects the stability of the ecosystem, and this adds to pressure as almost all land users seek to follow their own individual interests and to maximize profit. The challenge is to balance the interests of the government, livelihoods of land users and ecological benefits in the allocation and management of

[1] Tucson, and other locations in Arizona, have successfully established retirement settlements in the desert (see Squires, Chap. 8, this volume).

natural resources (Squires 2012). The focus on global drylands is shifting from an emphasis on negative images of desertification to a more forward-looking perspective concerning human livelihoods, based on interactions between and among human activities and natural-world processes.

In this millennium, global drylands face a myriad of problems that present tough research, management and policy challenges. Recent advances in dryland development, however, together with the integrative approaches of global change and sustainability science, suggest that concerns about land degradation, poverty, safeguarding biodiversity and protecting the culture of 2.5 billion people can be confronted with renewed optimism. The functioning of dryland ecosystems and the livelihood systems of their human residents is explained by Reynolds et al. 2007) in a new synthetic framework – the Drylands Development Paradigm (DDP). The DDP centres on the livelihoods of human populations in drylands, and their dependencies on these unique ecosystems, through the study of coupled human-environmental (H-E) systems (Qi et al. 2012). The DDP responds to recent research and policy trends that link ecosystem management with human livelihoods in order to best support the large, and rapidly expanding, populations of dryland dwellers. The DDP represents a convergence of insights and key advances drawn from a diverse array of research in desertification, vulnerability, poverty alleviation and community development. The DDP, supported by a growing and well-documented set of tools for policy and management action, helps navigate the inherent complexity of desertification and dryland development, identifying and synthesizing those factors important to research, management and policy communities.

Case Studies of Significant Subregions

1. North Africa

    This section draws on pasture profiles for Algeria (Nedjraoui 2001; Saidi and Gintzburger 2013), Morocco (Berkat and Tazi 2004) and Tunisia (Kayouli 2000). These North African countries have large areas of grazed land and many pastoral features in common and stretch from 13°E to 12°E and from 19°N to 37°19N; vast areas of their southern part are desert. The relief is in two broad categories, the Atlas and the Sahara. The Atlas is a group of ranges running southwest to northeast roughly adjacent and parallel to the Mediterranean coastline. South of the Atlas, a series of steppic plateaux descend to the Sahara, which is a great barrier between the Mediterranean zone and the tropics.

    The northern mountains capture most of the precipitation, and agriculture lands are concentrated in the north; the highest Atlas lands are forest and summer grazing. The climate is typically Mediterranean, with hot summers and rain occurring during the cool season. Temperature is governed both by altitude and the degree of continentality. The region has all the Mediterranean bioclimates, from per-humid to per-arid for bioclimatic levels and from cold to hot for temperatures.

Livestock are important throughout the zone, and in most farming systems, sheep are the most important and are the main livestock of the steppe, although small flocks are kept in most areas for domestic use; several local breeds are used according to regional adaptation. Cattle are mainly kept in the northern farming areas and are commonly fed on crop residues, by-products and concentrates; the traditional breeds were *Bos taurus* of the Atlas Brown type, but there are now many crosses with exotic dairy breeds, notable black and white ones.

2. The Near East (Often Lumped with North Africa and Called MENA)

2.1 Syrian Arab Republic

The country is largely pastoral, with 45% of its land being grazing and pasture and 20% desert (Masri 2001). The climate is typically Mediterranean and precipitation is low, decreasing towards the interior. Most of the grazing land is in the semi-desert and desert (*badia*) with less than 200 mm rainfall; there is a little mountain grazing; plains with over 200 mm rainfall are now under rainfed crops. Cattle are kept in the agricultural areas but are absent from the main grazing lands.

From earliest times until the end of the Second World War, Syrian grazing lands were under tribal control, population density was low, and the herders were nomadic, moving seasonally with their flocks. Pastoral communities evolved codes of laws and customs and the organization of groups and subgroups based on family relationship. Each group used to maintain grazing rights on certain resources in its traditional land as *hema* (pasture reserved for use in drought or emergency) and negotiated when necessary with the other groups for movement of its livestock to areas of more favourable climatic conditions during periods of drought. The chief was the first among equals and unanimously obeyed and respected by members. The social structure of the pastoral groups was close to a cooperative organization.

Large areas of grazing land were only accessible once the autumn rains had fallen, and herds had to leave them once surface supplies of water ran out, so the pastures were rested for a long period of the year. There was no external feed source, so stock numbers were limited to what could be carried through the lean season on available pasture and water. There was no rainfed cropping on marginal lands.

After the war, the situation changed rapidly. The central authorities became much stronger and the tribal system was disintegrating. Motor transport, introduced during the war, allowed transport of goods, water and feed, making large areas of grazing accessible for much of the year. Grazing land was nationalized and became an open-access resource with no supervision over its use. Settlement of the Bedouin became an official policy; this greatly improved their access to medical care, education, water and other services and led on the one hand to a rapidly increasing population and on the other a great reduction in mobile herding. Cheap cereals allowed increasing numbers of stock to be kept through the lean season.

Marginal land was increasingly cleared for rainfed cropping. Yields are low and uncertain; if they seem too low or the crop is unlikely to mature because of drought, it will be grazed. Clearing of grazing land was encouraged by granting land rights to those who developed it.

Sheep and goat production is the main and sometimes only agricultural activity available to populations living on rangelands in the arid regions around the Mediterranean. Desertification threatens large areas of the Mediterranean, especially the North African arid rangelands but remains difficult to describe, quantify and accurately locate for management purposes (Saidi and Gintzburger 2013; Hirata et al. 2005). Sheep are the main grazing livestock; the only local breed, the *Awasii*, is a milch sheep that is well adapted to harsh desert conditions, and its fat tail provides a reserve of nutrients for periods of feed shortage. They graze in the *badia* from late autumn till late spring, with supplements, and then they migrate to the rainfed and irrigated areas, clearing all crop residues (cereal, cotton, beet and summer vegetables) before returning again to the *badia*. The main constraint to sheep production is degradation of grazing land which increases dependency on supplementary feed.

The subsidized state feed policy puts pressure on the already degraded pasture through an increase in sheep numbers, which get most of their food as concentrates but continue to eat any available herbage. The sheep population was 2.9 million in 1961; it rose to 5.5 million in 1971, 10.5 million by 1981 and peaked at 15.5 million in 1991; it then fell to just over 10 million and for the past 7 years has been just over 13 million (FAOSTAT 2004). Goats are the second most numerous livestock; their numbers rose from 439,000 in 1961 to 1 million in 1981 and have remained at that level. Two main types of goat are kept; the Shami goat is a milch breed, and they are kept around homesteads; the other is the mountain goat, which grazes in the mountain ranges.

Before the Second World War, the Syrian badia was in good condition; climax plants like *Salsola vermiculata*, *Atriplex leucoclada*, *Artemisia herba-alba* and *Stipa barbata* were widespread; and flocks of gazelle were present. Herders went to the *badia*[2] with the onset of rains in autumn and had to leave when the water supply dried up in late spring. Range livestock depended on grazing until 1958, when concentrate feeds were introduced. The rate of concentrate use increased to 25, 50 and 75% in the 1960s, 1970s and 1980s, respectively.

Jordan

About 90%, or 80,771 km^2, of the Kingdom is grazing land, 69,077 km^2 of which receives less than 100 mm of rainfall and 1,000 km^2 of marginal grazing with 100–200 mm annual rainfall. Natural and man-made forests cover 760 km^2, out of 1,300 km^2 registered as forests (Al-Jaloudy 2001). There are also about 500 km^2 of state-owned land used for grazing in mountainous areas.

The average altitude of the highlands ranges from 600 m in the north to 1,000 m in the middle and 1,500 m in the south. There is a semiarid zone (350–500 mm annual rainfall) with a small subhumid zone (over 500 mm annual rainfall). The arid

[2] Badia is a general term for semi-desert.

zone comprises the plains between the badia and the highlands. Rainfall ranges between 200 mm in the east and 350 mm in the west. Rainfed crops are mainly barley (in areas with 200–300 mm rainfall) wheat and fruit trees (in areas with between 300 and 350 mm rainfall). Badia (eastern desert), which covers about 8 million hectares – 90% of the Kingdom – has very sparse vegetation cover and an annual rainfall of less than 200 mm. In the past, it was only used for grazing. In the last two decades, however, 20,000 ha have been irrigated, using underground water.

Jordan is on the eastern margins of the Mediterranean climatic zone. This climate is characterized by hot, dry summers and cool, wet winters; more than 90% of the country receives less than 200 mm annual precipitation.

There are four bioclimatic zones.

- *Mediterranean*: This region is restricted to the highlands from 700 to 1,750 m above sea level. The rainfall ranges from 300 to 600 mm. The minimum annual temperature ranges from 5 to 10 °C.
- *Irano-Turanian*: A narrow strip that surrounds all the Mediterranean ecozone except in the north; it is treeless. The vegetation is mainly small shrubs and bushes such as *Artemisia herba-alba* and *Anabasis syriaca*. Altitudes range from 500 to 700 m, and rainfall ranges from 150 to 300 mm.
- *Saharo-Arabian*: This is the eastern desert or *badia* and comprises almost 80% of Jordan. It is flat except for a few hills or small volcanic mountains. Altitude ranges from 500 to 700 m. The mean annual rainfall ranges from 50 to 200 mm, and mean annual minimum temperatures range from 15 to 2 °C. Vegetation is dominated by small shrubs and small annuals in the wadi beds.
- *Sudanian*: It starts from the northern part of the Dead Sea and ends at the tip of the Gulf of Aqaba. The vegetation is characterized by a tropical tree element, such as *Acacia* spp. and *Ziziphus spina-christi*, in addition to some shrubs and annual herbs.

Badia (Semi-desert)

The most significant use of this zone is pastoralism. Sheep and goats graze the forage produced on the desert range in the short period following rainfall; precipitation is less than 100 mm/year, which falls off towards the east and the south till it reaches 50 mm or less. Most are state lands. *Artemisia herba-alba*, *Retama raetam*, *Achillea fragrantissima* and *Poa bulbosa* are common in the wadi beds, while the unpalatable *Anabasis* sp. is present in most places. Despite its deterioration, this is the main grazing land of Jordan. The average annual dry matter production is 40 kg/ha in normal years; this can rise to 150 kg/ha in protected areas and range reserves. Steppes were used generally for grazing, but it is estimated that about 90% of the steppe has been privatized and ploughed for barley.

There are 2,200,000 estimated heads of sheep and goats in Jordan. Nomadic grazing has declined to less than 10% of the sheep and goats, which belong to less than 5% of herders. The ratio of semi-settled herds has increased to more than 70% of sheep and goats. The remaining small ruminants (about 20%) follow a system that is mixed with agriculture, especially in the west of the Kingdom.

Small ruminant production systems developed gradually in the middle of the past century as a result of a number of changes: increasing settlement of the nomadic Bedouin in the marginal areas, a change to sheep and goat raising instead of camels, deterioration of traditional grazing systems (eastward and westward trips), widespread use of vehicles for movement of flocks and equipment and increased dependence on imported feed.

The *traditional mobile system* prevails in the arid to semiarid east and south. Herds move from one place to another, on foot or by truck, looking for grazing or water. The sheep depend on natural herbage as their main source of feed, in addition to the feed given in winter for a period that varies with availability of herbage.

In the *seminomadic system*, sheep depend partially on grazing and crop by-products. They move to a land adjacent to the fields and spend the winter around the houses, where they survive on the feed given to them.

In the *settled (semi-extensive) system*, stocks are kept in fattening units but graze in the morning and return to their units in the afternoon. They feed on crop by-products and the adjacent natural grazing. Supplementary feed is given as required.

In the *intensive system*, sheep are kept on permanent farms with modern facilities and equipment. They are given balanced feed, and health care is provided.

Existing statistics indicate that there are 2,200,000 small ruminants, which depend for half their food requirements on imported feed. Natural grazing supplies only 25–30% of their requirements, as its productivity has declined to half of its potential and the area has decreased. In the past, the availability of fodder and water, and the search for them, were the limiting factors for movement of herds. Nowadays, food and water are transported to herds wherever they are, and it is possible to quickly transport the herds themselves. In 1930, the sheep herd was 229,100 and remained at a similar level until 1950, by 1970 it had doubled, and by 1990 it had reached 1.5 million, where it currently stands. Goat numbers in 1930 were 289,500; they had risen in recent years to 479,000 in 1990 and 547,500 in 2003, but nothing like the extent of sheep, which are far better suited for intensive fattening.

Existing policies are not comprehensive and are incompatible with national needs and development plans. Feed subsidy policies from the 1980s to 1997 brought about the unusual increase in sheep and goats numbers and the deterioration in local production of feed. Also allocation of wide tracts of the best range to private ownership caused their deterioration and desertification.

Pastoral communities informally claim common tribal rights and enjoy free access and use of natural resources in their rangelands, but these claims are only recognized in settled areas. In all the unsettled areas, the state asserts ownership regardless of customary tribal claims. State claims over grazing lands changed the traditional welfare system, caused the breakdown of resource allocation mechanisms and transformed secured-access rights into secured-tenure rights. Consequently, customary management rules are often no longer being enforced. State appropriation did not deny local communities access to their traditional pasture but favoured a situation of open access to grazing and expansion of barley cultivation.

11.5 Summary and Conclusions

The rangelands of North Africa and the Middle East used to provide the population with fodder for their flocks and now mostly fuel wood for domestic use. The small livestock graze the steppe vegetation by the end of winter and in spring (March), collecting nearly all available annuals and ephemeroids on the rangelands. Between December and March, depending upon the precipitation, they are heavily dependent on hand-fed concentrates, agroindustrial by-products, cereal straw (mostly barley *T'ben*) and legume straw (chickpeas and lentils). In summer and autumn, livestock are now found grazing cereal stubble and irrigated residues in cropped areas, while in earlier days, they used to browse the chamaephytic vegetation (*Artemisia herba-alba*). This is due to the increase in both the human and small ruminant populations. In Syria, for example, the sheep population increased from some 3 million heads in 1961 to nearly 14 million in 2000 with a 4% average annual growth rate that continues – causing great concern.

According to Gintzburger et al. (2006) "the future of rangeland resources of the Middle East and Middle Asia, essential to local population, remains quite gloomy unless proper conservation measures are implemented by strong and relentless political will and enforced without further delay". Similar views have been expressed about the drylands in the north of the Mediterranean Sea (Safriel 2006). Gintzburger et al. (2006) in their excellent review paper do a forensic examination of the situation in the region. They dissect the various contributing factors and offer recommendations about ways to arrest and reverse land and water degradation.

Expanding grazing land in the MENA region is a limited option. The development in agriculture is increasingly driven by shifts in human diets towards livestock products, which in turn influences crop production decisions and patterns. Meat supply in MENA steadily increased for red meat from the early 1960s to 2010. During this period, the annual per capita (sheep and goats + bovine meat) supply moved from 7.7 + 2.5 kg in 1961, increasing to 10.8 + 2.5 kg in 2002 in Syria, 9.5 + 8.3 kg to 4.0 + 17.3 kg in Lebanon, 5.2 + 1.5 kg to 2.6 + 5.8 kg in Jordan, 1.1 + 7.7 to 1.3 + 22.2 kg in Israel, 9.0 + 3.6 kg to 4.7 + 4.7 kg in Turkey and 4.9 + 2.7 kg in 2002 for Palestine. Despite the shift from sheep and goats to bovine red meat, especially in rich countries, it still shows the importance of sheep and goat meat for the local population.

Government subsidies to provide for cheap animal feed and concentrates have contributed to the keeping of too many small livestock on degraded rangelands. In crop-livestock-rangeland rainfed mixed systems, livestock substitutes for natural and purchased inputs, in addition to producing meat and milk. Until the mid-1950s, about 65% of the small livestock population was based on the steppe where feed requirements were covered without any supplementary feed. In the mid-1990s, 75–80% of the flocks are steppe-range based. They however do not get most of their feed from the range but mostly as supplementary feed, complements and crop residues. The low current contribution of rangeland feeding is due to the tremendous increase in sheep numbers but also to the loss of traditional management tools and to the modification of land tenure arrangements and "use rights".

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