

Chapter 2

The Intercontinental Biosphere Reserve of the Mediterranean

Abstract The creation of the Intercontinental Biosphere Reserve of the Mediterranean (IBRM) is a joint endeavour between Spain and Morocco; countries with very similar natural and biophysical conditions, but different socio-economic contexts and policy frameworks. Water related impacts of climate change in the region mean that on the one hand, increasing levels of drought are heightening inter-sectoral competition for water resources, and on the other hand, more intense and recurrent floods are leading to soil erosion, biodiversity loss, and negative consequences for ecosystem services. There is a marked socio-economic contrast between Spain and Morocco with the Moroccan side of the IBRM being particularly dependent on natural resources and exposed to climate change impacts. However, water-related impacts have the potential to affect human security on both sides of the IBRM. This was evidenced, for example, by the extensive droughts of the 1990s which had substantial effects on the agricultural economy in both Spain and Morocco, threatening food and water security and provoking migratory flows to urban centres. In this way, unfavourable effects of global change within the IBRM also affect society, economy and human security in the wider region.

Keywords Mediterranean basin • Spain • Morocco • Climate change • Floods • Water scarcity • Drought • Human security • Food security • Water security • Agriculture • Migration

2.1 Background

The Intercontinental Biosphere Reserve of the Mediterranean (hereafter IBRM) is located on the Western side of the Mediterranean Sea basin within the coordinates 4°41'24" W, 36°57'29" N (NW) and 5°50'25" W, 34°47'38" N (SE) (Fig. 2.1). The Reserve straddles the continents of Europe and Africa, passing through the Strait of Gibraltar and covering a surface of around one million hectares. The Reserve was created in 2006, in a joint endeavour between Spain and Morocco under the UNESCO Man and Biosphere Reserve Programme. This international cooperation

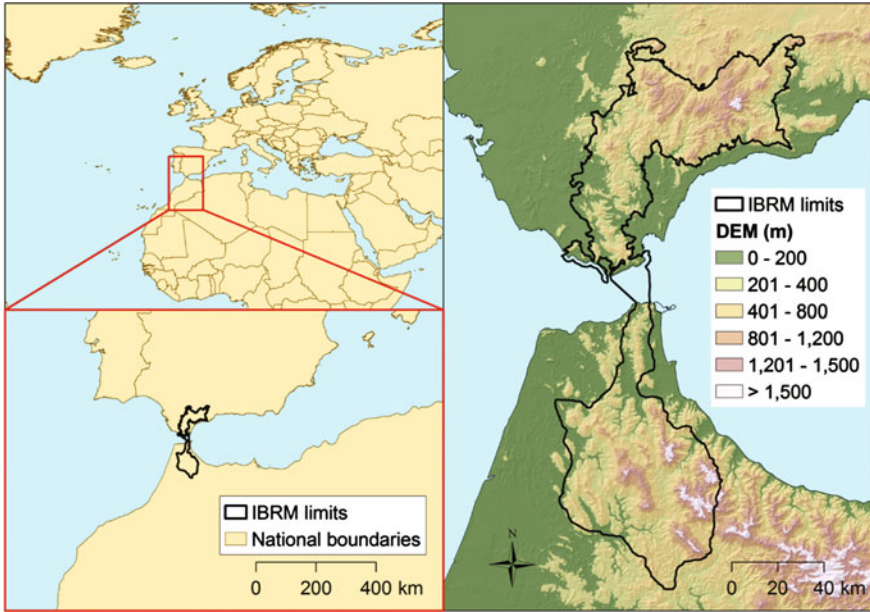


Fig. 2.1 Location of the IBRM (*left*). Detail of the IBRM boundaries (*right*), digital elevation model (DEM in meters)

involves the creation of a common management model for the sustainable territorial development of the Reserve, the preservation of the shared ecosystem and the conservation of the region's natural diversity and cultural heritage (Molina and Villa 2008). A Memorandum of Understanding on the Coordination of the IBRM was signed between the Spanish and Moroccan governments in 2011 and an Action Plan (2011–2015) was developed for the Reserve.

The IBRM is located in the semi-arid zone of the Mediterranean Basin where the climatic conditions are known for their seasonal contrasts, characterised by a high annual variability in precipitation (500–800 mm/year) and frequent episodes of drought. Due to its geographic location, the IBRM is influenced by both the winds of the western Mediterranean Sea and cold fronts from the Atlantic. These wet fronts are responsible for the discharge of a high percentage of the Reserve's annual precipitation, increasing the annual precipitation to around 2000 mm/year in some parts of the Reserve such as Grazalema (Spain). In addition, the high mean annual temperature (16–19 °C) and the high solar radiation in the region lead to extensive evapotranspiration, increasing the threat of drought, especially during the summer months.

Although both sides of the IBRM share very similar natural and biophysical conditions, the impact of human activities has shaped the landscape very differently resulting in diverse land use patterns: 70% of the Spanish side is covered by forest areas, scrubland and grassland while on the Moroccan side this amounts to around

29% (GlobCover v.2.3. 2009, 2010). In parallel, cropland covers around 39% of the Spanish side but accounts for more than 60% of coverage on the Moroccan side, while water bodies and artificial areas cover around 1% of the area in the Spanish side of the reserve, and 0.25% of the Moroccan side of the Reserve. Differing land use patterns are also reflected in the extension of protected areas: 70% of the Spanish side of the Reserve is protected in contrast to 30% of the Moroccan side (Molina and Villa 2008).

The Reserve has 556,359 inhabitants within its boundaries (INE 2016) but the reference population (including surrounding towns that share a border contact with the IBRM) is 719,293 inhabitants. Rapid socio-economic growth and technological transformation in the areas surrounding the IBRM have taken place in recent decades. For example, on the Spanish border of the IBRM, the Costa del Sol, has seen a high level of urban expansion, while near the Moroccan border, the opening of the Tanger-Med cargo and passenger port in 2007 has led to a substantial increase in human pressures. High demand for freshwater services for tourism and irrigation can lead to excessive water abstraction and the overexploitation of water resources (Llamas and Martinez-Santos 2005; Iglesias et al. 2007) as well as increasing land degradation. The demand for freshwater, energy and food is also expected to increase significantly over the next decades under the pressure of population growth, economic development, trade, urbanisation, and climate change (Hoff 2011). At the same time, regional projections indicate that precipitation will become scarcer (Magnan et al. 2009). If socio-economic development is carried out in an unsustainable manner, and given the paucity of structural water resources in the IBRM region, there is a potential that the wider hydrological cycle could be significantly affected.

2.2 Impacts of Climate Change on the Physical Environment

In the Rif region on the Moroccan side of the IBRM, researchers concur that the latter half of the twentieth century was one of the driest in the last nine centuries, causing net declines in dam water reserves, deficits in groundwater resources and limitations to drinking and irrigation water supply (Parish and Funnell 1999; Agoumi 2003; Touchan et al. 2010). After the 1970s, the decreasing trend in precipitation levels in Morocco provoked water deficiency in many areas (Ouassou et al. 2005). In the last decades, the already frequent incidence of droughts in the IBRM region has shown a significant tendency to increase (Karaky and Arndt 2002; INE 2016). These drought events have negative impacts on water quantity and quality. They affect the production of hydroelectric power due to declines in dam water levels, lead to interruptions in drinking water treatment plant services and affect the healthy functioning of a range of ecosystems, resulting in fish deaths,

water that is unsuitable for human consumption and the increase of waterborne diseases (Bennis and Sadeq 1998; Ameziane et al. 2001).

Bruggeman et al. (2010) developed climate change scenarios for the IBRM that point to a maximum rainfall decrease of 24–25% in 2040–2069, compared to 1961–1990, with summer and autumn periods more affected (A1B scenario). The same scenario projects a temperature increase of 2.4–2.5 °C for the same period. Even under the lower emission B1 scenario, the projected temperature increase is expected to be between 1.7 and 1.8 °C. These climatic stresses are expected to deeply affect water resource availability by decreasing water runoff and aquifer recharge. Spain's Mediterranean basins are already under very high stress and will have to meet a growing part of demand from "unconventional" sources by 2025, such as water re-use and desalination processes (Blinda et al. 2006). Andalusia currently reuses around 21 hm³ water per year and desalinates 23 hm³ per year accounting for 1.9% and the 2.1% respectively of total available water resources within the region (AAA 2011). During the same period, at a national level, Morocco will still be within the limits of its renewable water resources; however, the country may experience localised or exceptional stress in some areas given the unequal distribution of water resources (Blinda et al. 2006).

At the other end of the spectrum, floods—and flash floods in particular—have significant impacts on the Reserve. Greater storm intensity is expected to accelerate runoff, increasing soil erosion (Agoumi 2003), which is further exacerbated by deforestation and inappropriate agricultural practices. Annual losses of soil exceeding 4000 Mg/km² have been registered in the region of the Rif in Northern Morocco (Ouassou et al. 2005) and are threatening 21% of the soil of the province of Malaga in Southern Spain (RME 2008). As a consequence, a massive loss of biodiversity is expected, which—linked with projected biodiversity loss as a direct consequence of human pressures—could imply a drastic reduction in associated ecosystem services in the near future (Garcia et al. 2010; Magnan et al. 2009). Examples of impacts to ecosystem services from soil erosion include decreased freshwater supplies, soil productivity, forest productivity, plant pollination and fish stocks. Furthermore, although flash floods have significant impacts within the area of the Reserve, their effects also increase downstream, impacting not only the IBRM, but the coastal regions outside its boundaries.

2.3 Impacts of Climate Change on Socio-economic Sectors

While the impacts of climate change can have significant consequences for society and economy, human pressures and global change are also responsible for compounding these climatic effects. Sectors such as agriculture and tourism are threatening freshwater ecosystems such as the Guadalhorce river basin on the Spanish side of the IBRM, which is at risk of not meeting the environmental objectives of the Water Framework Directive (Carrasco et al. 2008). These human

pressures negatively impact freshwater ecosystem services, such as fisheries, water purification and flood prevention and what is more, have a knock-on effect for the poorest local communities in the IBRM (Garcia et al. 2010). Climate change is expected to intensify these pressures in the Mediterranean basin (Magnan et al. 2009) threatening water quality and quantity and the sustainability of socio-economic activities in the IBRM.

Within the IBRM region, the vulnerability of the regional population is highly linked to the climate and its fluctuations since the main economic activities (agriculture and tourism) are strongly dependent on water availability (Agoumi 2003). However, there is a marked socio-economic contrast between Spain and Morocco as depicted in Table 2.1 which shows a higher level of dependency on natural resources in Morocco than in Spain, and thus a higher vulnerability to climate change effects.

In Andalusia, on the Spanish side of the IBRM, people involved in primary sectors e.g. agriculture, are also identified as the main vulnerable groups, followed by those working in tourism (Mestre-Barceló 1995; Roberts 2002). Although the agricultural sector is smaller on the Spanish than on the Moroccan side, agriculture is seen to have an important role in maintaining economic activity and employment in rural areas (Eurobarometer 2014). Recurrent droughts have led to serious losses and injuries to flora and fauna in forestry, cropping and pastoral sectors on the Spanish side of the IBRM. In particular cereals, vines, and olive trees are among the

Table 2.1 Some socio-economic indicators for Morocco and Spain

Indicators	Morocco	Spain
GDP/per capita in US Dollar (2009 est.) ^a	4600	33,700
Per capita—by occupation:^b		
• Agriculture	18.8%	3.4%
• Industry	32.6%	26.9%
• Services	48.6% (2009 est.)	69.6% (2009 est.)
Labour force—by occupation:^c		
• Agriculture	44.6%	4%
• Industry	19.8%	26.4%
• Services	35.5% (2006 est.)	69.5% (2008 est.)
Population living in rural areas (%)	47	22.4 (in Andalusia)
Population living in Rural area in IBRM (%)	93	—
Land ownership (average farm size in ha.)	2–3	35
Use of total water resources (%)^d	43	32
Water resources per capita (m ³ /person/year) ^e	895	2557
Water use for agriculture (%)	86	70
Water use for tourism (%)	—	13
Irrigated agriculture (%)	10	90

^a<http://www.theodora.com/wfbcurrent>

^b<http://www.theodora.com/wfbcurrent>

^c<http://www.theodora.com/wfbcurrent>

^dMillennium Development Goal indicators 2000

^e<http://earthtrends.wri.org>

most affected agricultural crops. The tourism sector is affected by shortages in water supply to numerous villages, adding to the effect of higher extremes in summer temperatures (Méndez 2008).

In Spain, agricultural production is primarily commercial; whereas in Morocco, and indeed within that side of the IBRM, traditional agriculture and extensive farming act as the main means of subsistence for a large proportion of the population (Table 2.1). Unfavourable weather conditions are the main sources of risk to subsistence farming systems, especially in marginal land, where drought years can affect directly farmers' income. The Moroccan population has adopted two main strategies to avoid negative impacts to their livelihoods and human security in recent decades: (1) the development of unsustainable agricultural practices (overgrazing, illegal cannabis cropping in higher gradient slopes, forest overexploitation) with a high environmental impact in terms of soil degradation (Moore et al. 1998; Barrow and Hicham 2000); and (2) the migration from rural areas to coastal cities (Bennis and Sadeq 1998). Periodic drought episodes and significant rainfall variability do not only affect subsistence farming, but also agricultural production and its contribution to gross domestic product (GDP) more generally (Ameziane et al. 2001; Karaky and Arndt 2002).

Water-related impacts on the physical environment and on socio-economic sectors have the potential to affect human security on both sides of the IBRM. For example, the extensive droughts in Spain, Morocco and Tunisia in the mid-1990s impacted food production in rain-fed agriculture (i.e. primarily Morocco) as well as irrigation-dependent systems (i.e. primarily Spain). During this time, cereal production dropped dramatically from 9.5 million tons in 1994 to 1.6 million tons in 1995 (Skees et al. 2001) and many systems had cease production due to insufficient water reserves (CRED 2010). In Spain, the effects of the 1990s droughts on the agricultural economy were severe, with over 6 million people affected, many of whom moved from rural areas to cities to ensure drinking water supply (personal communication, stakeholders' meeting 2012).

The IBRM is one of the key migratory routes to Europe. The Moroccan side of IBRM has received migrating populations from other parts of Africa for many years, placing additional pressure on the region's society, economy and infrastructure. In addition, during especially dry periods, inhabitants of the IBRM, living in rural areas and with greater vulnerability to climate change, add to the movement towards urban centres and in some cases towards the EU (ENPI 2007). This migratory trend has been particularly intense during the region's frequent periods of poor harvests (Refass 1992). Migration is further expected to increase as a possible consequence of climate change, (Fermin 2009a, b) although exact estimates are hindered by the complex interplay of economic and political conditions, social and cultural context. The possible rise in sea water level implies groundwater salinising the soils may lead to even further reasons for land abandonment and the creation of "uninhabitable" places (Zghibi et al. 2013). These migratory patterns have important effects on the rural economy of the IBRM which would be negatively affected by any permanent loss of local knowledge and human resources.

Adapting to Climate Change

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