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# State of the Environment and Development 2019: Preliminary version of Chapter 6: Food and water security

Plan Bleu
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# Introductory Note

Please refer to Introductory Note from working document PBRAC WD.3 SoED 2019.

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**Contributions compiled in this document have been provided by several partners with different institutional backgrounds, fields of expertise and styles of writing. The current preliminary version of this chapter is still work in progress. Contributions have not yet undergone a thorough harmonization process.**

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## 6.1 Transversal introduction

Water, energy and food are essential to human well-being, poverty reduction and sustainable development. These strategic resources share many comparable characteristics: i) billions of people do not have secure access to them; ii) global demand is rapidly growing; iii) all are 'global goods' involving international trade with global implications; iv) their supply and demand vary geographically and across time; v) and all operate in heavily regulated markets (Bazilian *et al.*, 2011; FAO, 2014a,b).

**Food security**[1] is achieved when all people have, at all times, physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Health Summit, 1996). The nutritional dimension is an integral part of food security (Committee on Food Security, 2009). This broadly accepted definition underpins the second Sustainable Development Goal of the 2030 Agenda: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture".

Food security status and challenges vary across Mediterranean countries. At the regional level, **food availability** is dependent on imports, with a regional agricultural trade deficit of 36.6 billion USD in 2017 (WTO, World Trade Statistical Review, 2017). Only France and Spain produce an agricultural surplus. Mediterranean countries account for one-third of world cereal imports, for only 7% of the world population. Egypt and Algeria are among the world largest cereal importers. Import dependency ratio for cereals in the Mediterranean (import / consumption ratio) is very high (86% in Lebanon, 72% in Algeria, 60% in Tunisia, 42% in Egypt[2]). Importing countries are thus very sensitive to the volatility of international prices, and were strongly hit by the food crisis of 2007-2008.

Beyond food availability, **access to food** depends on multiple factors including purchasing power and state of infrastructure. In many Mediterranean areas, territorial fractures separate well-served coastal urban areas and remote rural areas, especially in the mountain ranges, where economic activity is often stricken and chronic food insecurity may occur.

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[1] Data on global food security come from: FAO, IFAD, WHO, WFP and UNICEF. 2017. The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security Rome, FAO.

[2] FAO statistics. Statistical pocketbook 2018.

From a **nutritional** point of view, worsening of overweight and obesity is alarming in all Mediterranean countries (e.g. with 30% obese adults in Eastern Mediterranean countries); and a high prevalence of anemia affects women of childbearing age.

Factors that may disrupt food security in the region include: volatility of international food prices, political instability and conflicts, global warming and erosion of natural resources (soils, biodiversity). Among these risks, rising water insecurity is a key factor, water and food being intimately linked.

**Water security** is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN-Water, 2013). Water resources are unevenly distributed across the basin, with critical limitations in southern countries, which hold only 10% or the total renewable water resources in the region. Six Mediterranean countries experience absolute water scarcity (<500 $m^3$ per capita per year) and five additional ones are under the water scarcity threshold of 1000 $m^3$ per capita per year (AQUASTAT, FAO, 2014). Most northern Mediterranean countries are water-secure with over 1700 $m^3$ per capita per year.

In North Africa and the Middle East, shared aquifers are the most important source of fresh water (Aureli *et al.* 2008). Satisfying the simultaneous needs for high quality drinking water and a high water demand for irrigation is a particularly complex problem. Water scarcity induces tensions and possible conflicts between users of groundwater and land owners, and between countries. Tensions are exacerbated by the increasing water demand for irrigated agriculture in a context of demographic growth. In numerous Mediterranean areas, groundwater quality is also under threat from pollution, sea water intrusion and overexploitation.

Pre-existing water scarcity in the Mediterranean region being aggravated by population growth, urbanization, growing food and energy demands, pollution, and climate change, ensuring water security will require inclusive approaches and coordinated responses across sectors. The **Water-Energy-Food Nexus** has emerged as a useful concept to describe and address the complex and interrelated nature of those three resources (Figure 1), on which we depend to achieve a range of social, economic and environmental goals (FAO, 2014b).

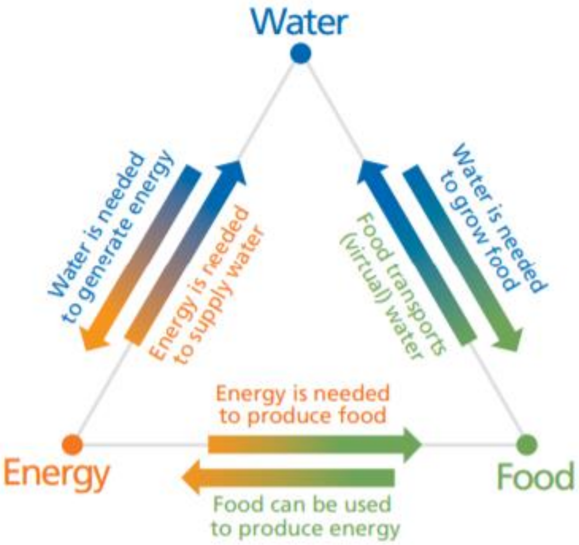

**Figure 1 The Water-Food-Energy Nexus (UN-Water, 2013 - adapted from: Water - A Global Innovation Outlook Report, IBM, 2009)**

As water, food and energy are interconnected resources, policies designed for one component often impact and sometimes negatively affect others. Water plays a role in energy production (e.g. for powering hydroelectric plants, cooling fossil-fuel and nuclear plants, growing biofuels, even in emerging technologies such as fracking for oil and gas, and concentrated solar power). Energy is required to process and distribute water, treat wastewater, pump groundwater, and desalinate seawater. Water is the keystone for the entire agro-food supply chain, while agricultural intensification impacts water quality. Energy is also an essential input throughout the agro-food supply chain, from pumping to processing and transportation. Aquifers and wetlands face over-abstraction to meet food-related goals, and subsidized energy fuels groundwater depletion due to over-pumping.

Non-conventional water resources, such as wastewater recycling and reuse, rainwater and storm water capture, and desalination, are expected to be increasingly mobilized in upcoming decades to meet growing demands. Assuming present-day technologies and production costs, more than 40 billion USD will need to be spent in non-conventional water supplies in the broader MENA region by 2050, with a large part of those dedicated to desalination infrastructure (World Bank, 2018). **Desalination** is a key Nexus interlinkage with energy consumed to increase water supply. The production of desalinated seawater in the MENA region is projected to be 13 times higher in 2040 than 2014. Currently, desalination for municipal use is already gaining importance in islands and coastal cities with limited water resources. In absolute terms, the largest production of freshwater through desalination in the Mediterranean region takes place in Algeria (0.62 $10^9 m^3/yr$), Egypt (0.20 $10^9 m^3/yr$), Israel (0.14 $10^9 m^3/yr$) and, Italy and Spain (both 0.10 $10^9 m^3/yr$) (FAO, 2016). In relative terms, Malta is the desalination leader, with more than half of its drinking water supply coming from desalination.

Positive experiences in the region show that **wastewater** can be safely recycled to be used in irrigation and managed aquifer recharge, especially in coastal aquifers to prevent saltwater intrusion. Water recycling is a typical example of a Nexus interlinkage. Water recycling not only contributes to water and food security goals, it can also be achieved at zero-net energy use by capturing and reusing for energy generation wastewater treatment by-products, such as biogas and sludge thus reducing emissions from the water sector and overall energy demand. However, about 80 percent of the MENA region’s wastewater is still being discharged in the environment without being reused (World Bank 2017).

Agriculture accounts for 2/3 of the increase in water withdrawals in the Mediterranean basin. Increasing water scarcity in the southern and eastern Mediterranean are expected to have significant negative impacts on **food production** and to affect the types of crops grown. Specifically, the production of wheat and other grains is projected to suffer most from water availability constraints. The cost of producing crops is expected to rise as groundwater levels drop and the costs of pumping deeper increase. The availability of water for agriculture will likely face further constraints due to competition from high-value and inelastic demand in urban areas and industrial sectors. Increasing water scarcity and the resulting declines in agricultural production are also expected to accelerate migration especially in the most agriculture-dependent economies, and increase food trade.

In the MENA[3] countries, groundwater pumping, water transfer and wastewater treatment are some of the most energy intensive activities. Pumping for irrigation and drainage consumes around 6% of total electricity and diesel used in the MENA region (World Bank 2018).

In Albania and Montenegro, **hydropower** is the dominant source of electricity generation (with 100% and 59% of domestically produced electricity respectively), while in Bosnia & Herzegovina hydropower represents about a third of the production. In both Montenegro and Bosnia &

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[3] Middle East and North Africa

Herzegovina, the rest of the domestic electricity generation comes exclusively from coal (IEA statistics). All countries in the EU or EU accession process have adopted renewable energy targets by 2020 (e.g. 38% for Albania, 40% for Bosnia and Herzegovina and 33% for Montenegro; all three countries being expected to meet these targets). In 2018, the 16th Ministerial Council of the Western Balkan countries recognized the need to establish targets on energy efficiency, renewable energy sources and greenhouse gas emission. However, there is a clear possibility that to meet these targets, countries will rely disproportionately on expanding their hydropower capacities, a development that may pose environmental risks on some of the healthiest and most pristine waterways in Europe. Hundreds of new hydro plants, mainly of a micro scale (<10 MW), have been announced and are at various stages of planning[4].

Without proper planning, river dams - including those intended to produce hydropower - can have significant impacts on the longitudinal river continuum for biota and sediments, potentially leading to a loss of ecological integrity, and serious river degradation processes downstream of dams (channel incision) down to the coastal zone, leading to coastal erosion, deterioration of deltaic and marine ecosystems. Such impacts do not only affect the environment; coastal tourism may suffer as well. Moreover, countries that rely heavily on hydropower may face reduced generation and higher prices in a case of protracted drought.

Interlinkages are also evident in the case of the **coastal wetlands**. The assessment of all major Mediterranean coastal wetlands carried out under the MedPartnership (2012-2015) confirmed that all are to various degrees dependent on coastal groundwater resources, and that their functioning is being impaired by the decreasing water quantity and quality of the coastal aquifers feeding them. The excessive use of groundwater resources from coastal aquifers can result in the drying up of wetlands that depend upon them. In addition, saline intrusion and pollution, which occur when coastal aquifers are overexploited and pollutants introduced into the aquifers, can degrade wetlands health and functioning. Both threats are strongly associated with agricultural practices (water abstraction, fertilizers) locally and upstream.

**All the interconnections above described justify considering a water-food-energy Nexus**, as the relevant approach to plan for and manage sustainability transitions in the Mediterranean. Taking into account water-food-energy interactions can help reduce trade-offs and generate benefits that outweigh the costs associated to a stronger integration across sectors. Such gains should encourage governments, private sector and civil society to take on coordination efforts.

## 6.2 Water resources/water security

### 6.2.1 Precipitation and soil moisture

The Mediterranean climate is generally characterized by mild and wet winters, and dry and hot summers. However, precipitations strongly differ across sub-regions, especially in winter. Long-term average precipitations[5] range from 33 mm per year in Egypt to 1325 mm per year in Slovenia, i.e. 40 times more (Table 1 and Figure 2), with a clear North/South divide. Notable in-country variability is

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[4] According to their National Renewable Energy Action Plans for 2020, compared to 2016, Albania plans to increase its hydro capacity from 1,838 MW to 2,324 MW, Bosnia and Herzegovina from 2,180 MW to 2,700 MW and Montenegro from 674 MW to 826 MW.

[5] During the period 1961–2015.

associated in particular with the orography of the continental regions with larger precipitation in mountainous areas than plains (Figure 3)[6].

**Table 1 Long-term average annual precipitation by country (1961-2015). Source: World Bank, 2016[7]**

| Country | Precipitation (mm) |
|---|---|
| **North** | |
| **Albania** | 981 |
| **Bosnia-Herzegovina** | 1072 |
| **Croatia** | 1066 |
| **Cyprus** | 468 |
| **France** | 841 |
| **Greece** | 649 |
| **Italy** | 927 |
| **Malta** | 428 |
| **Montenegro** | 1135 |
| **Portugal** | 839 |
| **Slovenia** | 1326 |
| **Spain** | 610 |
| **South** | |
| Algeria | 83 |
| Egypt | 33 |
| Libya | 44 |
| Morocco | 315 |
| Tunisia | 271 |
| **East** | |
| Israel | 258 |
| Lebanon | 565 |
| Palestine | 413 |
| Syria | 289 |
| Turkey | 568 |

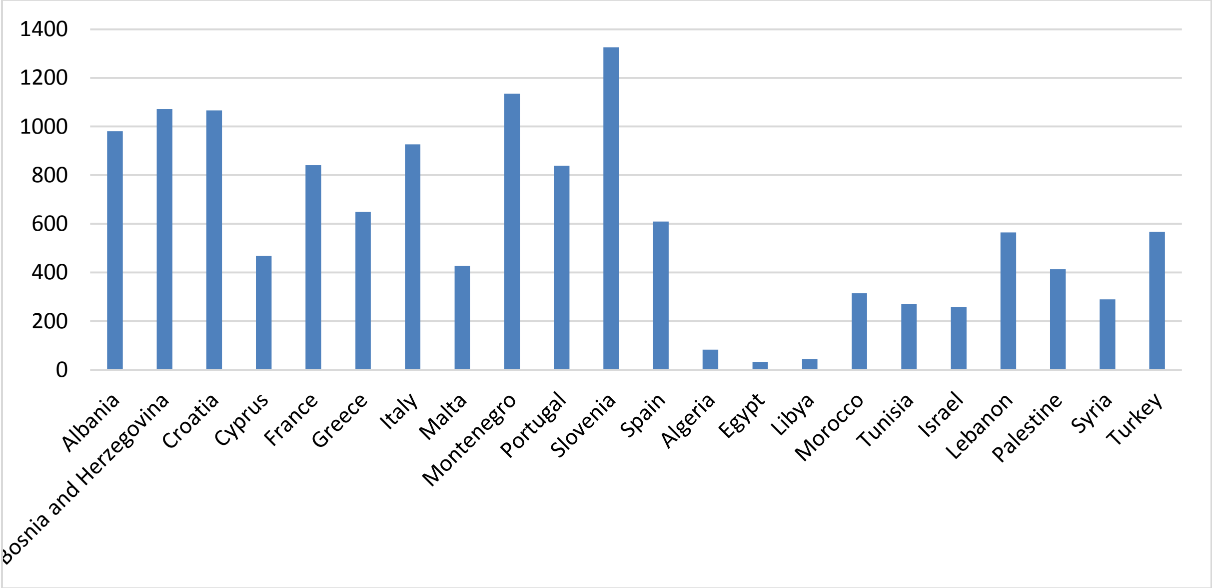

**Figure 2 Long-term average annual precipitation by country (1961-2015). Source: World Bank, 2016**

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[6] The maximum precipitations are recorded over the Alps and Dinaric Alps with over 1500 mm per year. While the minimum precipitations are found over Southern Mediterranean with important precipitations on the Atlas Mountains in Algeria and Morocco.

[7] Calculated as the average annual precipitation between 1961 and 2015 from data extracted from the World Bank Climate Change Knowledge Portal.

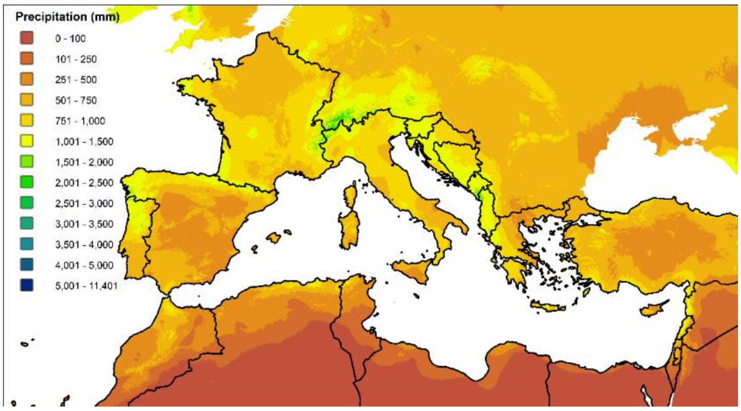

**Figure 3 Total Annual Precipitation, derived from WoldClim bioclimatic variable BIO12. Source: adapted from WorldClim, CIAT (see Hijmans, *et al*. 2005). Precipitation layer downloaded from: https://www.arcgis.com/home/item.html?id=0698165058384852b23f31b26ae7cace** *[Figure to be revised and updated]*

Precipitation over the Mediterranean region is critical to the availability of water resources. It provides the water that flows in rivers and infiltrates to recharge groundwater (blue water), as well as the water that is stored in the soil as soil moisture (green water). The latter controls the exchange of energy and water between land surface and the atmosphere, which impacts the rainfall–runoff processes. Thus, soil moisture is vital for the ecosystem and agricultural outputs (food security). In southern and eastern Mediterranean, soil moisture is very low due to low precipitation and high temperatures, limiting the possibility of rainfed crop production. As in these parts of the Mediterranean region, precipitation is considerably less than potential evaporation, any future decrease in precipitation will often cause a decrease in soil moisture.

The Mediterranean region has been recognized to be one of most vulnerable regions to climatic changes. According to García-Ruiz *et al.* (2011), the annual precipitation is projected to decrease in 2040–2070, compared to 1960–1990, by around 15% in South Mediterranean countries and the Middle East; while this decrease is expected to be around 10% in South Italy, Greece and South Turkey (Figure 4). On the other hand, temperature increase is projected to range between 2 °C to 3 °C, impacting mostly South Mediterranean, Turkey and the Balkans. It is projected that southern and eastern Mediterranean countries as well as south Spain will experience a decrease in winter precipitation, which are most important in the Mediterranean region. More detailed information and projections are available in Chapter 2 on climate change.

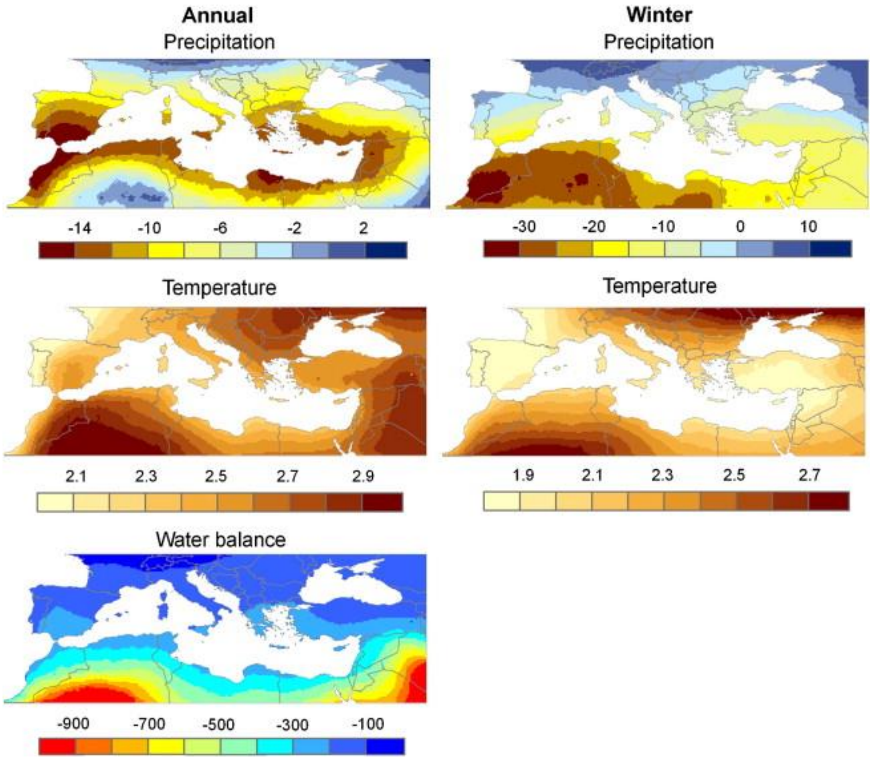

**Figure 4 Mean annual and winter climate changes, precipitation (P, %), temperature (T, °C) and water balance (P−T, mm) projected for the Mediterranean region between 2040 and 2070 in comparison to 1960–1990 by nine general circulation models. BCCR: BCM2, CCMA: CGMA3T3, UKMO: HADCM3, NIES: MIROC3HI, CNRM: CM3, CSIRO: MK3, NCAR: CCSM3, CNRM: CM3, and MPIM: ECHAM5. Source: García-Ruiz *et al.* (2011)**

### 6.2.2 Freshwater availability

#### 6.2.2.1 Total Renewable Water Resources[8]

Freshwater resources are unevenly distributed across Mediterranean sub-regions: 67% are located in the North, 10% in the South, and 23% in the East, of which more than 20.5% in Turkey (Aquastat database; FAO, 2016). Those heterogeneities are further emphasized by uneven population growth, as population stagnates in the water rich North and continues growing in the water poor South (Figure 5). With less than 500 $m^3$ per capita per year, Algeria, Israel, Libya, Malta, the State of Palestine and Tunisia face absolute water scarcity. With more than 500 $m^3$ but less than 1000 $m^3$ per capita per year, Cyprus, Egypt, Lebanon, Morocco and the Syrian Arab Republic are water scarce (AQUASTA, FAO, 2014). On the contrary, most of the northern Mediterranean countries population is water-secure, with some countries considered as living in the comfort of water abundance, such as the Balkans.

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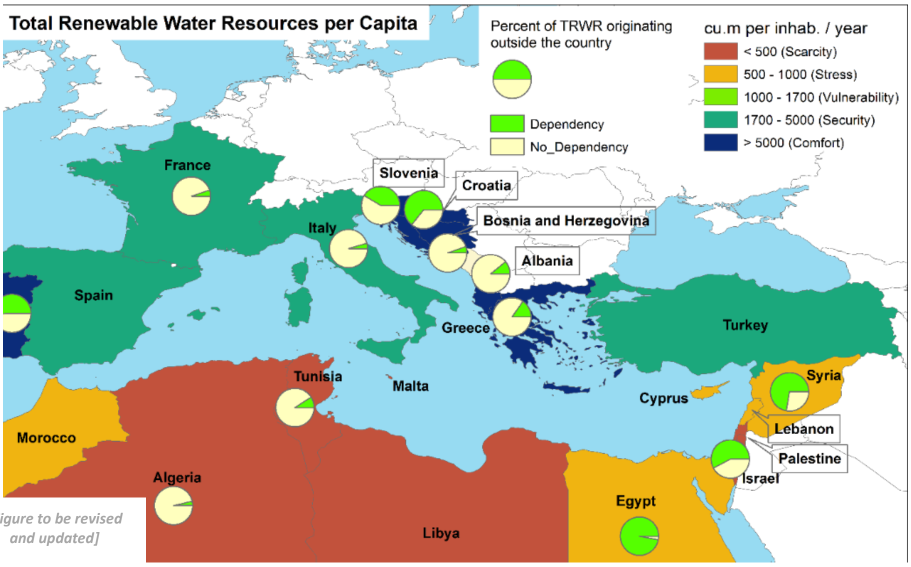
[8] The Total Renewable Water Resources (TRWR) is defined as the sum of internal renewable water resources (IRWR) and external renewable water resources (ERWR). It corresponds to the maximum theoretical yearly amount of water available for a country at a given moment. Source: FAO, AQUASTAT, Glossary.



*[Figure to be revised and updated]*

**Figure 5 Total renewable water resources per capita in the Mediterranean. Source: data extracted from Aquastat database. FAO, 2016**

Figure 6 represents the total renewable water resources (i.e. the sum of internal and external resources), which can hide the dependency of some countries on external water resources, i.e. water originating from outside of their borders. For instance, Egypt depends for 97% of its freshwater resources on external water, the Syrian Arab Republic for 72 % and Israel for 56% (Figure 6). Total renewable water resources in the Mediterranean Region amount to 1,030 Km$^3$ (FAO, 2016).

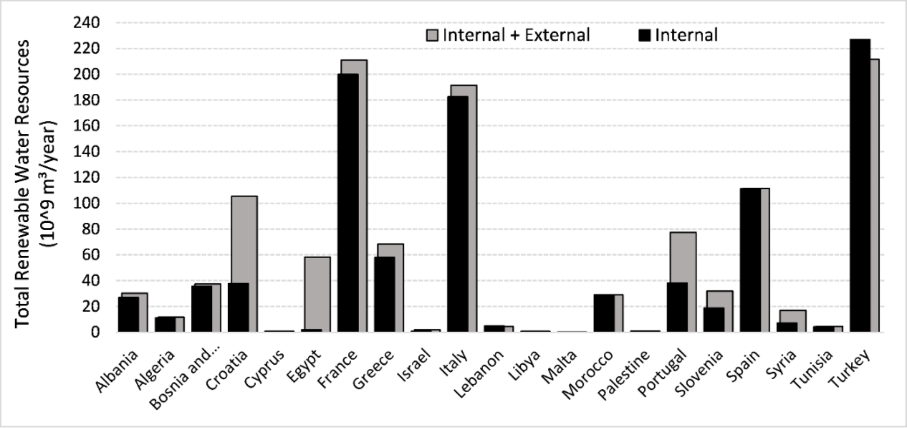


**Figure 6 Internal and external renewable water resources in the Mediterranean. Source: data extracted from Aquastat database. FAO, 2016**

The water resources of Mediterranean countries have deteriorated. Internal freshwater resources per capita have decreased by 29% between 1997 and 2014. The most affected countries are Lebanon (- 45%) and the State of Palestine (-37%). Between 1997 and 2014, the available freshwater resources per capita have on the contrary increased on average by 5% in the Balkan countries while they decreased by 4% on average in the European Union.

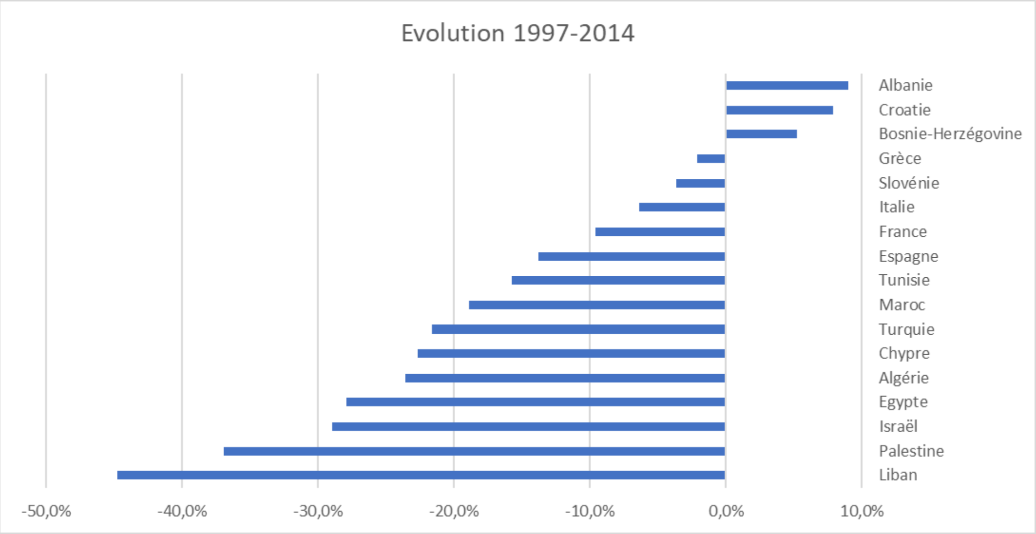


**Figure 7 Evolution des ressources renouvelables d'eau douce intérieures par habitants entre 1997 et 2014 (variation en %) Sources : IDM Banque Mondiale** *[Figure to be translated]*

### 6.2.2.2 Surface water and groundwater

Mediterranean countries are highly dependent on both surface and groundwater resources, and both are affected by unsustainable consumption patterns and over-abstraction. Excessive groundwater abstraction for irrigation is leading to rapid aquifers depletion (Dalin, et al., 2017) threatening the sustainability of food production, inducing significant environmental degradation, such as land subsidence and seawater intrusion (Caló, et al., 2017; Custodio, 2018), and contributing to the major transboundary challenges affecting the Mediterranean region (UNEP-MAP, UNESCO-IH, 2015).

Overall, renewable groundwater resources in the Mediterranean are estimated to be around 340 km$^3$/year, of which 72% in the northern shore, 23% in the Middle East and only 5% in the southern shore. Surface water is located for 75% in the North, 17% in the East and 8% in the South (Figure 8). In the southern sub-region, surface water represents 85% of water resources, and up to 96 % in Egypt.

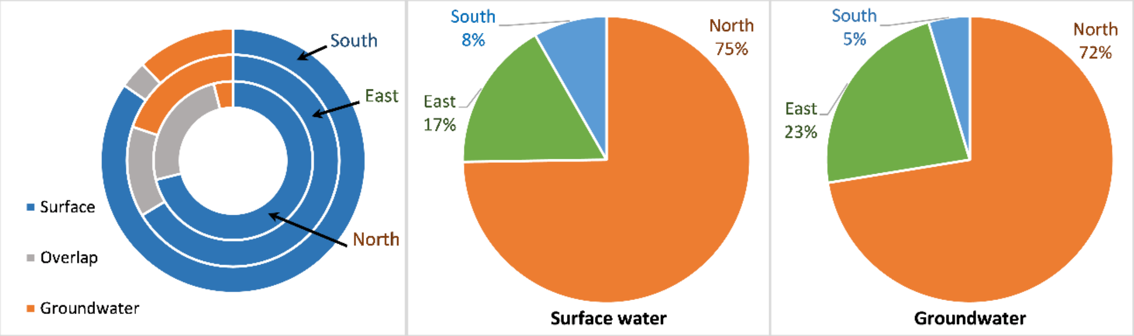


**Figure 8 Surface and Groundwater Renewable Water Resources by sub-region. Source: data extracted from Aquastat database. FAO, 2016**[9]

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[9] The 'overlap' represents the part of the renewable freshwater resources common to both surface and groundwater.

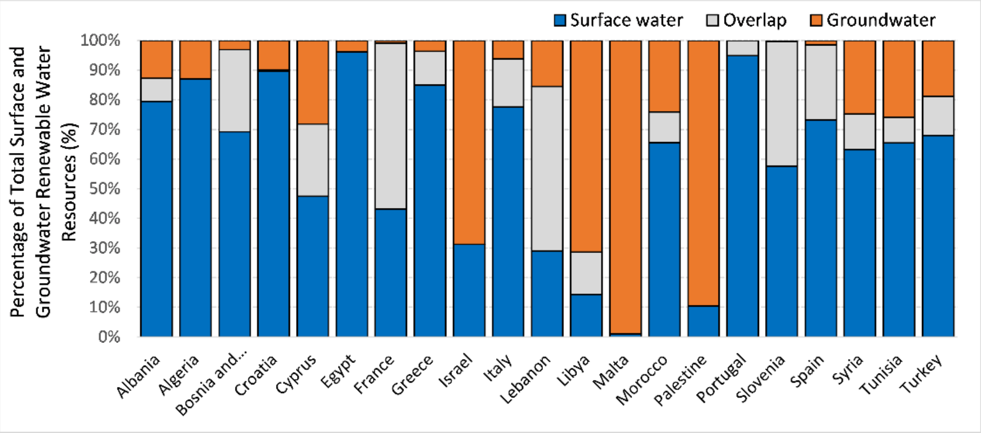
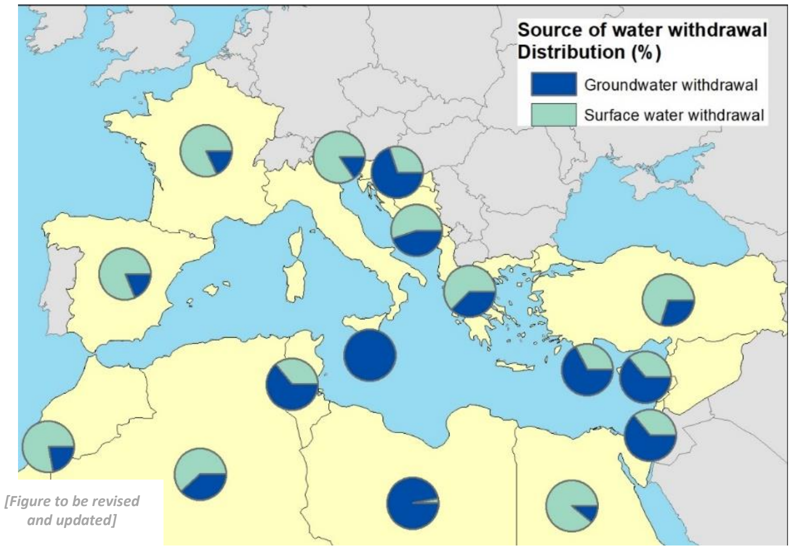


**Figure 9 Surface and Groundwater Renewable Water Resources by country. Source: data extracted from Aquastat database. FAO, 2016**

Algeria, Morocco and Tunisia rely on both surface and groundwater for their freshwater withdrawals (Figure 9). Malta relies entirely on groundwater. Groundwater supplies above or around 70 % of freshwater withdrawals for Cyprus, Croatia, Libya and Tunisia (Figure 9). Most islands in the sub-region use all renewable groundwater and over-abstract their resources at an increasing cost as the water table goes down. Some islands are even dependent on expensive transportation of water from mainland to deal with structural shortages (Greek islands, Croatian islands) or during droughts (MED-EUWI WG, 2007). In the eastern sub-region, the State of Palestine and Israel rely mostly on groundwater, the other countries rely on both surface and groundwater resources.

Unsustainable consumption and over-abstraction of surface and groundwater resources already contribute to water shortages and threaten long-term sustainable development.



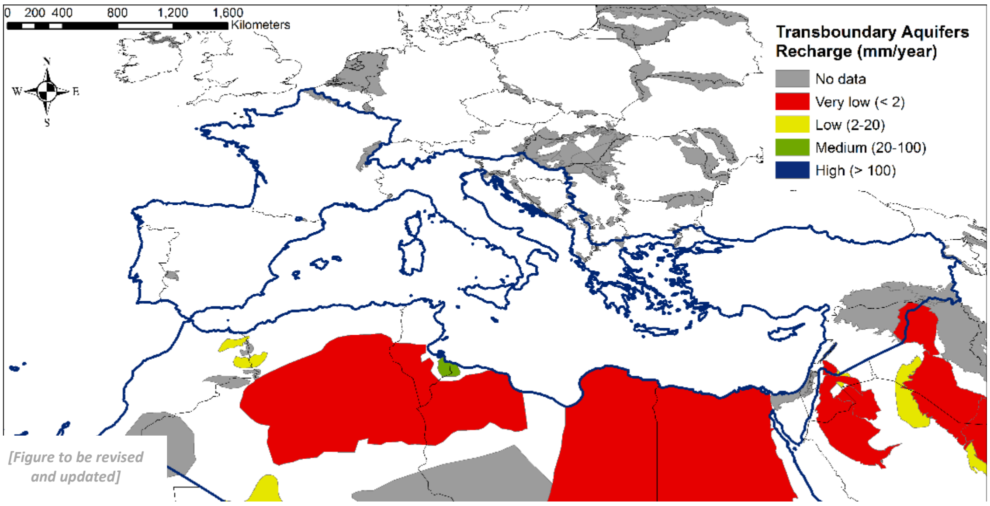
*[Figure to be revised and updated]*

**Figure 10 Part of total Water Demand supplied by groundwater in Mediterranean countries. Source of data: FAO, latest value available on AQUASTAT. The statistical value from the State of Palestine and for the Western Sahara in Morocco, Albania, Italy, Monaco, Montenegro and the Syrian Arab Republic are not included in the figure due to missing data in AQUASTAT**

As a consequence of irrigation, aquifers with declining groundwater levels are common in the Mediterranean region, in particular in the southern and eastern part and some northern areas. Custodio *et al.* (2016) cite examples in Spain such as the 300 m decline in the Crevillente aquifer (province of Alicante) in 30 years or in the extreme case of Libya, ranked by Wada *et al.* (2012) as the Mediterranean country with the highest groundwater depletion. Over-exploitation associated with irrigated agriculture may also lead to groundwater pollution and seawater intrusion in coastal areas.

In addition, tourism has expanded considerably in the Mediterranean since the 1960s and weighs heavily on groundwater. Tourism induces a high additional demand in peak seasons in coastal areas that in most of the cases are coincident with the dry season and might thus put considerable strain on available water resources as well as wastewater infrastructure (Gössling *et al.* 2012).

Most of the aquifers in the region are transboundary, such as the large Saharan aquifers shared between Algeria, Libya and Tunisia, and between Egypt and Libya (Figure 11). The North-Western Sahara aquifer system has a renewal rate of only 40% of the withdrawals (Goncalves *et al*, 2013), indicating high vulnerability of the oasis systems that depend on it. Some of these aquifers are deep (in particular Algeria, Egypt and Libya) with substantial water resources but this water is not renewable. Figure 11 shows the critical aquifers in the region with very low recharge. Sustainable use of these aquifers is essential to protect this valuable resource.



*[Figure to be revised and updated]*

**Figure 11 Transboundary aquifers (Source: layer extracted from GRAC-UNESCO-IHP, 2015) and mean annual groundwater recharge (Source: layer extracted from UNESCO-IGRAC, 2016)**

### 6.2.2.3 Climate change influence on freshwater availability

Water availability in the Mediterranean Basin is expected to reduce in the upcoming decades as a consequence of (i) precipitation decrease, (ii) temperature increase, and (iii) population growth especially in the countries already short in water supply. Its quality is also expected to decrease due to pollution and salt intrusion on the coast. Both phenomenon may increase conflicts over freshwater use. Overall, there is high confidence of strong increases in dryness and decreases in water availability in the Mediterranean and southern Europe from 1.5°C to 2°C of global warming.

Due to climate change (enhanced evapotranspiration and reduced rainfall) alone, freshwater availability is likely to decrease substantially (by 2 to 15% for 2°C warming), among the largest decreases in the world (Cisneros *et al* 2014; Gudmundsson and Seneviratne, 2016; Gudmundsson *et al.*, 2017). The IPCC 1.5°C special report projects for the Mediterranean a mean decrease of 10% per °C in precipitation minus evapotranspiration budget but with a large uncertainty. Koutroulis *et al* (2016) has calculated that on a 18% reduction of water availability in Crete under a +2°C scenario, 6% only are due to the precipitation reduction and 12% to the evapotranspiration increase. In Greece and Turkey, water availability may fall below 1000 $m^3$ per capita and per year for the first time in 2030 (Ludwig *et al*, 2010). In Southeastern Spain and on the southern shores, water availability may drop to below 500 m$^3$ per capita per year[10]. People inhabiting river basins particularly the Middle East and Near East are expected to become newly exposed to chronic water shortages even if warming is under 2°C. Significant increases are also expected in the length of meteorological dry spells (Kovats *et al*, 2014; Schleussner *et al*, 2016) and droughts (Tsanais *et al*, 2011). Impact on wheat and barley production is expected to be maximum in the Syrian Arab Republic and neighbouring countries. The importance of covering environmental flow requirements for assuring the healthy functioning of aquatic ecosystems will call for maintaining certain amounts of water in the systems, further limiting availability for human uses (Hermoso and Clavero, 2011).

Under climate change scenarios, river flow is generally reduced, particularly in the South and East of the region where water is in critically short supply (Forzieri *et al*, 2014). Because precipitation decrease, low river flows are projected to decrease in the Mediterranean under 1.5°C of global warming (Marx *et al*., 2018) with associated significant decreases in high flows and floods (Thober *et al*., 2018). The seasonality of stream flows is very likely to change, with earlier declines of high flows from snow melt in spring, intensification of low flows in summer and greater and more irregular discharges in winter (Garcia-Ruiz *et al*, 2011).

Water levels in lakes and reservoirs will likely decline. For example, the largest Mediterranean lake, the lake Beyşehir in Turkey, may dry out by the 2040s if its outflow regime is not modified (Bucak *et al*, 2017).

Further challenges to water availability and quality in coastal areas will likely arise from salt water intrusion driven by enhanced extraction and sea level rise, and increasing water pollution on the Southern and Eastern shores (Ludwig *et al*, 2010) from new industries, urban sprawl, tourism development, migration and population growth. Recharge of groundwater will be diminished, affecting most of the region. Irrigation water requirements in the Mediterranean region are projected to increase between 4 and 18% by the end of the century due to climate change alone (for 2°C and 5°C warming, respectively). Population growth, and increased demand, may increase these numbers to between 22 and 74% (Fader *et al*, 2016). Water demand for manufacturing is also projected to increase between 50 and 100% by the 2050s in the Balkans and Southern France (Forzieri *et al*, 2014).

### 6.2.3 Status and trends of water uses and demands (breakdown by sector/categories of users, efficiency of water use)

#### 6.2.3.1. Water demand

The socio-economic development of the Mediterranean region is highly dependent on water availability. Substantial pressure on finite water resources is induced by rapidly growing population and urbanization requiring an increase in agricultural, energy and industrial outputs.

**Demand in Mediterranean watersheds**. While data at watershed (i.e. catchment) level is crucial in the Mediterranean, no recent data is available at this geographical scale for the entire region. The total water demand[11] in Mediterranean watersheds was last estimated to 119.5 billion $^3$/year (according to Margat & Treyer, 2004 and Milano *et al.*, 2012). Irrigated agriculture was the most

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[10] Assuming a constant population, Gerten *et al*. (2013) reveal that an additional 8% of the world population will be exposed to new or aggravated water scarcity at 2°C warming. This value is almost halved - with 50 % larger reliability - when warming is constrained to 1.5°C.

[11] Water demand means total withdrawals from resources (95% of the total, including leakage during pipage and usage) and non-conventional sources (desalination, reuse of treated wastewater, etc.).

water demanding sector with 66 billion m$^3$/year (55%), mainly for the production of cereals, vegetables and citrus. The other main sectors were the energy and domestic sector, which water demands amount for 21.8 billion m$^3$/year (19%) and 19.5 billion m$^3$/year (16%), respectively. Water demands for industries not connected to the municipal water network amounted to 12.2 billion m$^3$/year (10%). Significant differences in the proportion of water demands existed between catchments. Water demand for irrigation purposes represent more than half of the total water demand over all catchments, except in France and Italy where water demands for energy and industrial purposes prevail, and in Slovenia and Croatia where domestic water demands prevail (Figure 12).

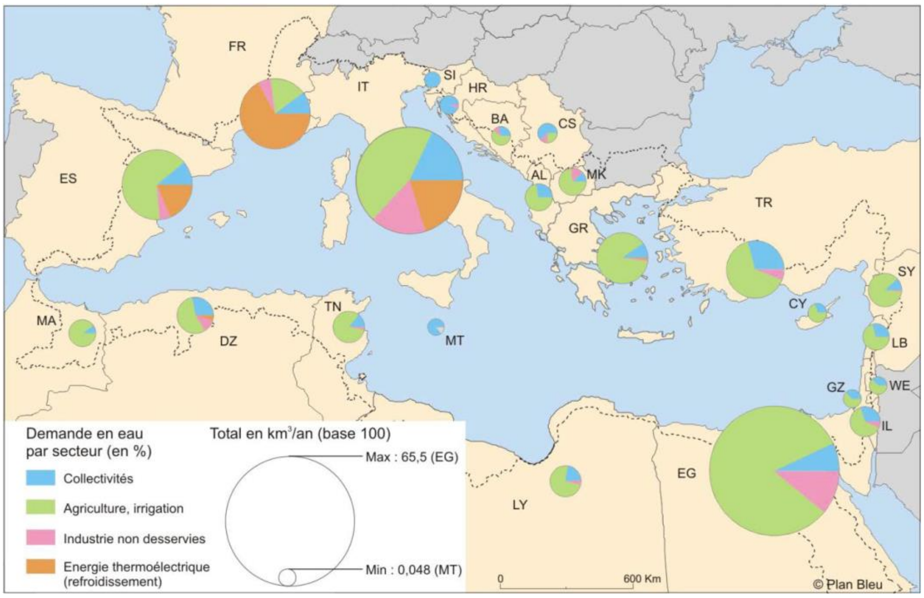

**Figure 12 Demand for water from the Mediterranean basin by country over the period 1995-2000 (to be updated with data from Margat & Treyer, 2004, Milano *et al.* 2012, and AQUASTAT 2013)**

Water demand can also vary significantly throughout the year. During summer, irrigation water demand increases due to hot and dry climatic conditions and maximum phenological stage (Collet *et al.*, 2013). Water demands from the domestic sector also increase as a result of tourism activities. For example, in riparian areas, domestic water demands can double in summer in la Costa Brava (Spain) or Côte d'Azur (France) compared to winter water demand (Plan Bleu, 2011).

**Withdrawal[12] in Mediterranean countries**. In Mediterranean countries, total water withdrawal from all sectors is 290 billion m$^3$ per year, but their distribution is uneven between the three mains sectors: irrigated agriculture, industry and services (Figure 13).

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[12] Water withdrawal describes the total amount of water withdrawn from a surface water or groundwater source. Measurements of this withdrawn water help evaluate demands from domestic, industrial and agricultural users. Water consumption is the portion of the withdrawn water permanently lost from its source.

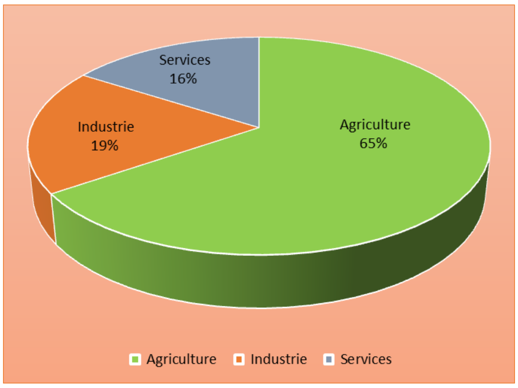

**Figure 13 Distribution of total water withdrawals between the three main sectors of water use in the Mediterranean region** *[Figure to be completed and updated]*

In the North, only 41% of water withdrawals are used for agriculture (Figure 14). The agricultural sector represents an even greater proportion of water withdrawals in the South and East with 84% and 81% of the total freshwater withdrawals (blue water), respectively.

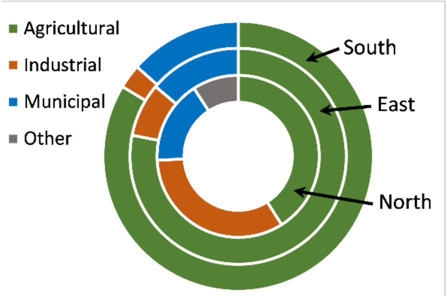

**Figure 14 Water Withdrawals by sector (Source: data extracted from Aquastat database. FAO, 2016)**

This finding emphasizes the importance of rainfall agriculture (green water[13]), which is not developed enough and could be further valued in the semi-arid and arid zones. Improved efficiency of rainfall agriculture by conserving water and soil would increase the rainwater storage capacity of the soil and thus limit the need to irrigate, while limiting the erosion and silting downstream.

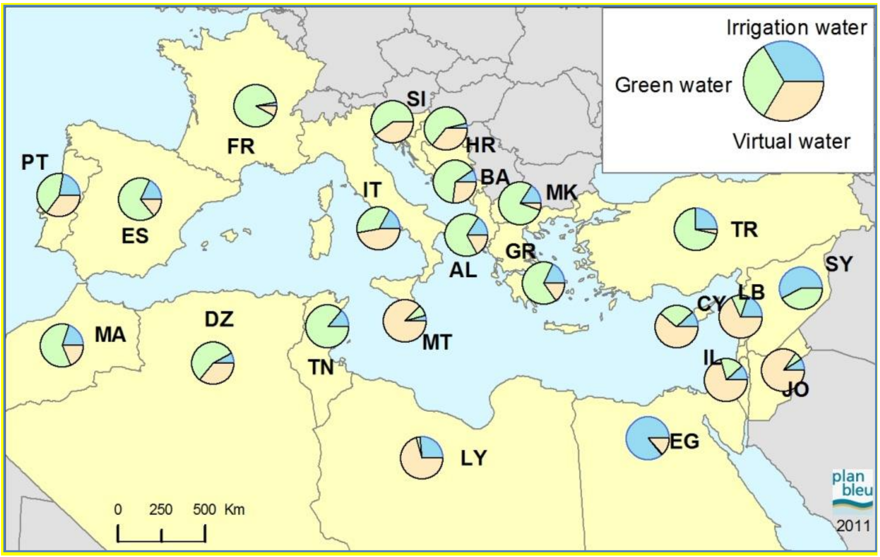

**Figure 15 Total balance of water for agriculture in the Mediterranean (1996 – 2005)**

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[13] Green water is the soil moisture from precipitation, used by plants via evapotranspiration

**(in % of the agricultural water), Source: Plan Bleu, Mekonnen, M.M. and Hoekstra, A.Y. (2011)** *[Map to be revised and updated]*

In the last decades, the rapid urbanization of the Mediterranean region created additional stress on fresh water availability and water quality, affected by untreated urban runoff and wastewater. Due to population increase and concentration, mainly in coastal areas and large cities, the South and East Mediterranean suffer from imbalance between population growth and natural fresh water resources availability. The vulnerability of water resources is expected to worsen in the coming decades due to the threats of rising food and energy demands, pollution, and climate change.

By 2050, under a business-as-usual water-use scenario, water withdrawals are projected to double or even triple in catchments of the southern and eastern rims due to population growth, expansion of irrigated areas and increasing crop water needs resulting from warmer and drier conditions (Milano *et al.*, 2012). In addition, crops in the new irrigated land (mainly maize and alfalfa) have higher water needs than traditional Mediterranean crops (cereals, olives, grapes). In the northern rim, agricultural water demands for irrigation are projected to increase mainly in the Ebro catchment (Spain) and in Greece due to warmer and drier conditions affecting crops' water needs (Milano *et al.*, 2012). Domestic water demands in the northern rim should remain constant or decrease as water access systems are already adequate (few spills) and as population is projected to stabilize over the northern rim by the medium term.

#### 6.2.3.2. Water stress

Level of water stress (indicator 6.4.2) refers to freshwater withdrawals as a proportion of available freshwater resources, taking into account environmental water requirements (the minimum amount of water required to maintain freshwater and estuarine ecosystems and their functioning included in the calculation).

Renewable freshwater resources of the Mediterranean region amount to 1123 billion $m^3$ per year (FAO, 2015). 84 % of average long-term flows are generated by precipitation inside the countries, and 16 % of water entering the countries, considering flows reserved for upstream and downstream by agreements or treaties. On the other hand, total freshwater withdrawals, defined by the volume of freshwater extracted in rivers, lakes, or aquifers for the needs of agriculture, industry and municipalities, is evaluated at 290 billion $m^3$ per year (FAO, 2015). Hence exploitation is estimated at 37 % (Blinda, 2018), which remains well below the 70 % threshold indicating severe water stress and potential water shortage. However, the level of water stress differs across countries with three groups:

- Algeria, Egypt, Israel, Lybia, the Syrian Arab Republic and Tunisia exploit more than 70% of their available freshwater resources and their level of water stress tends towards serious water shortage;
- Cyprus, Italy, Lebanon, Malta, Morocco, State of Palestine, Spain and Turkey exploit between 25% and 50%, and are at risk of reaching more severe levels of water stress in the near future;
- Bosnia & Herzegovina, Croatia, France, Greece and Slovenia exploit less than 25% of their available freshwater resources.

A regional-scale investigation was conducted for the Mediterranean basin (Milano *et al*., 2013a). It highlighted that 112 million people are experiencing high to severe water stress, i.e. water shortage conditions. The most vulnerable regions are southern Spain, Libya, Tunisia, and the south-eastern Mediterranean (Israel, Lebanon, State of Palestine and Syrian Arab Republic). By 2050, 236 million people should be living under high to severe water stress. If water use efficiency objectives set by the 2005 Mediterranean Strategy for Sustainable Development are met, the number of people living under high to severe water stress could trim down to 228 million. The occurrence of severe water stress situations could be moderated in Albania, Greece and Turkey but efficiency improvements alone would not be able to reduce water tensions in Spain and in the South of the Mediterranean basin.

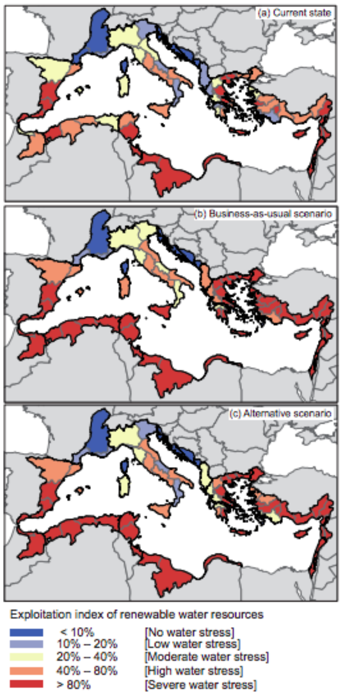

**Figure 16 Evolution of hydric stress in the Mediterranean. Current water stress over the Mediterranean basin (a) and changes by the 2050 horizon according to a business-as-usual scenario (b) and an alternative scenario (c). Source: Milano *et al*. 2012a; Milano *et al*. 2012b**

Differences may also occur within countries according to multiple factors such as the level of development, population density, the availability of conventional and non-conventional water resources, general climatic conditions, spatial and seasonal variability.

### 6.2.3.3 Water Efficiency

SDG 6 « Clean Water and Sanitation » emphasizes the need to ensure more efficient and sustainable water management. Target 6.4 encourages a substantial increase in water-use efficiency across all sectors and sustainable withdrawals and supply of freshwater to address water scarcity and reduce the number of people suffering from it. Water-use efficiency (indicator 6.4.1) is defined as the added value by quantity of water withdrawn, expressed as USD /$m^3$ for a given sector[14]. In the Mediterranean, it is estimated at 27 USD /$m^3$. As this is a new indicator, it is impossible to define a specific target for its value. But the indicator should, at a minimum, follow the same path as the country's economic growth.

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[14] The indicator is calculated as the sum of the value added of three sectors: irrigated agriculture, industries and services; weighted according to the proportion of water withdrawn by sector compared to total withdrawals. Only runoff (blue water) is taken into account when calculating the indicator. Agricultural production generated by rainfed agriculture in particular should be substracted from the overall sectoral added value.

$WUE = Awe \times PA + Iwe \times PI + Swe \times PS$

WUE = Water use efficiency

Awe = Efficiency of water used in irrigated agriculture [Value added of irrigated agriculture in USD/ quantity of freshwater used in $m^3$]

Iwe = Efficiency of water used in industries [USD/ $m^3$]

Swe = Efficiency of water used in services [USD/ $m^3$]

PA = Proportion of water withdrawn by the agricultural sector over total withdrawal

PI = Proportion of water withdrawn by the industrial sector over total withdrawal

PS = Proportion of water withdrawn by the services sector over total withdrawal

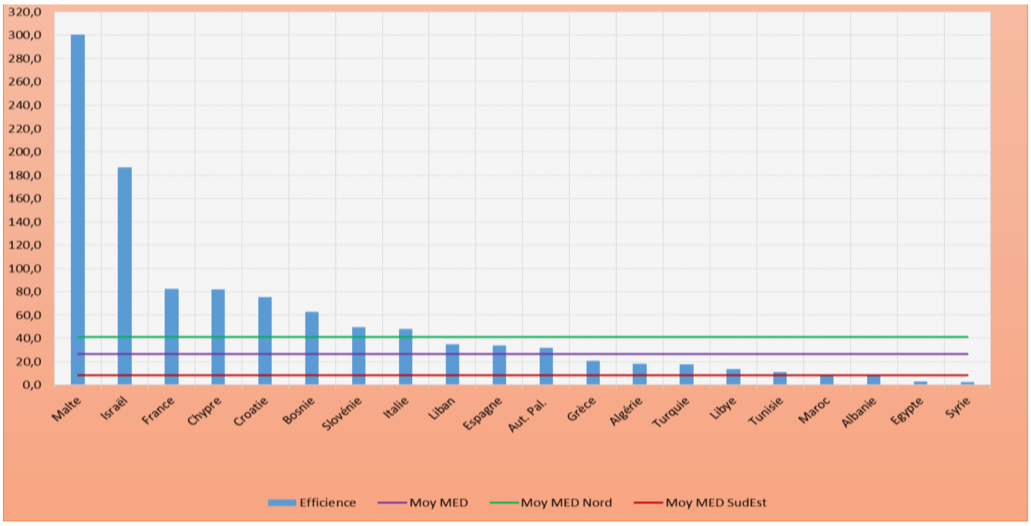


**Figure 17 Water use efficiency calculated for the Mediterranean countries** *[Figure text to be made bigger and to be translated]*

Economic efficiency is also unevenly distributed among sectors (Figure 18).

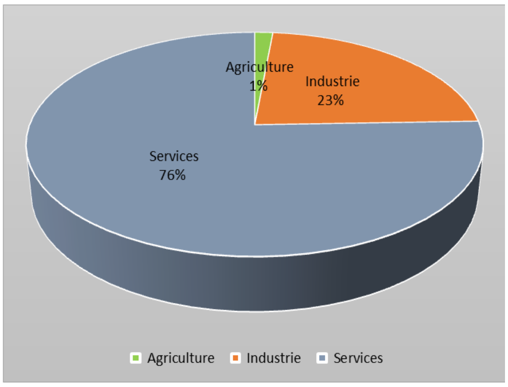


**Figure 18 Distribution of economic efficiency between the three economic sectors of water use in the Mediterranean region** *[Figure to be completed and translated]*

In the Mediterranean, irrigated agriculture takes 189 billion m$^3$, or 65% of total water demand (world average: 69%, FAO, 2016), considered as the most water-consuming sector. But its water use efficiency in this sector is only 1 % of the total. Water demands for services and industry are 16% and 19% respectively. Their water use efficiencies, on the other hand, reach 76% and 23% respectively. Important water losses undermine water efficiency in the agricultural sector, which calls for a modernization of irrigation systems and farmer awareness raising programmes on water saving practices. While water efficiency in agriculture could be significantly improved, agricultural growth probably has a greater role to play in reducing poverty and ensuring food security, than as an economic growth driver, as many poor work in this sector, particularly in the least developed countries. Global employment in agriculture dropped from 43% in 1990 to only 26% in 2017 (WB, 2018) as a result of the combined attraction of the industrial sector and the desire to leave agricultural activity because of the impacts of climate change and drought.

### 6.2.3.4 Environmental flows

*[Section to be edited and completed]*

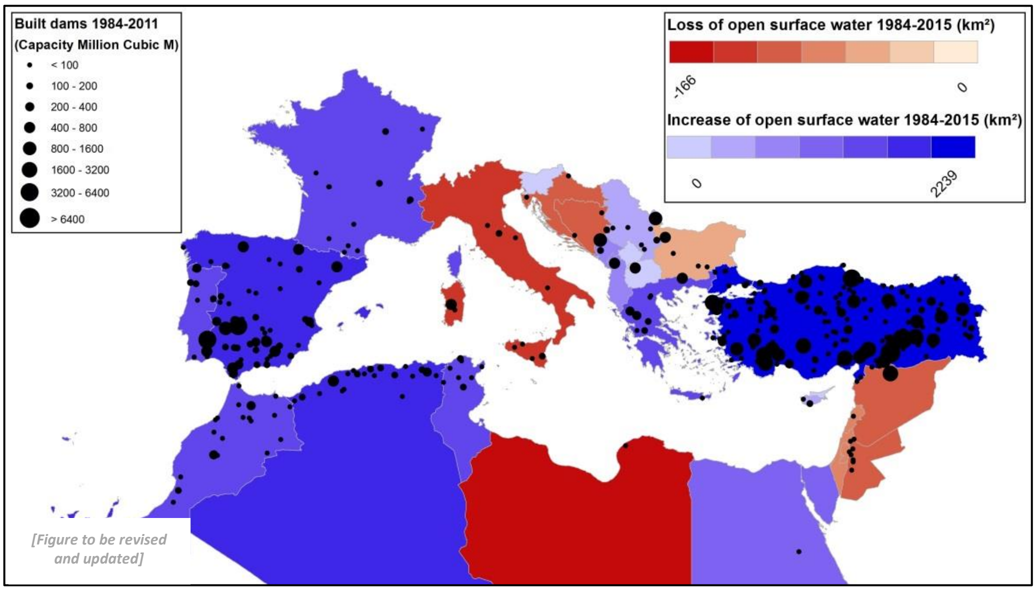
River runoff throughout the Mediterranean basin and water discharge of specific quantity, timing and quality into the Mediterranean Sea support nutriment, sediment and carbon flows which are essential for the functioning of coastal and marine ecosystems.

Environmental flows, or environmental water requirements, describe “the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being” (Arthington *et al*. 2018). Environmental flows (EF) are increasingly recognized as a key component of River Basin Management Plan and Water Allocation Plans. FAO recently launched new guidelines for incorporating environmental flows into the SDG indicator 6.4.2. “level of water stress” to assist countries to improve water management by ensuring a sustainable water supply that meets the needs of people, agriculture, energy, industry and the environment within the limits of availability (FAO, 2019).

In European Mediterranean countries, EF are monitored under the EU Water Framework Directive 2015, and defined as a “flow regime consistent with the achievement of the environmental objectives of a water body” (i.e. good ecological status for natural water bodies; good ecological potential for heavily modified and artificial water bodies, and good quantitative and chemical status for groundwater bodies) (de Jalón *et al*. 2017).

The increase in the number and capacity of dams in Mediterranean countries (Figure 19), as well as changing land covers, and increasing pollution, has notable impacts on downstream ecosystems and the services they provide. Flow regulation infrastructures affecting land-sea interactions (esp. ecological connectivity) are often related to water supply, energy and agricultural developments, therefore requiring an integrated management.

Water demands in coastal areas of the Mediterranean region are largely met by water transfers from the hinterland of the Mediterranean basin. For example, in France, canals transport water from the Rhone and Durance basins to large coastal cities like Marseille. Other transfers, from outside to inside the Mediterranean basin, take place to support Mediterranean coastal population and activities, e.g. the Tagus in Spain, from Jordan to Israel, from the Atlantic basin to Morocco and from the aquifers of the Sahara to Libya. These transfers have an impact on riverine ecosystems which is not negligible.



*[Figure to be revised and updated]*

**Figure 19 Loss and increase in open surface water area and number and capacity of dams (Source: Global Surface Water Explorer and Global Reservoirs and Dams database).**

Over the past three decades, despite notable geographical disparities, Mediterranean countries as a whole have experienced a strong population growth accompanied by a marked increase in cultivated area (about 1.6% average annual increase between 1992 and 2015) and increase in open water areas (approximately 12.3% between 1984 and 2015). The latter seems to be correlated with the number and capacity of water infrastructures, especially dams for agriculture (Pekel *et al.*, 2016). The vast majority of these infrastructures are related to agricultural projects, and there is therefore a link between agriculture, the development of surface water infrastructures, water dynamics and natural wetlands, which for many of them, directly depend on inflow from upstream freshwater bodies. This results in profound modification and alteration of the ecological functioning and could lead, in certain cases, to their gradual drying up or even complete disappearance. It is therefore recommended to partially or entirely rethink the models of agriculture development of the Mediterranean countries, so that agriculture, a key economic sector, does not enter in conflict with the conservation of natural wetlands and the services they provide (surface water purification, groundwater recharge, flood regulation, drought mitigation, biodiversity conservation, etc.).

**Box 1 Environmental flows for the Jucar River Basin in Spain**

Water is a scarce resource in many Spanish regions including in the Jucar River Basin (Valencia). The general objective of the river basin management plans (RBMPs) is to achieve a fair sharing among water users while ensuring its preservation and improving its quality. Spanish legislation through a variety of laws and texts identifies environmental flows as a primary restriction before any water abstraction or use, and underlines the necessity to assign environmental flows (E-flows) in the RBMP.

**The case of Jucar River Basin Environmental flow (E-flow) control accomplishment**

The Jucar River Basin Authority applied an E-flow assessment methodology for the first time with the publication of the Public Order legislation the 13th of August 1999 [ref]. Since then, one of the basic component of E-flows, i.e. the minimum flow, has been assigned and approved in the RBMP. The first minimum flows values were determined for the first planning cycle (2009 – 2014). Other components of the E-flows were assessed and approved (e.g. maximum flows) for the first and second (2015 – 2021) planning cycles. However, while some of the E-flows studies have improved the E-Flows with the aim of improving the ecological conditions, a set of locations suffered a reduction of E-flows below 10 % across the river basin.
So far, minimum flow values have been assigned to 39 and 61 out of 314 water bodies to be accomplished during the 1st and 2nd hydrological planning cycles, respectively. Figure 20 shows the proportion of water bodies where monitoring systems (in general gauging stations) were not in place (no data) during the 1st cycle against the 61 controlled during the 2nd cycle; and the percentage of the minimum flow value in relation to its Mean Annual Flow (MAF) in those water bodies under regular monitoring, for the first and second planning cycles.

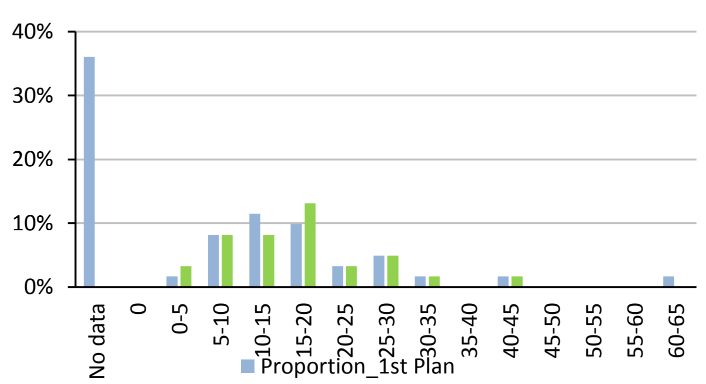


**Figure 20 Proportion of minimum flow values to the natural mean annual flow (MAF). 1st and 2nd Hydrological Planning Cycles are compared.**

According to the JRBA reports, both 1st and 2nd cycles apply hydrological and habitat suitability methods to obtain minimum flows intended to sustain the habitat of the aquatic and riparian endemic species. There is no doubt of the advance in the assessment and implementation of some components of Environmental Flows in the Jucar River Basin for the last decade; however, some fundamental components such as the spates or high flows to facilitate fish migration, and the recruitment of native riparian vegetation, as well as the limitation of maximum flows in regular dam operations, are fundamental challenges where much improvements are necessary. Furthermore, bigger efforts are still necessary by the JRBA because the percentage of water bodies without regular flow monitoring is still very high (253 out of 314).

**Erreur ! Source du renvoi introuvable.** 20 shows the proportion of water bodies where the minimum flow is in the range f 10-15% has decreased by the 2nd period from 11% down to 8%, while the proportion in the range of 15-20 % has increased. However, from a historical perspective, the number of sites with minimum flows smaller than 10 % has slightly increased, which suggests that the improvement of the ecological status in some areas is has been neglected for prioritising other water uses.

**Jucar river basin E-flow related indicators**

Besides the minimum flow values, three more components of the E-flows must be considered in Spain under the legal frame of hydrological planning: the maximum flows in regular operation or management ($Q_{max}$), the limitation to the rate of change, and the high flows or small floods; in addition, the temporal variability should be considered for the four components. **Erreur ! Source du renvoi introuvable.** shows the percentage of the water bodies where maximum flows and ratio of change were approved; the percentage of water bodies with control of minimum flow accomplishment; and the percentage of water bodies where minimum flow was accomplished.

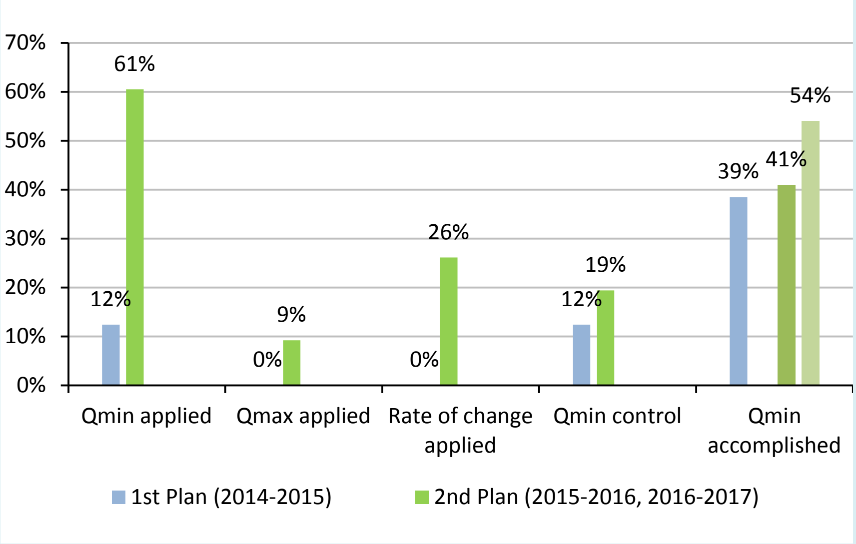


**Figure 21 Comparison on five indicators about legal forcing and accomplishment of environmental flows in the Jucar River Basin, for the 1st vs. 2nd cycle of hydrological planning. Percentage (perc.) of water bodies where minimum flow is approved, and similar perc. for maximum flow (Qmax) and rate of change. And, perc. of water bodies with control of E-flows accomplishment (gauging), and of water bodies where minimum flow was actually accomplished.**

Minimum flow is legally approved in an incremental number of water bodies (up to 61%). Other two components, i.e. the maximum flow and rate of change began to be controlled in the 2st cycle, in a relatively small percentage of the water bodies. From the total number where the minimum flow is applied, 19% are being monitored for accomplishment, from which 54% actually accomplish the minimum flow.

### 6.2.3.5 Existing and emerging conflicts between uses

*[Section to be completed]*

**Box 2 Compatibility potential between agriculture and tourism development**

Among the many impacts that climate change can have on the economy, the impact on tourism activities is one of the most important. Climate conditions are obviously crucial in determining tourism destination choices, so any change in climate conditions will have consequences in terms of number of incoming/outgoing tourists, tourism revenues, consumption patterns, income and welfare.

In Roson and Sartori (2014), the economic impact of variations in tourism flows for some Mediterranean countries, possibly induced by the climate change, and their implications for water consumption, were assessed. Some studies indicate that climate change will make the Mediterranean a more attractive tourist destination in the spring and autumn, especially for tourism related to beaches. As it is well known that the per capita water consumption of an average tourist is far higher than that of a local, one should conclude that an increased tourism activity would bring about higher pressure on scarce water resources.

However, this is not necessarily the case, when tourism is considered in the broader framework of structural adjustments of the economic system. More incoming tourists will increase income and welfare, but this phenomenon will also induce a change in the productive structure, with a decline in agriculture and manufacturing, partially compensated by an expansion of service industries.

The reduction in agricultural production is especially relevant, because agriculture covers about two thirds of total water consumption in the Mediterranean, meaning that even a modest decline in agriculture could more than compensate the increased tourists' demand. Not all water savings obtained in agriculture could be redirected to supply water for tourists, though. Much of the water used in agriculture is “green water”, embedded into the soil moisture, and typically related to rainfed agriculture. Water used for irrigation, which could potentially be transferred to other uses including tourism, is termed instead “blue water”.

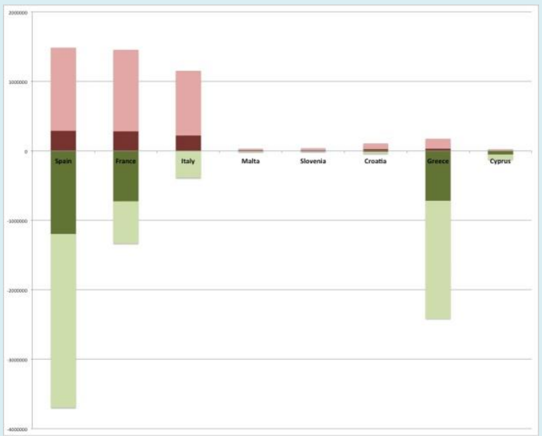


**Figure 22 Variations in direct and indirect water consumption (L/yr)** *[Figure to be updated and updated]*

The likelihood of reductions in total water consumption is assessed by considering several parameters in the calculation model as random variables, so that the results are expressed as probabilities. Results showed that there would be a 92 % probability that water savings exceed extra demand from tourism in Spain, which means that this would be a quite likely event, and possible in France (60 %). On the other hand, net savings are quite unlikely in Croatia (18 %), Italy (13 %) and Malta (18 %).

Interestingly, the countries in which net savings are foreseen are also the most arid ones. This is not a coincidence: relatively arid countries are characterized by more irrigation in agriculture, so any decline in agricultural production would free surface water, which then becomes available for the tourism industry.

These results should therefore be interpreted in terms of “potential of compatibility” between agriculture and tourism development, suggesting that compatibility is possible and can be achieved through specific policies aimed at making water demand (by both agriculture and tourism) more evenly spread over time and space. For example, policies in tourism development should be geared at making tourism flows more continuous over the year, reducing seasonal peaks (thereby reinforcing the effect induced by the climate change itself). They should also avoid further development in over-exploited areas. One way to provide efficient access is to allow water trading where this is possible in engineering terms.

### 6.2.3.6 Water footprint[15] in the Mediterranean

In the Mediterranean region, trade in raw materials and manufactured products induces virtual water transfers that impact on water resources management at different scales. A first quantification of virtual water flows related to foreign trade in agricultural products of Mediterranean countries suggests that for some countries, virtual water imported exceeds national exploitable water resources (Plan Bleu, 2007). This analysis also revealed that some countries facing water stress situations also export a significant part of their irrigation water (blue water). Trade and food security policies are thus impacting virtual water flows and water uses.

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[15] The water footprint is an indicator of freshwater use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated or incorporated into a product) and/or polluted per unit of time. A water footprint can be calculated for a particular product, for any well-defined group of consumers (for example, an individual, family, village, city, province, state or nation) or producers (for example, a public organization, private enterprise or economic sector). The water footprint is a geographically explicit indicator, showing not only volumes of water use and pollution, but also the locations. (Source: Water Footprint network)

As far as Northern countries are concerned, Spain, France and Italy are net virtual blue water exporters in the Mediterranean with respectively 9050 $Mm^3$/yr, 7400 $Mm^3$/yr and 7100 $Mm^3$/yr. Spain is the largest net exporter of virtual water in the Mediterranean, linked to trade in bovine meat, even if a large amount of virtual water is imported through grain for animal feed.
However, when considering global virtual water, including blue, green and grey waters, Italy and Spain are generally net importers; with 51 $Gm^3$/yr and 14 $Gm^3$/yr for 1997-2001, they occupy the 2nd and 9th position in the world.
In the eastern rim, Turkey is the first exporter of virtual blue water (and in the whole Mediterranean) with 11,370 $Mm^3$/yr followed by the Syrian Arab Republic with 3300 $Mm^3$/yr.
In the southern rim, Egypt and Morocco are the countries that most export virtual blue water, respectively 6800 and 2400 $Mm^3$/yr.

Moreover, the inter-Mediterranean trade seems low compared to trade with the rest of the world. The Mediterranean region is the world's largest importer of cereals (Plan Bleu, 2007). Guaranteeing these imports is thus a major challenge for food security. The demand for virtual water related to agricultural products in the Mediterranean for the period 1996 - 2005 is estimated at 168 $Gm^3$/year.

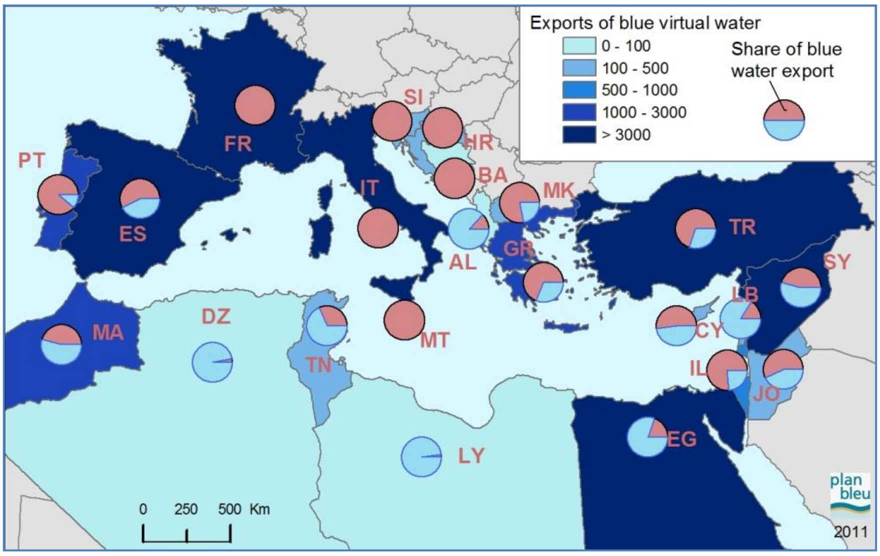

**Figure 23 Share of virtual blue water exported from the Mediterranean countries, period 1996-2005 (in percentage of the total blue water consumed in the country), Source: Mekonnen, M.M. and Hoekstra, A.Y. (2011)**
*[Map to be updated]*

Mediterranean people use lots of water for drinking, cooking and washing, but even more for producing things such as food, paper, cotton clothes, *etc*.

A water footprint has three components: green, blue and grey. The blue water footprint refers to consumption of blue water resources[16]. The green water footprint is the volume of green water[17] consumed. The grey water footprint is an indicator of the degree of freshwater pollution and is defined as the volume of freshwater required to assimilate the load of pollutants based on existing ambient water quality standards.

In the Mediterranean region, when the water footprint and available water resources are compared per country, two situations emerge:
- One group composed of the NMC with the water footprint lesser than available water resources[18];

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[16] Fresh surface and groundwater, i.e., the water in freshwater lakes, rivers and aquifers
[17] The precipitation on land that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation.
[18] Turkey, France, Italy, Spain, Croatia, Albania, Bosnia and Herzegovina, Slovenia

- A second group especially the SEMC with the water footprint exceeding the available water resources[19].

In order to make comparisons between countries in the region, it is useful to calculate the average footprint of water per capita per country ($m^3$/capita/yr).

Generally, we can define three major factors that determine the water footprint of a country.
- The first is the overall volume of consumption. This is directly related to the wealth of a country;
- A second factor is the lifestyle of the inhabitants: a diet rich in meat significantly increases the footprint of a country. The industrial goods consumption also account for a large part in the ranking;
- The third factor is the climate. In hot climates, evaporation and water use for agriculture is particularly high, in addition to poor agricultural practices often water-consumers.

In the Mediterranean, the water footprint per capita for developing countries has a similar variation as in industrialized countries. For developing countries, values are found in a range of 1050-2200 $m^3$/yr per capita. At the high end there are Tunisia (2217 $m^3$/capita/yr), Lebanon (2112 $m^3$/capita/yr) and Syrian Arab Republic (2107 $m^3$/capita/yr). With the disclaimer that the extreme values can also partially relate to weak basic data on consumption and water productivity in those countries, the differences can be traced back to differences in consumptions patterns on the one hand and differences in the water footprints of the products consumed on the other hand. What the ranking in Figure 24 shows is that in the range of relatively large water footprints per capita there are both industrialized and developing countries. The latter are in that range generally not because of their relative large consumption – although relative large meat consumption can play a role – but because of their low water productivities, i.e. large water footprints per ton of product consumed.
The ranking of countries shows also that industrialized countries have water footprints per capita in the range of 1780-2500 $m^3$/yr. Another factor behind the differences in the water footprints is the water consumption and pollution per unit of product per country.

The average water footprint of the Mediterranean countries (2082 $m^3$/capita/year) is higher than the world average (1385 $m^3$/capita/yr).

The national water footprint includes two components: the part of the footprint that falls inside the country (internal water footprint) and the part of the footprint that presses on other countries in the world (external water footprint). The distinction refers to the appropriation of domestic water resources versus the appropriation of foreign water resources.

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[19] Egypt, Morocco, Syrian Arab Republic, Algeria, Lebanon, Tunisia, Israel, Cyprus, Lybia, Montenegro

**Figure 24 Water footprint of Mediterranean countries (1996-2005), Mekonnen, M.M. and Hoekstra, A.Y. (2011)**

*[Figure to be updated]*

The virtual-water export of a country is the volume of virtual water associated with the export of goods or services from the country. It is the total volume of water required to produce the products for export. The virtual-water import of a country is the volume of virtual water associated with the import of goods or services into the country. It is the total volume of water used (in the export countries) to produce the products. Viewed from the perspective of the importing country, this water can be seen as an additional source of water that comes on top of the domestically available water resources. The virtual-water balance of a country over a certain time period is defined as the net import of virtual water over this period, which is equal to the gross import of virtual water minus the gross export. A positive virtual-water balance implies net inflow of virtual water to the country from other countries. A negative balance means net outflow of virtual water (Source: Water Footprint Network definition).

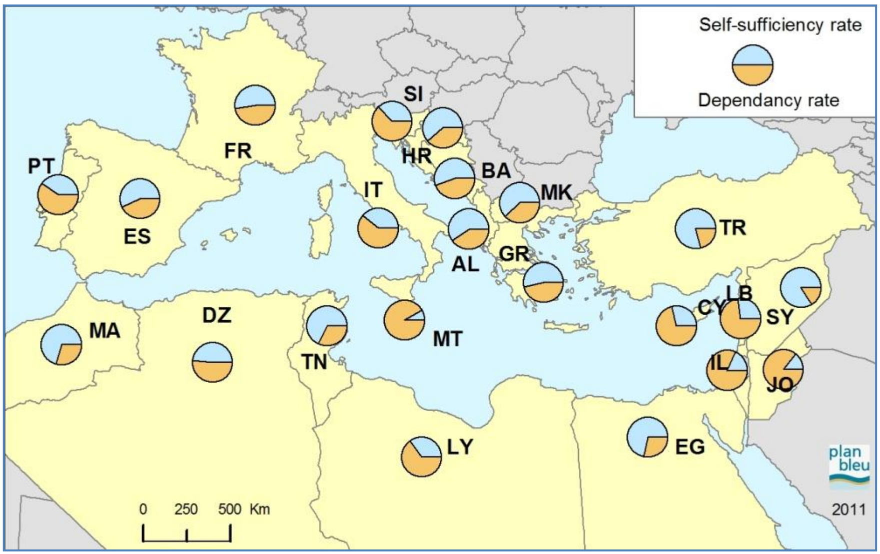

**Figure 25 Self-sufficiency and dependency rate[20] in relation to the water footprint (1996-2005), Mekonnen, M.M. and Hoekstra, A.Y. (2011)** *[Figure to be updated]*

The 'water self-sufficiency' of a nation is defined as the ratio of the internal water footprint to the total water footprint of a country or region. It denotes the national capability of supplying the water needed for the production of the domestic demand for goods and services. The 'dependency rate' of a country is defined as the ratio of the external water footprint of the country or region to its total water footprint.

All external water footprints of Mediterranean countries together constitute 43% of the total global water footprint (Plan Bleu, 2011). The share of external water footprint, however, varies from country to country. Some North Mediterranean countries, such as Malta, Cyprus, Slovenia and Italy have external water footprints contributing 60% to 92% to the total water footprint. On the other hand, some countries such as Morocco, Egypt, Turkey and the Syrian Arab Republic have small external water footprints, i.e. 30% of the total footprint, which means a low dependency rate.

Countries with a large external water footprint apparently depend upon freshwater resources in other countries. Highly water-scarce countries that have a large external water dependency are for example: Malta (dependency 92%), Jordan (86%), Israel (82%), Lebanon (73%) and Cyprus (71%). However, not all countries having a large external water footprint are water scarce. In this category are many Northern European countries like Slovenia and Portugal. They depend upon freshwater resources elsewhere, but the high dependence is not by necessity (they have respectively 15931 m3/capita/yr and 7337 $m^3$/capita/yr), since these countries have ample room for expanding agricultural production and thus reduce their external water dependency.

A number of Mediterranean countries reduce the use of their national water resources (blue water) through the import of agricultural and industrial products. These countries decreased their blue water demand such as Spain 13.5 $Gm^3$/yr (40%), Libya 6.5 $Gm^3$/yr (152%), Morocco 6.0 $Gm^3$/yr (60%) and Italy 5.3 $Gm^3$/yr (60%). In terms of blue water saved, Spain, and a number of countries in the Middle East come on top of the world list.
The term 'saving' is used in a physical sense, not an economic one. Besides, the 'water saving' does not necessarily imply that the water saved is allocated to other beneficial uses (De Fraiture *et al.* 2004). In water scarce countries, however, 'water saving' is likely to have positive environmental, social and economic implications.

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[20] The 'virtual-water import dependency' of a country or region is defined as the ratio of the external water footprint of the country or region to its total water footprint.

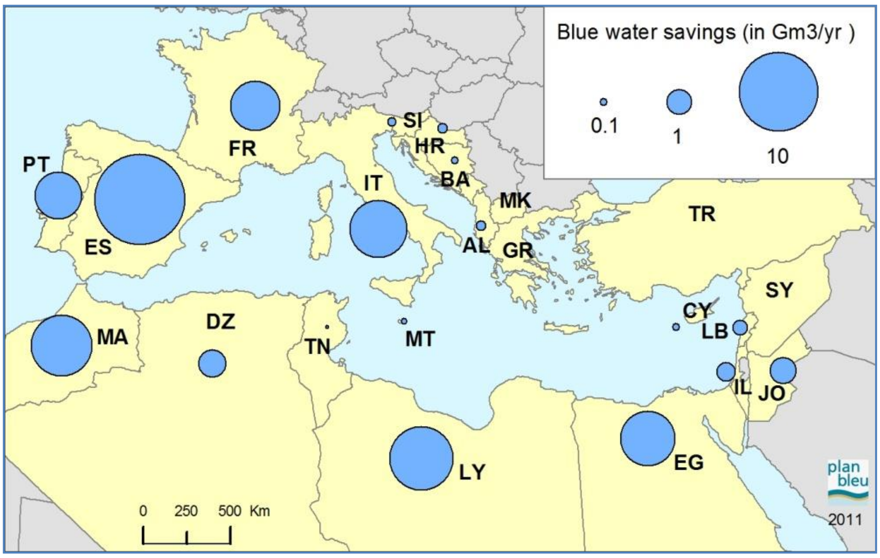


**Figure 26 Blue water savings in each Mediterranean country (1996-2005), Mekonnen, M.M. and Hoekstra, A.Y. (2011)**

The global water saving related to trade in agricultural and industrial products in the period 1996-2005 in the Mediterranean was 43 Gm$^3$/yr (99% from agricultural products, 1% from industrial products). This volume is equivalent to 5% of the global water footprint which is 809 Gm$^3$/yr (Plan Bleu, 2011). So the Mediterranean contributes to about 44% of blue water savings in the world.

Imports of virtual water related to international trade of agricultural products or other water users can help to cope with water crises and shortages, thus reducing the overall water footprint on the planet. However, the international trade in agricultural goods is driven largely by factors other than water. Therefore, import of virtual water is often unrelated to relative water scarcity in a country (Yang *et al.*, 2003; De Fraiture *et al.*, 2004; Oki and Kanae, 2004; Chapagain and Hoekstra, 2008; Yang and Zehnder, 2008). As shown by Yang *et al.* (2003), only below a certain threshold in water availability can a relationship be established between the country's per capita water availability and its cereal imports.

### 6.2.4 Non-conventional water resources

To cope with situations of water stress, water demand management remains a priority and represents a cost-efficient set of tools with further potential to be leveraged in Mediterranean countries. However, the region also increasingly relies on non-conventional water resources such as desalination of seawater or brackish water and the reuse of treated wastewater. Wastewater reuse and seawater desalination have considerable potential in many Mediterranean countries to reduce water stress and can contribute to sustainable development.

The Mediterranean region produces 28.4 Km$^3$ per year of municipal wastewater, divided between the three sub-regions as 44% of wastewater is produced in the North, 33% in the South and 23% in the East (Figure 27). Yet about 80 % of wastewater in the MENA region is released into the environment without being reused (World Bank, 2017), whereas positive experiences in the region demonstrate that wastewater can be safely recycled for irrigation or aquifer recharge. The total wastewater treated in the region amounts to 21.4 Km$^3$ per year (57 % in the North, 22 % in the South and 21 % in the East, from the total treated wastewater in the region). The South and the East of the Mediterranean have great potential to improve wastewater treatment, especially for agricultural use that consumes most of the fresh water resources. The reuse of drainage water in agriculture can also reduce the pressure on water resources. For instance, Egypt and Syrian Arab Republic directly use 2.7 and 2.3 million m$^3$ of agricultural drainage water, respectively. Particular attention to water quality degradation of drainage water should be paid. Israel is reuse leader in the SEMCs, with a reuse rate of over 85 % of collected wastewater. In Europe, Cyprus and Malta are the most advanced countries in terms of reuse, with 90 % and 60 % of their treated wastewater reused, far ahead of other countries (around 2.4 % on average in Europe) and ahead of the rest of the world. France reuses 0.2% of its wastewater (IPEMED, 2019).

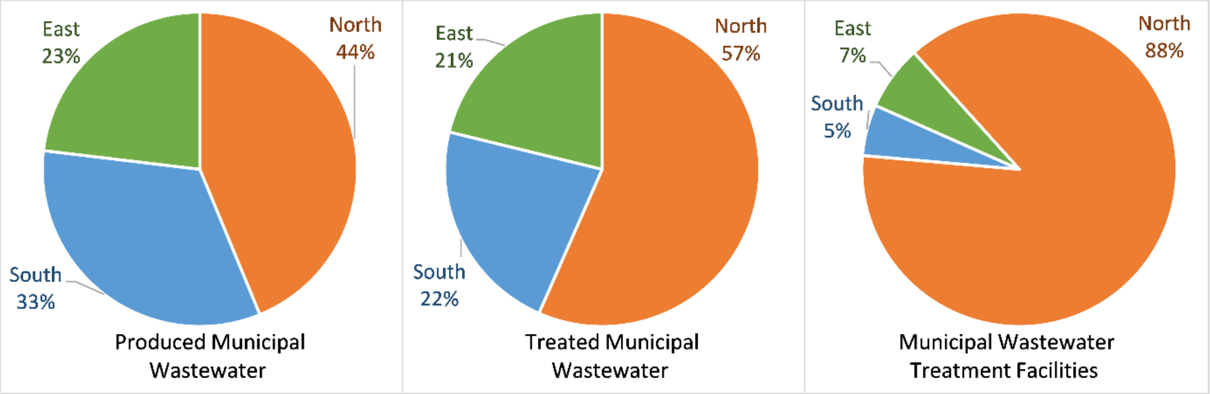


**Figure 27 Distribution of municipal wastewater produced and treated, in reference to the total wastewater in the Mediterranean. Source: data extracted from Aquastat database. FAO, 2016**

First developed in situations of island isolation (Balearic Islands, Cyclades, Cyprus, Dalmatia, Malta, ...) and in coastal zones in Libya or in the desert of Algeria, particularly to meet the needs of tourism, freshwater production from desalination of seawater or brackish water now extends all around the Mediterranean, mainly for domestic use. It constitutes up to 60 % of the drinking water supply in Malta. Spain, the fourth largest producer in the Mediterranean, has the particularity of allocating a significant portion of desalinated water to the agricultural sector (Figure 28). Many coastal cities have been equipped with desalination plants for their municipal water supply. Algeria is the higher producer of desalinated water with 615 million $m^3$ (2012), representing 45 % of the total desalinated water in the Mediterranean. As of 2018, the country has constructed 11 desalination plants since 2003, and is proposal to build two new desalination plants with capacity of 300,000 $m^3$ per day each. This is part of the plan to have 13 facilities and total capacity of 2.31 million $m^3$ per day. The two new plants will bring desalinated water to 25 % of the national drinking water supplies, up from 17 % currently. Other countries such as Egypt, Israel and Spain are also working towards increasing their capacity for seawater desalination to reduce the impact of water scarcity on development sustainability and food security.

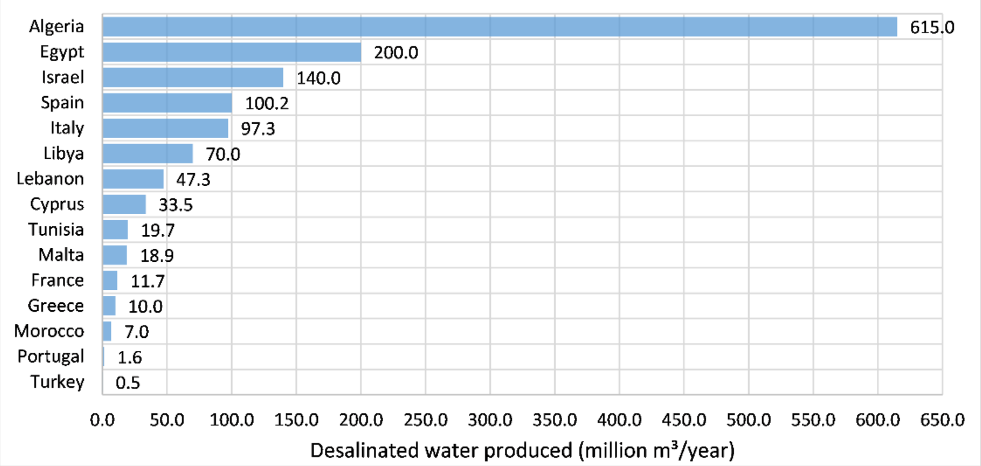


**Figure 28 Production of Desalinated water in the Mediterranean. Source: data extracted from Aquastat database. FAO, 2016**

In the Mediterranean, desalination production in 2008 was 10 $Mm^3$ per year and could triple or even quadruple in 2030. However, large-scale desalination remains a costly option that consumes large amounts of energy and emits greenhouse gases. The cost of water produced by desalination of seawater is around 0.4 to 0.6 € per $m^3$ for large units, which is about 2 times higher than that of conventional water and does not take into account the initial investment. Desalination has, moreover, negative impacts on the environment, related to the development of coastal infrastructure but also to the discharge of brines. However, options with low $CO_2$ emissions are possible. The most energy-efficient desalination systems must be upgraded: reverse osmosis, in combination with thermal power plants, energy recovery from residual pressure within desalination plants and improvement of existing facilities. Renewable energies (wind, solar) applied to desalination, are promising for the future, even if their development remains linked to issues of financing and competitiveness.

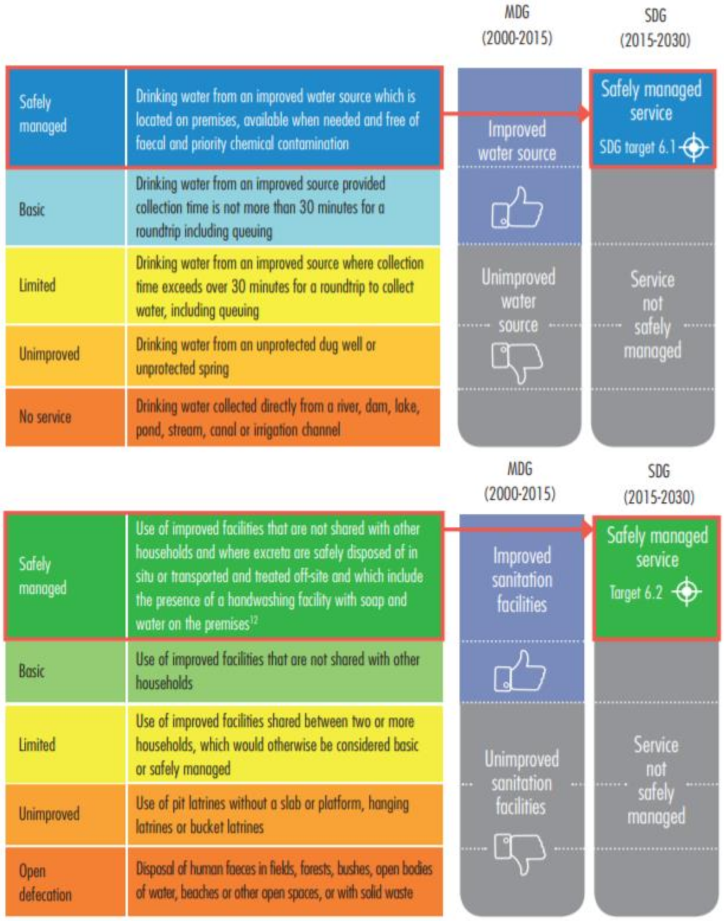
### 6.2.5 Water supply and sanitation

In the Mediterranean, access to water and sanitation remains a major challenge for the coming years, despite significant progress. This progress must be pursued because the stakes are high to achieve the objectives of sustainable development by 2030. These aim to guarantee access for all to safely managed water and sanitation services.

It should be noted that there has been a change in the definition of indicators for access to water and sanitation. Until 2015, the Millennium Development Goals (MDGs) focused on access to water and sanitation using two indicators, related to target 7.c, "By 2015, halve the proportion of people without sustainable access to safe drinking water and basic sanitation":
- the proportion of the population using an improved drinking water source (7.8)
- the proportion of the population using improved sanitation facilities (7.9).

At the Sustainable Development Summit in September 2015, the Sustainable Development Goals (SDGs) were adopted to consider the different dimensions of sustainable development: economic growth, social integration and environmental protection (UN, 2015). SDG 6 is to “ensure availability and sustainable management of water and sanitation for all”. At present, access to water takes into account the notions of availability, accessibility of service and potability of the water supplied, which represents a significant step forward in comparison to MDG 7.c, which was limited to the existence of a water point, without taking into account the quality of the water distributed nor the functionality and accessibility of this water point. Targets 6.2 on sanitation and hygiene and 6.3 on pollution reduction broaden the MDG framework beyond the consideration of toilets and now cover the entire sector, highlighting the importance of sludge management and treatment.

The novelty of the SDG indicators in relation to the MDG indicators is the introduction of the notion of "safely managed" drinking water and sanitation services, which corresponds to the top of the scale in terms of access to water and sanitation, above the level "improved", which was used in the MDG indicators. The previously used “improved” level corresponds to the now-called "at least basic" level, including the “basic” and “safely managed” water levels.



| | | MDG (2000-2015) | SDG (2015-2030) |
|---|---|---|---|
| Safely managed | Drinking water from an improved water source which is located on premises, available when needed and free of faecal and priority chemical contamination | Improved water source | Safely managed service<br>SDG target 6.1 |
| Basic | Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing | | Service not safely managed |
| Limited | Drinking water from an improved source where collection time exceeds over 30 minutes for a roundtrip to collect water, including queuing | Unimproved water source | |
| Unimproved | Drinking water from an unprotected dug well or unprotected spring | | |
| No service | Drinking water collected directly from a river, dam, lake, pond, stream, canal or irrigation channel | | |

| | | MDG (2000-2015) | SDG (2015-2030) |
|---|---|---|---|
| Safely managed | Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated off-site and which include the presence of a handwashing facility with soap and water on the premises[12] | Improved sanitation facilities | Safely managed service<br>Target 6.2 |
| Basic | Use of improved facilities that are not shared with other households | | Service not safely managed |
| Limited | Use of improved facilities shared between two or more households, which would otherwise be considered basic or safely managed | Unimproved sanitation facilities | |
| Unimproved | Use of pit latrines without a slab or platform, hanging latrines or bucket latrines | | |
| Open defecation | Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or with solid waste | | |

**Figure 29 Source: Ps-EAU 2018 The Sustainable Development Goals for Water and Sanitation Services; Interpreting the Targets and Indicators.** *[Figure to be adapted]*

In 2015, around 18 million Mediterranean people do not yet have access to an improved drinking water supply (JMP 2017), i.e. 3.6% of the total population of the Mediterranean region, 89 % of which come from the South-East. Countries in this region recorded an average rate of access to improved water of 96 %, which is higher than the world average of 91 % (WB). It should be noted that if we consider the number of people without access to a safe water service (as defined in SDG 6, i.e. having access to drinking water from an improved source, located/accessible on premises, available when needed, and free from contamination), this figure increases to 26 million Mediterranean people. Having access to water in a sustainable way directly impacts the living conditions of women who can spend hours fetching water, and increases girls' schooling.

In 2015, it is noted that around 23 million people, with disparities between countries, do not yet have sustainable access to adequate sanitation (WHO / UNICEF, 2017), or 5% of the total population of the Mediterranean region, 80% of which come from the South-East.
As for access to water, the countries of this South-Eastern Mediterranean region have also made very encouraging progress, with an average sanitation access rate of 91%, which is higher than the world average of 68% (World Bank). Considering access to safely managed sanitation services (as defined in SDG 6, i.e. an improved sanitation facilities that are not shared with other households and where excreta are safely disposed of in situ or offsite), 182 million Mediterranean are not yet served. An enormous effort still remains to be made in the sanitation sector in particular.

Good hygiene habits, such as hands washing with soap and water after using the toilet and before food preparation and consumption, are equally important in limiting the spread of communicable diseases.

The SDG indicator 6.a.1 is the "Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan". It is defined as the proportion of total disbursements of public support for development related to water and sanitation included in the governmental budget. Between 2000 and 2015 the amount of public aid for development related to water and sanitation allocated to North Africa (Algeria, Egypt, Libya, Morocco and Tunisia) rose from 455 million USD to USD 777 million (UN: statistic division, 2015), representing a growth rate of 71% unequally distributed among the 5 countries. Disparities are significant between countries registering a minimum of USD 430,000 for Libya and a maximum of USD 404 million for Morocco.
This increase in ODA devoted to water and sanitation can be explained by the considerable progress recorded over the same period, in particular in terms of access to drinking water and sanitation in the Southern Mediterranean region (rise from 88 % to 96 % and from 65 % to 90 % respectively; WHO / UNICEF, Blinda, 2018).

### 6.2.6 Status and trends of water quality

*[Section to be completed, pending]*

SDG Target 6.3 calls for "*[improving]* water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally".

Considering the 16 River Basin Districts monitored in terms of surface water pollution and habitat degradation along the Mediterranean coastline, 49% of water bodies on average are failing to achieve the Good Ecological status, the highest proportion being found in Sicily, Italy, and lowest in Corsica, France (EEA, Ecological Status of Surface Water Bodies, 2018).

### 6.2.7 Stability/fragility

#### The Vicious Cycle of Water Security and Fragility

The World Bank considers that four of the top five global risks (water crises, failure of climate change adaptation and mitigation, extreme weather events, and food crises) are directly related to water management and water-related risks, while the fifth global risk, profound social instability is a common characteristic of fragile states (Sadoff *et al.*, 2017). As the most water scarce region in the world, the Mediterranean region is a stark illustration of the links between water security and regional stability.

Water security can be defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability" (UN Water, 2013). The concept of water security is therefore located at the nexus between environmental, socio-economic and political factors. In its absence, short- to long-term processes leading to political instability, livelihood depletion, ecosystem degradation and population displacement may arise. What is more, water insecurity and fragility feed into a vicious cycle – as fragility makes it more difficult to achieve water security, the failure to achieve the latter in turn leads to greater social, political, economic and environmental costs and consequences, thereby further exacerbating fragility (Sadoff *et al.*, 2017).

#### Water, Instability and Population Displacement

One of the ultimate manifestations of this vicious cycle is population displacement. Recent phenomena in the Mediterranean region, such as the Syrian refugee crisis and the ongoing flux of migrants crossing the Mediterranean to reach its northern shores, highlight the complex interlinkages between water security and voluntary migration and forced displacement in the Mediterranean region.

When and where long-term efforts to adapt to climatic variability fail, the capacity of populations to ensure their livelihoods (notably through agriculture) is strongly impacted, which can lead to migratory crises and conflict situations due to competition for resources, as well as increased pressure on host communities . Nonetheless, it is widely agreed that it is not possible to simply "blame the drought", namely environmental factors such as climate change, for instability linked to water resources in the region. Water scarcity or water-related factors rarely figure in migrants' and refugees' decisions to flee their homes (Jobbins *et al.*, 2018). Rather, the water insecurity and fragility dynamic plays out in the mid- to long-term, feeding into processes of rising instability that may lead up to forced displacement or voluntary migration. Initially, however, it is more often than not instigated by water governance failures, such as:

- Failure to provide water services
- Failure to protect against water-related disasters
- Failure to preserve surface, ground and transboundary water resources (Sadoff *et al.*, 2017)

These policy failures can threaten social cohesion while increasing tensions between governments/policy makers and citizens, and can either be partly caused or exacerbated by long-term environmental factors, such as the numerous effects of climate change. In the Syrian Arab Republic, the wave of rural to urban migration and the following broader crisis and conflict resulted from broad governance failures, and not from the severe drought which struck the Syrian Arab Republic starting from 2005 (de Châtel, 2014). Indeed, the drought did not lead to widespread migratory phenomena from rural to urban zones in other neighboring countries that were also affected, such as Iraq, Turkey, Lebanon and Jordan (Weinthal, Zawahri and Sowers, 2015). Rather than focusing on the potential for extreme weather events and climatic factors to cause long-term displacements (as opposed to short-term emergency displacements due to sudden floods) the literature argues that the true challenge for achieving water security in relation to migration depends on the extent to which governments and utilities can strengthen governance and water services to better respond to its effects of migration (Jobbins *et al.* , 2018). Nonetheless, while water resources and WASH services are most often not the main drivers of large-scale migration, they can fuel underdevelopment and marginalization in migrants' communities of origin and economic opportunities in host communities (Jägerskog and Swain, 2016).

**Emerging from the "vicious cycle" of water insecurity and instability**

When studied in situations of fragility (such as migration and conflict), caution is needed since there are no "easy answers" to achieving water security (Jägerskog and Swain, 2016). Profound social instability is one of the main factors that prevent integrated water strategies to take root in fragile areas. Without stability in water service provision, water policy and management and water infrastructure, large swathes of populations can be cut off from this primordial resource and deprived of their capacity to access clean drinking water, proper sanitation, and to produce food to ensure their subsistence and revenues. Indeed, food crises can be directly related to water shortages or water supply inefficiencies. Indeed, food is effectively water that humans "eat": when water is insufficient due to environmental or human factors, food production is directly impacted further down the chain. Unable to feed themselves or to obtain sufficient incomes from their agricultural produce, populations are forced to migrate to survive. Finally, the vicious cycle also has numerous negative effects on the health of ecosystems in affected areas, which bear the brunt of water scarcity and populations' often efforts to maintain their subsistence in increasingly barren areas. Thus, the vicious cycle can also instigate protracted processes of environmental degradation caused by resource depletion.

Devising new strategies to emerge from the vicious cycle of water scarcity and fragility is a fundamental regional challenge for the Mediterranean. It involves thinking beyond immediate water supplies to ensure sustainable resource management and affordable water provision services (FAO and World Bank, 2018). This long-term, regional and collaborative approach is instrumental in building regional resilience to human or environmental shocks such as conflict, forced displacement and extreme weather events and ongoing environmental degradation.

The Syrian up-rising, which began in March 2011 is the outcome of complex but interrelated factors (Gleick and Heberger, 2014; Kelley *et al*, 2015). While the main target of the multi-sided armed conflict has been a political regime change, the uprising was also triggered by a set of social, economic, religious and political factors leading to a disintegration of the country with a growing rural-urban divide, rising unemployment, and growing poverty (De Chatel, 2014). The climate hypothesis has been fiercely contested and although causality cannot to be found in such a simple direct relationship, it cannot be denied that drought played a significant role in triggering the crisis, as this drought was the longest and the most intense in the last 900 years (Cook *et al*, 2015).

## 6.3 Agroecosystems, soils and food security

### 6.3.1. Agroecosystems

*[Section to be completed, with Figures and trends]*

Agroecosystems are generally defined by a dominant agricultural activity influencing the living and non-living components interacting in an ecosystem. Mediterranean agroecosystems include irrigated agriculture, rainfed agriculture, pasture and aquaculture, which can be found in two different zones, providing differing agroecosystem services:

- « fertile » areas, where large irrigation schemes and rainfall agroecosystems occur. They are said favorable, because they receive more than 400 mm annual rainfall and are limited spatially by resource availability (water and land). Oasis, peri-urban and lagunar systems are also integrated in this zone.
- « handicap/marginal » areas characterised by mountains and semi-arid, non-irrigated fields, where agriculture is often marginal and interferes with pastoral economy, the latter becoming dominant in steppes. Agricultural economy in these areas can be called « agro-sylvo-pastoral ».

In the fertile areas, the most significant type of ecosystem services rendered is provisioning of food, fuel (timber) and fiber (e.g. from Egyptian cotton) contributing to food and energy security and export earnings. Other services provided by these systems, to a lesser extent, include:

- cultural services, including aesthetic and existence values and recreational activities, which contribute to the quality and attractiveness of the "Mediterranean landscapes" and impact possibilities of tourism development;
- regulating services, including:
  - the capacity of irrigated systems to create microclimates favorable for the life of plants, animals and humans, which are particularly important in arid zones, both in the oases of North Africa and the Middle East, and throughout the Nile Valley;
  - carbon sequestration, while the sprawl of rural areas leads on the contrary to reduce the infiltration of water and increase GHG emissions (growth of transport consumption...);
  - fire prevention by grazing activities, which decrease woody vegetation density;
  - water regulation through specific agrarian and forestry practices;
  - pollination through the maintenance of higher floral diversity communities; recycling of urban effluents; habitat creation and safeguarding of agricultural biodiversity.

In the « handicap/marginal » zones, the main ecosystem services are:

- provisioning of water for the benefit of the downstream users (essential roles of "water towers" and provision of hydroelectricity potential); and to a lesser extent, food (agricultural

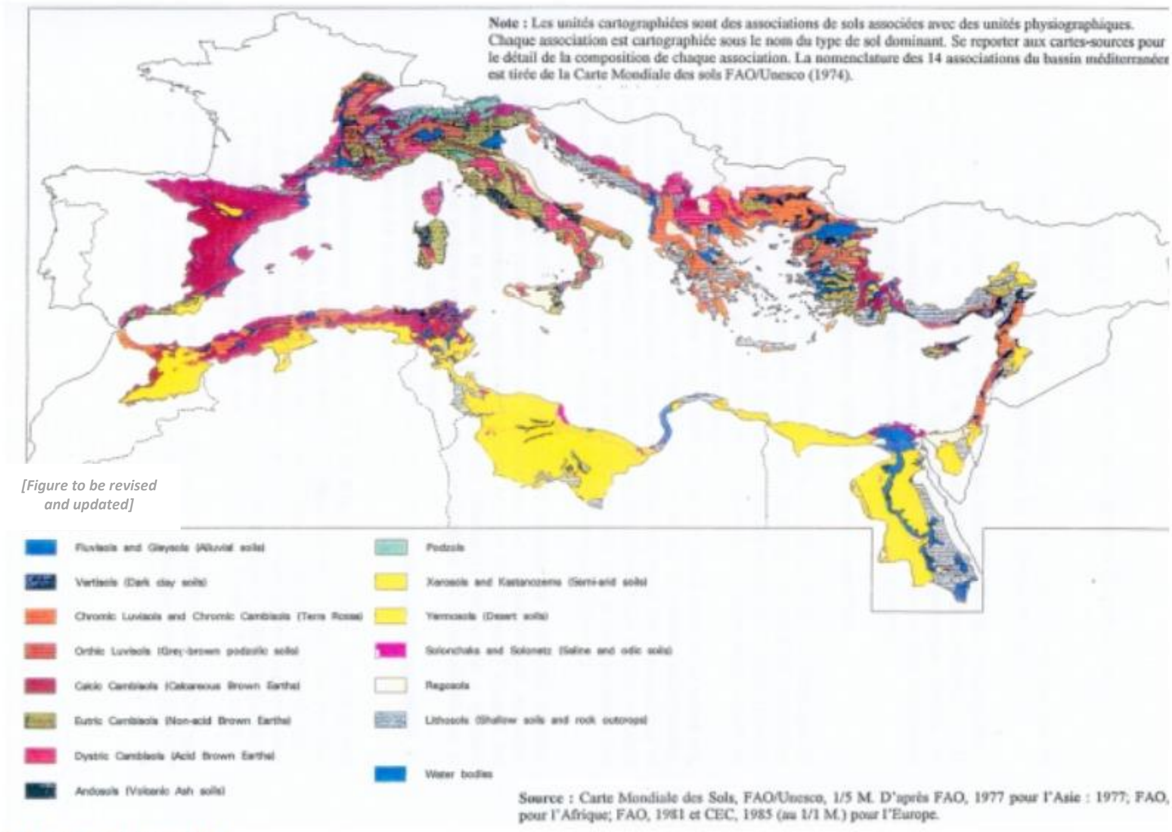
and pastoral) and wood production with limited productivity, complemented by honey, mushrooms and aromatic and medicinal plants;
- regulating services, mainly infiltration of water, which can contribute to a positive hydrology and the storage and reorganization of carbon, but also safeguarding of biodiversity;
- cultural services rendered by the mountainous areas including aesthetic, recreational and spiritual functions.

Mediterranean agroecosystems are characterized by trade-offs between interdependent ecosystem services. While regulating and cultural services are necessary for certain provisioning services, the maximization of provisioning services can alter certain regulating and cultural ecosystem services.

### 6.3.2. Soils

Soil is one of the main contributors to agroecosystem function and food security, being as precious as water throughout the Mediterranean. In Mediterranean history, the disappearance of some civilizations can be associated with a decline in food production due to the large development of soil salinity stemming from weakly drained, mismanaged alluvial soils.

The Mediterranean basin is located between two very different pedogenetic zones: in the North, where the climate is wetter, soils are generally richer in organic matter and have a higher humidity; in the South, because of extreme temperatures, soil mineralization is accelerated and soils are very sensitive to desertification (Plan Bleu, 2003). The dominant soils in the Mediterranean basin are cambisols (Figure 30), which are mostly fertile and appropriate for agricultural production. Fluvisols, young alluvial soils, are especially productive and are found along major river basins such as the Ebro and Rhône.



Note : Les unités cartographiées sont des associations de sols associées avec des unités physiographiques. Chaque association est cartographiée sous le nom du type de sol dominant. Se reporter aux cartes-sources pour le détail de la composition de chaque association. La nomenclature des 14 associations du bassin méditerranéen est tirée de la Carte Mondiale des sols FAO/Unesco (1974).

*[Figure to be revised and updated]*

Source : Carte Mondiale des Sols, FAO/Unesco, 1/5 M. D'après FAO, 1977 pour l'Asie : 1977; FAO, pour l'Afrique; FAO, 1981 et CEC, 1985 (au 1/1 M.) pour l'Europe.

(Source: FAO in Plan Bleu, 1996 [79])

**Figure 30 Main soil types in the Mediterranean region**

*[Figure to be updated]*

Soils are shaped due to several soil forming factors including geology, topography, biota, climate, vegetation, time and human influence. They provide essential ecosystem services for food security and beyond, including organic matter decomposition, primary production, nutrient cycling, water quality regulation, water supply regulation, climate regulation and carbon storage, erosion regulation, food supply, fibre and fuel supply, raw earth material supply, surface stability, refugia for biodiversity, aesthetic and spiritual, archive of geological and archaeological heritage (FAO and ITPS, 2015). These services are supported by a myriad of organisms, many of which invisible to the naked eye but extremely diverse, abundant and active. For example, bacteria and fungi play a role in biogeochemical cycles and are responsible for nutrient supply by mineralizing organic matter (Orgiazzi *et al.*, 2012). Small hexapods and earthworms play an important role in litter decomposition and microstructure formation (Renaud *et al.*, 2004).

Around half of the world's soils are degraded and in the Mediterranean basin, about 8.3 million hectares of arable land have been lost since 1960 (Zdruli, 2014), affecting mainly poor populations. At the level of the Mediterranean basin, scientific literature currently lacks a comprehensive synthesis of the state and trends of Mediterranean soil.

The area of arable land decreased by an average of 13% over the period 1995-2015. This decline is particularly marked in the State of Palestine (-42%), Lebanon (-27%) and Turkey (-16%) and Israel (-14%). The total number of hectares of arable land decreased by an average of 10% in the Balkan countries between 1995 and 2016. At the country level, the number of hectares of arable land increased in Bosnia and Herzegovina (+ 21%) and in Albania (+ 8%), and decreased in other countries, particularly in Greece (-24%) and Croatia (-22%).

The area of arable land per capita (Figure 32) fell by an average of 41% over the same period, more than double that experienced by middle-income countries globally. The Mediterranean countries most affected by the decline in the number of hectares per inhabitant are the State of Palestine (-68%), Lebanon (-62%) and Jordan (-55%).

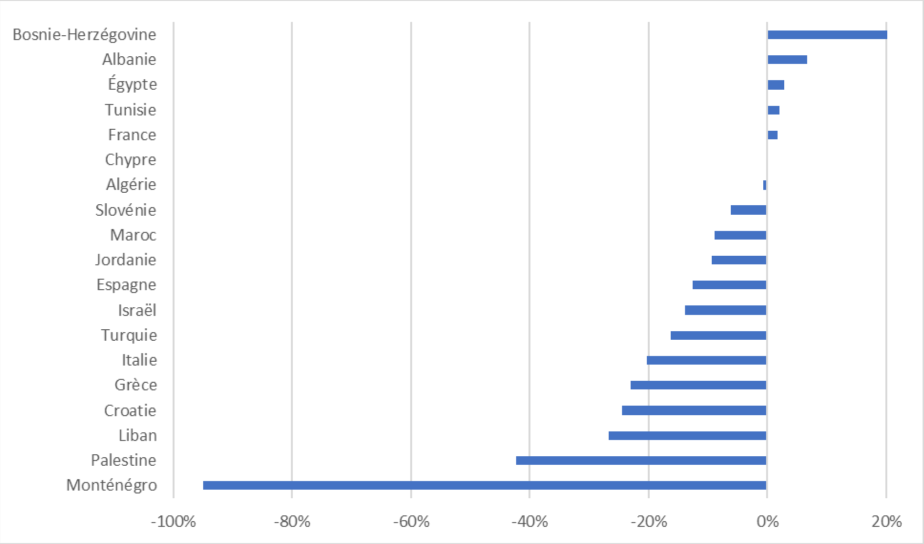


**Figure 31 Evolution de la surface des terres arables entre 1995 et 2015 (différence en %) Sources : IDM Banque Mondiale**

*[Figure to be translated]*

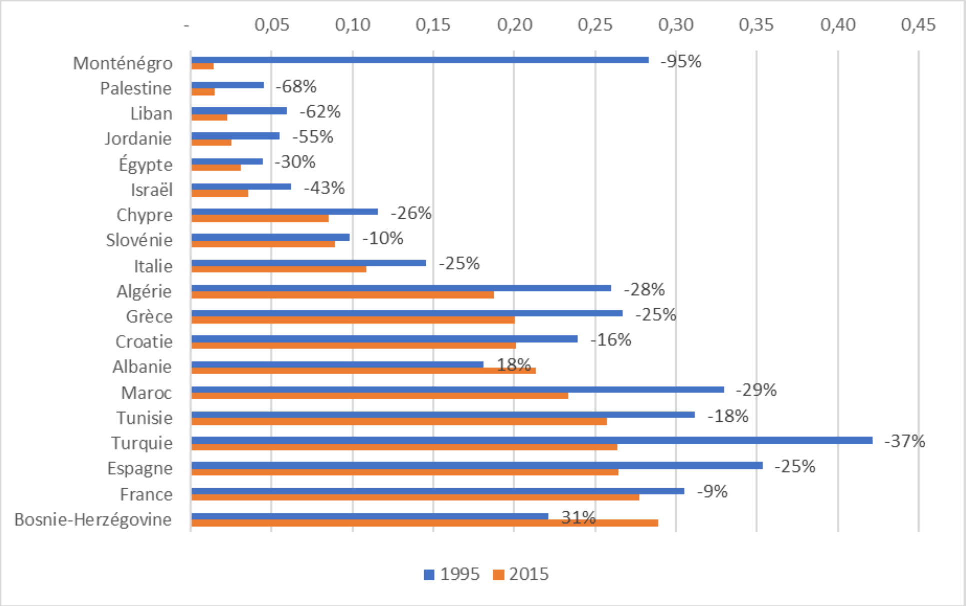


**Figure 32 Nombre d'hectares de terres arables par habitants en 1995 et 2015 et évolution entre ces deux dates Sources : IDM Banque Mondiale** *[Figure to be translated]*

## Factors influencing soil health and functions

The Mediterranean region combines factors that are conducive to soil degradation: an often sparse vegetation cover, a high annual climatic variability alternating wet and (very) dry years and frequent high intensity rainfall and wind events, rocks often of easily erodible, a rugged relief where 45% of the area having slopes greater than 8%, and relatively shallow soils (Garcia-Ruiz *et al.*, 2013). In addition, the region has a long history of human occupation with a continuous practice of agriculture and livestock since the Neolithic (Lahmar & Ruellan, 2007).

Soil degradation is mainly caused by agricultural and non-agricultural **land intensification**, resulting from the expansion of cultivation, industrial and urban areas in response to a combination of drivers: population growth (particularly in the southern rim of Mediterranean basin) and access to subsidies (countries subjected to EU Common Agricultural Policy); changes in agricultural practices (e.g. mechanization of tillage operations, land levelling to facilitate irrigation, cultivation of steep slopes, deforestation, overgrazing); littoralisation and urban sprawl; and construction of transport infrastructure. The processes of soil degradation include, among others: water and wind erosion, salinization and sodification, sealing and compaction, loss of organic matter and permanent loss of vegetation cover.

In parallel with intensification, many inland areas of the European Mediterranean countries witness an increasing rural land abandonment and associated depopulation and economic marginalization. Land abandonment brings about an aging and **depopulation of rural areas** and migration to urban areas. When rainfall conditions are favourable, a woody encroachment of former agricultural lands follows land abandonment. This secondary succession process results in higher biomass which can provide habitats for various species (while not been favourable to grassland specific species), but also result in an increasing fire risk.

**Soil erosion** is a natural process, but it becomes an issue when the rate of erosion is higher than the rate of soil formation. Natural erosion in balanced ecosystem has a tolerable level of annual surface horizon loss (5 tons/ha). This loss can be accelerated by human activities to rates higher than 50 tons/ha. The most evident on-site impact of erosion is the truncation of the soil profile that can result in the emergence of bedrock outcrops and loss of cultivable area, the depletion of soil nutrients, the reduction of the water holding capacity of the soil, and changes of other soil properties (e.g. coarsening soil texture). Erosion also affects the capacity of the soil to stock and regulate carbon, making it eventually a net contributor to greenhouse gas emissions. Studies in semiarid part of Spain revealed that the total organic carbon lost by erosion in the sediments was around three times higher in cultivated (5.12 g C $m^{-2}$) than forest land (1.77 g C $m^{-2}$) (Martinez-Mena *et al*, 2008). Off-site impacts of erosion include non-point pollution and eutrophication of downstream water bodies caused by the exportation of eroded sediments and the nutrients and pesticide attached to them, higher risk of flash flood transporting high loads of sediments, and reservoirs siltation. The reduction of reservoirs' capacity is a serious issue in North African and Eastern Mediterranean countries where water availability for irrigation and drinking mainly rely on surface water storage (Ayadi *et al*., 2010).

**Box 3 State of soil erosion**

Quantifying the extension and intensity of soil erosion has proved a difficult task subject to a high uncertainty. Erosion is scale-dependent with highly temporal variability that requests performing standardized, long-term and nested across scales monitoring systems to gather representative, reliable and comparable data.

Reported erosion rates show a wide variability depending of the approach used (whether measured in plot or modelled), the monitored processes (sheet, erosion, gully) and the scale (plot, hillslope or catchment). Based on an extensive review of published erosion plot data Olivier *et al*. 2010, estimated rill and interrill erosion rate of 1.3 t/ha/yr for the Mediterranean area of Europe. This accounts for 21.5 % of the total Pan-European soil losses. Measured erosion is strongly influenced by land use (Table 2). A similar study conducted by Maertens *et al.*, 2016 confirms the key role of land use as determinant of erosion rates in the Mediterranean. The annual mean rate for bare plots and plots where some type of crops have been cultivated range from 1 to 20 t $ha^{-1}$ $yr^{-1}$ while plots with some kind of permanent cover have erosion rates lower than 1 t/ha/yr.

The erosion rates are lower for bare and cultivated areas than observed in wetter part of Europe. On contrary, areas covered by (semi-)natural vegetation showed higher, yet low < 1 t/ha/yr, rates than in the rest of Europe. These counterintuitive low values of soil erosion obtained in Mediterranean region are explained by the large fraction of rock fragments on the topsoil and the importance of other erosion mechanism such as gully erosion, landslides and riverbank erosion that are not well represented at plot scales.

**Table 2 Estimated average erosion rates by land use in the Mediterranean region**

| Land Use | Erosion Rate (t/ha/yr) measured at plot scale | |
|---|---|---|
| | Olivier *et al*.2010 | Maertens *et al*.2016 |
| Bare | 9.05 | 9.1 |
| Arable | 0.84 | 2.9[1] |
| Forest | 0.18 | 0.4 |
| Grassland | 0.32 | 0.6-0.8 |
| Shrubs | 0.54 | 0.6 |
| Vineyards | 8.62 | 1.8 |
| Orchards | 1.67 | 11.6[2] |

[1] The data is shown as erosion rate for croplands (cereal, maize, sugar beet, sunflower) in the original paper

[2] This is referred to as tree crops (olive, almond, citrus) in the original paper

Modelling soil erosion rates provides, however, a slightly different picture in which the Mediterranean Europe is identified as a global hot spot (i.e. areas where soil loss rate are beyond 20 t/ha/yr) at global level (Borreli *et al*., 2017). At European level, Panagos *et al*, 2015 estimate soil erosion rate by using a revised version of the Universal Soil Loss Equation (RUSLE2015). The results showed that the Mediterranean climatic zone has a high erosion rate (4.6 t/ha/yr). In this study, estimated soil loss of eight Mediterranean EU Member States (CY, ES, FR, GR, HR, IT, MT and PT) amounts to 67% of the total soil loss in the European Union (28 countries) (Table 3). These higher values are mainly explained by having the highest rain erosivity and the presence of permanent crops, which include most of the vineyard, almonds and olive trees growing in Mediterranean region, and sparsely vegetated land areas, both land uses suffering from high erosion rates, 9.5 and 40.2 t/ha/yr, respectively.

**Table 3 Average soil loss rate per EU-Mediterranean country (all land, arable lands) and share of EU soil loss. Source: (extracted from original Panagos *et al*.,2015)**

| Country | | Estimated soil loss rate (t/ha/yr) | | % of the total soil loss in EU |
|---|---|---|---|---|
| | | Overall Mean | Mean in arable land | |

| | | | | |
|---|---|---|---|---|
| CY | Cyprus | 2.89 | 1.85 | 0.25 |
| ES | Spain | 3.94 | 4.27 | 19.61 |
| FR | France | 2.25 | 1.99 | 11.85 |
| GR | Greece | 4.13 | 2.77 | 5.31 |
| HR | Croatia | 3.16 | 1.67 | 1.74 |
| IT | Italy | 8.46 | 8.38 | 24.13 |
| MT | Malta | 6.02 | 15.93 | 0.01 |
| PT | Portugal | 2.31 | 2.94 | 2.01 |

**Soil salinisation** is one of the most spread soil degradation phenomenon that not only affects soil fertility, productivity and resilience against stressful environmental factors, but also reduces land use options (crop selection, land suitability) to match market conditions and demand. Salinisation results from excessive fertilizer input, over-irrigation or irrigation with low-quality water, inappropriate irrigation schedule, ineffective drainage and monoculture. Soil salinity and sodicity caused by the accumulation of salts and sodium (Na) respectively negatively affect soil fertility and productivity. High soil osmosis and head potential restrict water availability to plants which negatively affect plant growth and reduce crop production. Conditions causing low biological activity like low surface organic matter content after fires, weak microbial activity caused by salinity or pollution, and leading to insufficient oxidation-reduction and ammonification/nitrification potential, may reduce the efficiency of urea and other nitrogen fertilizers application and transformation in the soil-soil solution-root continuum.

**Global warming and climate change** in the Mediterranean has a special impact on soil functions and is associated with an increasing risk of **aridification**, i.e. the process of land degradation in arid, semi-arid and dry sub-humid zones. It is considered that approximately ten percent of the European territory is affected by different levels of intensity of desertification processes (Rubio and Recatala, 2006). Soil is the main actor in the processes of desertification: it constitutes a living environment with enormous biological activity that is highly sensitive to the availability of water and variation of climatic parameters. In Mediterranean terrestrial ecosystems, short-term effects of a drier climate on decomposition lead to a reduction of soil microbial biomass (Curiel-Yuste *et al*. 2011), reduced soil respiration (Emmett *et al*. 2004; Asensio *et al*. 2007; De Dato *et al*. 2010) and reduced soil enzyme activities (Sardans & Peñuelas 2005; Hueso, Hernández & García 2011). Mid-term (i.e. a few decades) effects impact on litter quality by reducing nutrient content (Wessel *et al*. 2004; Sardans *et al*. 2008) or by increasing recalcitrant compounds (molecules resisting microbial decomposition) (Munné-Bosch & Alegre 2000; Hernandez, Alegre & Munné-Bosch 2004), and altering the composition of decomposer communities by feedback processes.

**Soil degradation, in turn, affects important parameters of climate regulation and atmospheric chemical composition**, including: changes in albedo, radiative forcing, soil moisture, surface roughness, evapotranspiration, emission and retention of greenhouse gases (carbon dioxide, methane, nitrous oxide), changes in the condensation surfaces and the emission of aerosols and dust particles. Hence, the feedback of desertification processes increases the tendency of climate change (Rubio, 2007). In the Mediterranean, this **feedback mechanism** not only affects the stability and functioning of the natural environment, but also involves environmental security problems (forced migrations, water scarcity, food insecurity, forest fires) and important socioeconomic consequences.

### 6.3.3 Food security

The four pillars of food security are availability, access, utilisation and stability (Committee on World Food Security, 2009). In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, whose second goal (SDG 2) is to: “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”.

Although the Mediterranean is not the region most impacted by food insecurity in the world, it is facing an increasing number of complex and interlinked challenges. **Limited natural resources and population growth are preventing the region, particularly in the South and East, from being self-sufficient**. Conflicts are also a highly worrisome source of food insecurity. Food security for populations therefore depends on some stability, partially from internal production, but especially from trade and reliable international markets. Price volatility for agricultural commodities can damage countries with a vulnerable economy and limited public finances.

One of the visible manifestations of the world food crisis of 2007-2008 was the instability of agricultural commodities markets and price volatility. This volatility came at a time of prevailing difficulty for international markets for agricultural commodities, as evidenced in numerous studies. This instability resulted in price increases in 2008-2012, especially affecting **food expenditure, which in some countries represents up to 25% of total import expenditure**. To manage the inflation of food prices, governments in southern and eastern Mediterranean countries generally provide subsidies for bread and basic food products from compensation funds, which place a heavy burden on public finances. **Aiming to achieve complete national food self-sufficiency in countries in the region without the use of imports may be a utopian ideal due to the agroclimatic characteristics and available water and soil resources, but reducing external food dependency is an important goal.** Although a relative decline of agriculture in national wealth creation has been observed in recent decades, governments in the southern Mediterranean region have placed food security and agriculture at the heart of their national priorities.
This section will discuss each of the four pillars of food security in the Mediterranean, while reiterating its importance for political and social stability in these countries.

### 6.3.3.1. Food availability: imbalance between production in the northern and southern Mediterranean region and increased dependency of southern countries for basic food commodities

The Mediterranean is home to just over 6% of the world's available arable land. Mediterranean food production has a surplus of fruit and vegetables, wine and olive oil, but increasing cereal deficits.
The region's agroclimatic characteristics explain its 15% contribution to global fresh fruit and vegetable production in recent years (2015-2017) (30% for fresh tomatoes and over 40% for industrial tomatoes), and represents for the latter the first supplier in Europe.

The Mediterranean basin accounts for 20% of global citrus fruit production and more than half (53%) of global citrus fruit trade. It also provides 98% of global olive oil production and 50% of wine production, and accounts for 60% of global wine trade and a significant share of olive oil trade. For wine, three European countries (Italy, France, Spain) have the monopoly on the wine trade, while for olive oil, four major exporting countries (Spain, Italy, Greece and Tunisia) account for three quarters of global olive oil exports. Although Egypt, Algeria and Tunisia are the world's main date producers[21], Tunisia, and to a lesser extent Algeria, currently dominate the global market, while Turkey is one of the main global producers and exporters of dried fruit (raisins, dried apricots and dried figs)[22].
The main actors in the world agricultural trade are, in the Mediterranean, northern countries (Spain, France, Italy and Greece), three northern African Countries (Morocco, Egypt and Tunisia) and Turkey in the East. Finally, Croatia and Slovenia in Eastern Europe, Israel and, to a lesser extent, Lebanon in the Middle East, export fruit and vegetables across Europe and the world.

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[21] 5th most traded fruit in the world after citrus fruits, bananas, mangos and pineapples.

[22] Turkey is the largest global exporter of dried apricots. It is also the world's second producer and leading exporter of raisins (FAO-STAT, 2017).

Although France is one of the main exporters of cereals and dairy products, all Mediterranean countries, except Croatia and Turkey, register a net cereals deficit and a high cereals dependency ratio (see Figures 33 and 34 below).

**The climate regime and natural resources limit cereal production[23].**

Cereals are vital and strategic products for food security. Bread and semolina-based products are food staples in the region. Cereal crops in the Mediterranean region represent less than 10% of the land used for global cereal crop production (65.5 million ha compared to 718.1 million ha in 2014), and the Mediterranean's contribution to global production is relatively modest with under 7% of global cereal supply in recent years (FAO-Stat, 2017). In light of growing demand for cereals, food security in southern Mediterranean countries is now increasingly threatened, particularly in countries with high population growth and demand.

The MED-Amin network coordinated by CIHEAM was launched in 2014 in 13 countries to process information on cereal markets in the Mediterranean. The first Policy Brief (MED-Admin, 2016) summarised the cereal situation in the region as highly imbalanced as the region is facing strong constraints and is exposed to cereal markets reversals.

Figure 33 shows wheat import volumes between 2011 and 2013, which are some of the highest in the world (particularly for Egypt, which is the largest global importer), the self-sufficiency ratio for soft wheat, and the origin of wheat imports. The proportion of imports coming from the Mediterranean region was higher in the West than in the East for 2011-2013.

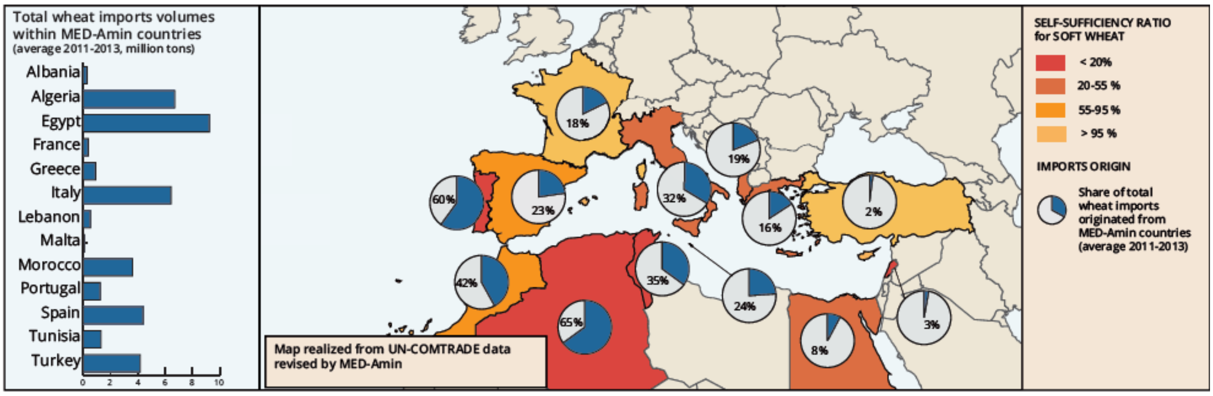

**Figure 33 Total wheat imports in Med-Amin countries**

The agricultural production deficit is primarily due to agroclimatic conditions and the scarcity of arable land and water resources[24].

Arable land is also unequally distributed across the Mediterranean, with over 46% of arable land in the North and only 31% in the South (FAO-Stat, 2018); Turkey has almost 23% of arable land. Taking into account population, the ratio of arable land per person is lower in southern Mediterranean countries with only 0.16 hectares per person compared to just over 0.20 hectares in northern Mediterranean countries.

Average rainfall in each country is another agricultural difficulty facing Mediterranean agriculture, particularly in Southern countries (Table 4).

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[23] This paragraph specifically mentions cereals given the importance of these crops in Southern and Eastern Mediterranean countries (SEMC).

[24] The Mediterranean is one of the world's regions that suffers most from water stress. Most southern countries currently abstract groundwater at a rate that is incompatible with internal freshwater renewal capacities (World Bank, 2018).

**Table 4 Land availability, rainfall and cereal crops in the Mediterranean**

| | Arable land (ha) **(2016)** | Hectares per person | Average precipitation mm per year (2014) | | | |
|---|---|---|---|---|---|---|
| | | | | Cereals (2016) | Permanent crops | Irrigated land as a % of usable agricultural area |
| Albania | 615,100 | 0.21 | 1,485 | 148,084 | 22.4 | 19.2 |
| Algeria | 7,762,100 | 0.19 | 89 | 2,207,307 | 3.1 | |
| Bosnia & Herz. | 1,029,000 | 0.29 | 1,028 | 319,265 | 20.1 | |
| Croatia | 844,100 | 0.20 | 1,113 | 527,374 | | 1.0 |
| Cyprus | 98,900 | 0.09 | 498 | 24,238 | 10.7 | 22.3 |
| Egypt | 2,895,860 | 0.03 | 51 | 3,403,715 | 2.9 | |
| Spain | 12,338,000 | 0.27 | 636 | 6,265,086 | 24.7 | 17.6 |
| France | 18,478,700 | 0.28 | 867 | 9,620,740 | 33.7 | 16.6 |
| Greece | 2,224,000 | 0.21 | 652 | 1,052,271 | 17.3 | 19.7 |
| Israel | 297,200 | 0.04 | 435 | 61,451 | 13.7 | 35.8 |
| Italy | 6,601,000 | 0.11 | 832 | 3,253,985 | 22.4 | 20.5 |
| Lebanon | 132,000 | 0.02 | 661 | 61,234 | 12.9 | |
| Libya | 1,720,000 | 0.28 | 56 | 321,232 | 1.0 | |
| Malta | 8,970 | 0.02 | 560 | 3,819 | 28.0 | 36.2 |
| Montenegro | 8,700 | 0.01 | | 2,152 | 0.6 | |
| Morocco | 8,130,000 | 0.23 | 346 | 3,804,161 | 18.2 | |
| Palestine | 64,000 | 0.01 | 402 | 24,497 | 10.6 | |
| Slovenia | 184,050 | 0.09 | 1,162 | 99,435 | 9.1 | 0.5 |
| Syria** | 4,662,000 | 0.25 | 252 | 2,244,751 | 25.4 | 9.4 |
| Tunisia* | 2,900,000 | 0.26 | 207 | 859,013 | 18.7 | 3.9 |
| Turkey | 20,645,000 | 0.26 | 593 | 11,359,619 | 26.8 | 13.6 |
| **Total** | **91,637,680** | - | - | | - | - |
| Global | 1,500,0000,000 | 0.19 | - | 718,123,234 | 11.0 | |

Source: World Bank Data, 2017 * 2016 ** 2007

Southern countries are affected by natural conditions that are generally more difficult for agriculture. Water resources are scarce and the extension of irrigated land is limited everywhere by non-sustainable agricultural practices and intensive water usage, resulting in groundwater depletion and soil salination due to lack of drainage.

In addition to these characteristics, the southern countries have major land ownership constraints, with small family farms with under 5 ha of arable land dominating the agricultural landscape.

**Imports are crucial to cover food needs**

Increased food demand and water and soil scarcity have resulted in increased dependency on imports of basic food commodities, on which many countries spend a large proportion of their export income.

Food imports represent over 20% of total trade for countries such as Montenegro (23.8%), Egypt (22.6%) and Algeria (20.6%) (WTO, 2017), with Egypt and Algeria experiencing rapid population growth, ongoing demographic transition and insufficient natural resources.

The Mediterranean is a region with some of the highest net importers of food in the world, taking into account all food products. Although France, Italy, Spain and Turkey are in the top 30 exporter countries in the world, they also feature alongside Egypt and Algeria in the list of the top 50 importer countries of agricultural and food products.

Recent changes between 1995 and 2016 have shown an increase in agricultural trade across all Mediterranean countries: both agricultural exports and imports have increased (FAO, 2018), as shown in Table 5 below:

**Table 5 Exports and imports, balance of agricultural trade (106 USD)**

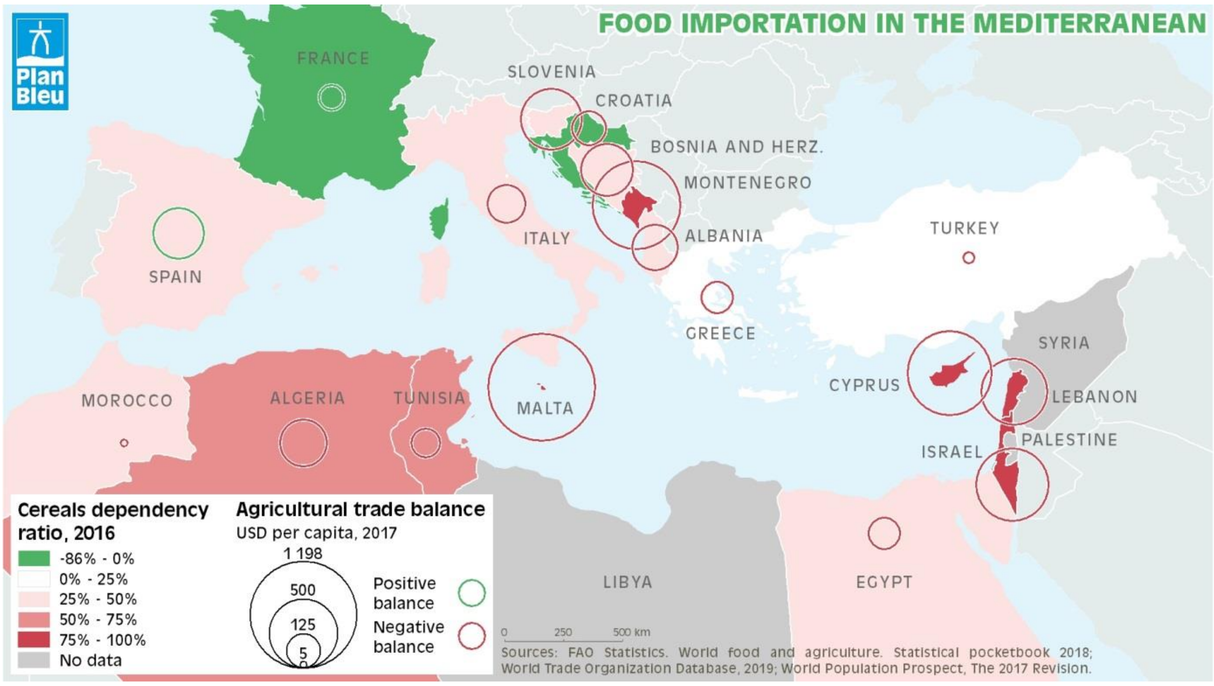
| | Exports | | | Imports | | | Balance of agricultural trade |
|---|---|---|---|---|---|---|---|
| | 1995 | 2005 | 2016 | 1995 | 2005 | 2016 | (2016) |
| Albania | 1 | 5 | 84 | 140 | 346 | 481 | -397 |
| Algeria | 92 | 86 | 373 | 2,778 | 3,455 | 7,388 | -7,015 |
| Bosnia & Herz. | 2 | 114 | 423 | 245 | 890 | 1,190 | -767 |
| Croatia | 333 | 576 | 1,484 | 683 | 1,005 | 2,113 | -629 |
| Cyprus | 212 | 160 | 296 | 272 | 456 | 702 | -406 |
| Egypt | 320 | 898 | 2,919 | 2,795 | 3,417 | 8,480 | -5,561 |
| Spain | 10,984 | 20,468 | 37,399 | 8,620 | 14,180 | 21,337 | 16,062 |
| France | 29,078 | 30,782 | 38,184 | 19,545 | 24,308 | 36,807 | 1,377 |
| Greece | 2,260 | 2,590 | 4,638 | 2,978 | 4,300 | 4,890 | -252 |
| Israel | 988 | 964 | 1,588 | 1,435 | 1,829 | 3,931 | -2,343 |
| Italy | 10,529 | 17,523 | 28,227 | 15,026 | 22,547 | 29,411 | -1,184 |
| Lebanon | 80 | 205 | 565 | 886 | 1,095 | 2,469 | -1,904 |
| Libya | 37 | 1 | 6 | 1,175 | 1,113 | 2,452 | -2,446 |
| Malta | 18 | 63 | 101 | 198 | 319 | 414 | -313 |
| Monaco | - | - | - | - | - | - | - |
| Montenegro | - | - | 30 | - | - | 404 | - |
| Morocco | 61 | 1,167 | 2,479 | 1,323, | 1,774 | 3,861 | -1,382 |
| Palestine | | | | | | | |
| Slovenia | 231 | 421 | 1,201 | 559 | 931 | 1,883 | -682 |
| Syria | 469 | 817 | 348 | 580 | 1,253 | 1,452 | -1,104 |
| Tunisia | 396 | 782 | 1,130 | 816 | 861 | 1,731 | -601 |
| Turkey | 3,530 | 6,612 | 13,571 | 2,031 | 2,361 | 7,819 | 5,752 |

Source: FAO Statistics. World food and agriculture. Statistical pocketbook 2018

**There is a large food trade deficit in the commercial balance of food products in the Mediterranean** of 36.6 billion USD (WTO, 2017).

The only Mediterranean countries with an excess agricultural trade balance are France (+3.4 billion USD) and Spain (+ 13.1 billion USD). Turkey registered a positive trade balance in 2016 of over 5.7 billion USD (FAO-Stat, 2017), but a negative balance (- 99 million USD) in 2017 (WTO, 2017).

In 2017, food import expenditure per capita varied by country. It was especially high in countries like Malta (1,198 USD per capita), Montenegro (820 USD per capita), Cyprus (738 USD per capita), Israel (547 USD per capita) and Lebanon (461 USD per capita). It is low in Tunisia (92 USD per capita), Croatia (78 USD per capita), Turkey (12 USD per capita) and Morocco (5 USD per capita) (Figure 34).



Sources: FAO Statistics. World food and agriculture. Statistical pocketbook 2018; World Trade Organization Database, 2019; World Population Prospect, The 2017 Revision.

**Figure 34 Agriculture balance and cereal dependency ratio for Mediterranean countries. Source: data from FAO Statistics and WTO, 2017** *[Figure compiling food imports and food dependency ratio, to be verified by CIHEAM-IAMM]*

**The Mediterranean basin is therefore unable to produce sufficient basic commodities for its own consumption, and the cereal deficit can be observed in all countries, except for France and Croatia.**
The Mediterranean countries received one third of global cereal imports (Abis, 2016): Algeria and Egypt are some of the largest wheat importers in the world and their deficit is likely to increase due to a failure to diversify food intake and population growth.
Wheat is the traditional basic food staple in the Mediterranean region and its consumption per capita currently stands at approximately 200 kg per person per year, around 60 kg more than the global average (OECD-FAO, 2018). Wheat is one of the most internationally traded food commodities, with demand concentrated in North Africa and the Middle East. In 2014, SEMCs spent almost 10 billion USD on wheat (3.5 times expenditure in 2000), and half of this import expenditure was for durum wheat (IPEMED, 2017).
The cereal import dependency ratio is especially high in this region, with the exception of France and Croatia (export countries) and Turkey (which only imports 4%), as shown in Table 6 below:

**Table 6 Cereal Import Dependency Ratio in the Mediterranean. Source: FAO Statistics. World food and agriculture. Statistical pocketbook 2018**

| Country | Cereal import dependency ratio (%) in 2016 |
|---|---|
| Albania | 40.2 |
| Algeria | 72.2 |
| Bosnia & Herz. | 37.0 |
| Croatia | -11.6 |
| Cyprus | 100 |
| Egypt | 42.1 |
| Spain | 31.8 |
| France | -86.3 |
| Greece | 18.2 |
| Israel | 93.2 |
| Italy | 25.3 |
| Lebanon | 86.5 |

| | |
|---|---|
| Libya | N/A |
| Malta | 92.8 |
| Montenegro | 91.4 |
| Morocco | 42.1 |
| Slovenia | 36.9 |
| Syria | N/A |
| Tunisia | 59.7 |
| Turkey | 4.0 |

*Negative values mean that the country is a net exporter of cereals
N/A: data unavailable

UN forecasts for 2050 predict that North Africa and the Middle East will remain the world's most cereal import-dependent region, with a deficit of up to 140 million tonnes (FAO Forecasts 2030/2050).

The contribution of national agriculture, and especially family farms, must not be overlooked. Crop and livestock systems on small family farms make a significant contribution to ensuring the food intake of rural households, including the farmers themselves, and help provide a diet suited to local tastes and the varying purchasing powers of urban households for some products (Marzin *et al.*, 2016). There is a clear link between food security in rural regions and the presence of small family farms to offset necessary imports. In Lebanon, in 2010, around 85% of agricultural products consumed were imported and over one third (37%) of farmers used their production primarily for their own consumption and food security. In North Africa, family farms supply fruit and vegetables to local rural souks, unpasteurised milk to dairy collectors and cooperatives, and contribute to the food security of agricultural households and local populations by eating their produce themselves (wheat, potatoes, eggs, milk, meat, etc.) or supplying domestic markets.

However, food security in the Mediterranean is closely dependent on the international trade of agricultural products. In the future, the region will need to manage uncertainty in terms of both supply and demand. For example, wheat supply is uncertain due to limitations associated with the sustainability of land areas suitable for production and highly exposed to climate change (FAO, 2018).

**Box 4 Impacts of climate change on agricultural production**

Food production in the Mediterranean region is changing rapidly, due to multiple local and global social and environmental changes. Food demand in areas unsuitable for agricultural production and with great water restrictions is increasing. The capacity to cope with these challenges is limited. For example, water reserves were not able to cope with extensive droughts in the last two decades in Spain, Morocco and Tunisia, causing losses in the irrigation dependent agricultural systems (Ponti *et al*, 2014).

Climate change has significant impacts on the sustainability of food production, soil and water use. In terms of crop yield, large uncertainties and high local-to-regional differences exist (Fraga *et al*., 2016; Funes *et al*., 2016). Warmer and drier conditions reduce the duration of the growing period and increase irrigation demand (Arbex de Castro Vilas Boas *et al*., 2017).

Livestock production systems play a central role in climate change and agriculture due their productive, environmental and social functions (Bernues *et al*., 2012; Herrero *et al*., 2013a). Currently, the Mediterranean region is characterized by mixed production system in the northern regions and in some southern ones, while grazing systems dominate the southern regions (Herrero *et al*., 2013b). The number of agricultural holdings with grazing livestock is in decline (but associated with an increase of animals per farm) (Bernues *et al*., 2011). The abandonment of marginal land threatens the future of these pasture-based systems. Transition to mixed crop-livestock system could help in reducing climate adaptation costs and increase resilience to climate extremes in the Middle East and North Africa (Weindl *et al*., 2015). In these regions, livestock units have increased by 25% from 1993 to 2013; however, the consumption growth has led to an animal food and feed import of around 32% of the total food import in 2014 and continues to increase (FAO 2016). The impacts of climate change on production potential, combined with the growing demand of animal products will increase the food import dependence of the south Mediterranean countries in the coming decades (estimated at around 50% for all food products in the Maghreb INRA 2015).

Overall, expected climate and socio-economic changes pose threats for food security in the Mediterranean region. These pressures will be not homogeneous across the region and sectors of production, creating further regional imbalances and trade disputes. Sustainability of food production represents an issue in unfavorable climate and socio-economic conditions.

### 6.3.3.2 Access to food: rural populations are more exposed to poverty and food insecurity

**One of the main factors in food insecurity is limited access to food for physical (lack of infrastructure, markets, etc.) or economic reasons (limited purchasing power, rising domestic prices, etc.).** Ensuring food security requires first and foremost adequate means of subsidence and standards of living. In the Mediterranean region, the situation is different between the North (EU) and the SEMC. The global economic, financial and food crisis of 2008 increased the impoverishment of entire sections of society, including in the European Union, especially in Mediterranean countries, accentuating economic difficulties in local economies and societies, especially among the most fragile populations (poverty, food insecurity, lack of social infrastructure and public services, etc.).

**Food insecurity returned to certain population segments, especially in rural areas, even in Europe.** Despite increasing urbanisation in the region, there is still a large rural population. Major territorial divides are forming between rural and marginalised zones (mountains, desert areas, etc.), and big cities and coastal areas. Alongside poor urban populations, statistically, rural populations are more affected by poverty and food insecurity. It is paradoxical that smallholder farmers, who produce their own food, are highly vulnerable to food insecurity. Nevertheless, this is the case, especially when they are not connected to markets, live in isolated rural areas and hold multiple jobs (with numerous professional activities requiring them to migrate to find work, often within the same country); an estimated 50% of agricultural households hold multiple jobs (Marzin *et al.* 2016).

**Statistics show that poverty rates are generally much higher in rural areas, where the agricultural sector is dominant, than in big cities.** Comparing socio-professional categories shows that agricultural workers and farmers are some of the poorest populations, and that the poverty rate varies significantly from one region to another within each country (Marzin *et al.*, 2016). The relationship between poverty, the unemployment rate and wages needs further assessment. In Egypt, the unemployment rate is lower in rural areas than in urban areas (7% compared to 11.7%), but poverty remains, on average, higher in rural than in urban areas (28.9% compared to 11.6%).

Young people are losing interest in agricultural jobs and rural activities for many reasons, including precarious and seasonal work, informal employment contracts, limited access to social security and other benefits, difficult working conditions, low wages and a poor social status (Mediterra, 2019). Cities are attractive due to real or supposed attractions (opportunities for work and independence, infrastructure, services, etc.). With little or no skills, capital, access to credit and land, rural young people have very limited opportunities. Migration from the countryside to cities is a strategy intended to improve the life of households through material and immaterial transfers from migrants, and constitutes a lever of local development, but also compromises the attractiveness of rural regions, particularly for young people. It also deprives the agricultural and agri-food sectors of necessary human capital.

In Mediterranean countries, intra-family and inter-generational solidarity within households (gifts, shared meals) still effectively contributes to preventing food vulnerability and collective social insecurity, particularly for rural populations.

At a political level, social protection (in the EU) and public subsidies for commodities (in SEMC) or social safety nets, help to mitigate food price increases and improve purchasing power to a certain extent. However, these policies are also limited, as demonstrated by the food riots of 2007-2008

(Egypt, Morocco) and more recent social unrest associated with purchasing power (France, Greece, Italy, Tunisia, etc.).

Public action associated with rural development policies (construction of community infrastructure, improved public services, job-creation and income-generating programmes, etc.) often fail to meet expectations. The issue of social protection, social insurance and pensions for smallholder farmers, and social assistance is currently emerging in some southern Mediterranean countries (Egypt, Lebanon, Morocco, and Tunisia).

#### 6.3.2.3 Nutrition, quality and use of food: the end of the Mediterranean diet?

Despite the Mediterranean Diet's inclusion on the UNESCO Intangible Cultural Heritage of Humanity list in 2010 and its worldwide reputation, one may wonder if the Mediterranean diet still exist in practice. The Mediterranean diet is more than just the high consumption of fruit, vegetables and legumes, moderate consumption of dairy products (cheese and yoghurt), low to moderate consumption of seafood and poultry, and low consumption of red meat, with olive oil as the main fat (Hachem *et al.*, 2016). More broadly, this notion covers a way of living and eating associated with social norms, traditions for preparing and eating meals, a certain frugality, social dining, the practice of moderate physical activity and adequate rest.

Food products from smallholder farming are more suited to these dietary traditions (cereals, olive oil, dairy products, etc.) and the Mediterranean diet persists better in rural areas. However, the transition towards high-energy diets with large amounts of animal protein, fats and refined cereals has accelerated in recent decades. The Mediterranean diet has been gradually abandoned due to urbanisation, changes to food distribution, the globalisation of markets and cultural models, and the relative prosperity of Mediterranean countries. Family and social structures have been transformed, moving from an extended family model where passing down culinary knowledge was encouraged, to a family model where this know-how has been lost. The role of women traditionally centred on preparing meals in patriarchal Mediterranean societies, is changing with their entry onto the employment market, and lifestyles are being transformed. In cities, major retailers are taking over from local shops, and fast food chains are thriving. Even the reputation of the Mediterranean diet's healthy model has worked against it, by promoting olive oil exports to rich countries that did not traditionally consume it (North America and Northern Europe, Japan, Australia, etc.) and replacing it with cheap vegetable oils in diets in the producing countries (SEMC).

The abandonment of the Mediterranean diet has resulted in a loss of sustainability with both environmental and nutritional impacts, including increased pressure on the environment for food production, a larger environmental footprint, loss of biodiversity and increased food waste... In many Mediterranean countries, a double or triple nutritional burden can be observed, with the combination of undernutrition, overeating (obesity and non-transmissible diseases) and nutritional deficiencies.

The most recent United Nations data (FAO, MAP, IFAD, UNICEF and WHO; SOFI 2018) show **a worrying increase in the number of people who are overweight or obese between 2012 and 2016 in all Mediterranean countries** (Figure 35). In 2016, the rate of obesity among adults exceeded 30% in Eastern Mediterranean countries (Egypt, Lebanon, Libya, Malta, and Turkey). It is lower in the Balkans, but still in excess of 20% (except in Bosnia & Herzegovina), leading to increased public health risks (cardiovascular diseases, type-2 diabetes, metabolic syndrome).

**Although undernourishment, emaciation and stunted growth in children under 5 have almost disappeared in the region (excluding countries in conflict and, to a lesser extent, Egypt and Lebanon), nutrition security is not fully guaranteed in the Mediterranean.**

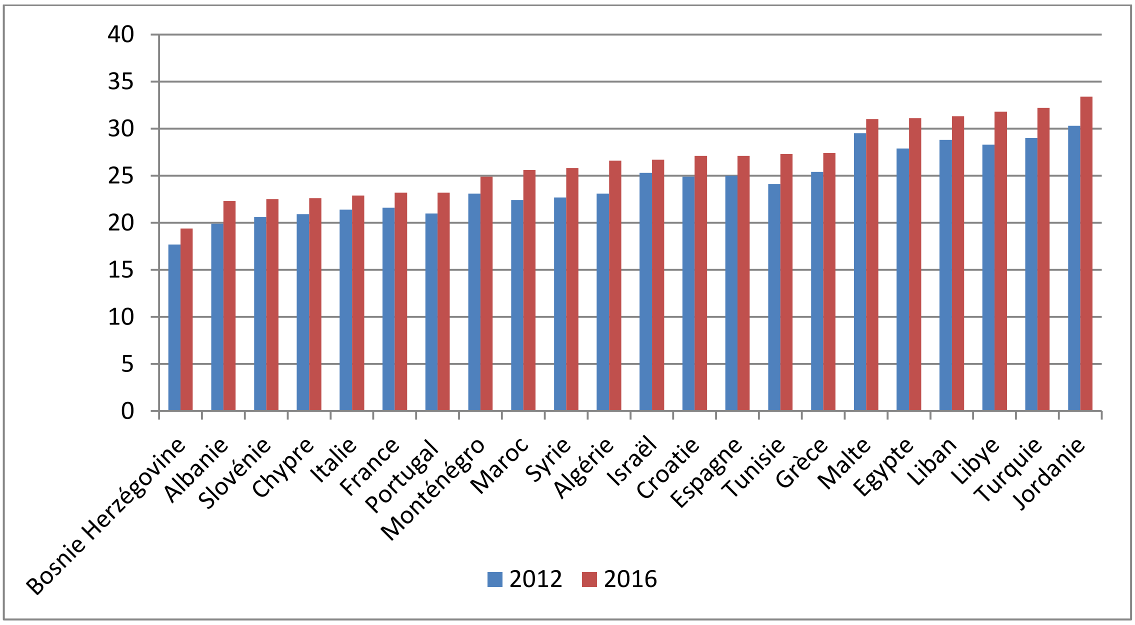


**Figure 35 Prevalence of obesity in adults (18 and over) in %. Source: SOFI data, 2018**

In addition to problems associated with overweight, nutritional deficiencies can be observed, including iron deficiency in women of childbearing age. **Anaemia increased in all Mediterranean countries between 2012 and 2016, except in Egypt** (Figure 36)**.** It exceeds 30% in Algeria, Lebanon, Libya, Morocco, Syrian Arab Republic, Tunisia and Turkey.

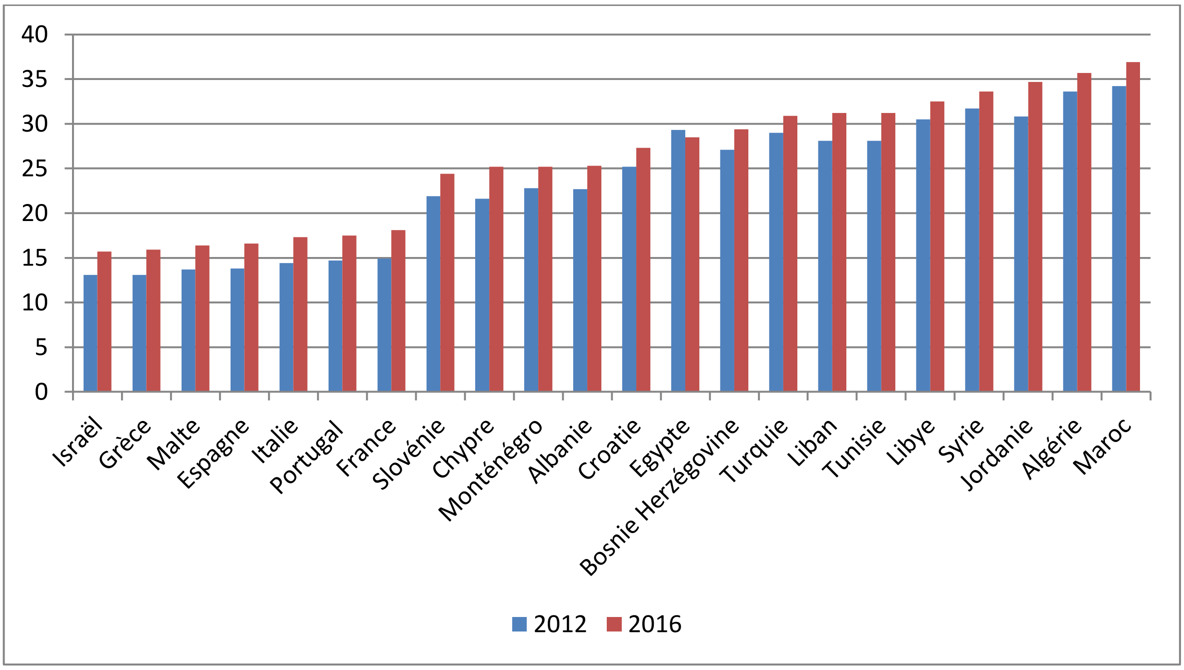


**Figure 36 Prevalence of anaemia in women of childbearing age (15-49 years). Source: SOFI data, 2018**

**Although food safety has generally improved in recent decades** with the rise of globalisation and major retailers, nutritional quality is somewhat lacking, with less food diversity, reduced consumption of local and seasonal products, the loss of traditional recipes and know-how for conservation. However, since the 1990s, citizens' movements have promoted short circuits and food that is local, organic or produced through responsible farming. Initiatives have been taken to teach young people about food (and not just nutrition).

### 6.3.2.4 Stability: conflicts and climate change are hampering food security in the Mediterranean region

Finally, the “stability” pillar in food security presumes that populations have more or less guaranteed stable access to adequate food, based on relatively regular supply. This dimension could be among the greatest challenges for food security in the Mediterranean region now and in the future. Three major factors are at play to weaken the stability of food supply.

Firstly, due to population growth, particularly in the South, and the natural limitation of agricultural production, **the region is highly dependent on international markets and therefore exposed to their volatility.** This volatility has been under relative control since 2012 thanks to several world records in cereal production especially, but this situation may not continue in the future. FAO-OECD estimates show that the price volatility of global agricultural products is likely to increase or remain high in the future. It is also highly dependent on the political decisions of the major producing countries (export restrictions or bans, closure of markets, etc.). The current uncertain geopolitical context challenges the sustainability of supply from world markets, as demonstrated by recent incidents (export taxes in Argentina, rumours of restrictions on Russian wheat exports that impacted the global wheat market, etc.). On the demand side, instability of the global markets for oil and other commodities, and exchange rate fluctuation (particularly with the US Dollar) are an economic risk factor for dependent countries, their external revenues and purchasing capacities.

**The second factor to take into account for the stability pillar is political instability, crises and conflicts.** Food security in the Mediterranean has deteriorated rapidly in recent years due to conflicts in several countries. The FAO (Regional Report, 2017) considers that in countries in the Middle East and North Africa directly affected by conflicts, 27.2% of people suffered from chronic hunger or undernourishment in 2014-2016. That is six times higher than the proportion of the undernourished population in countries not affected by conflicts (4.6% on average). For example, the prevalence of undernourishment in Libya or Syrian Arab Republic is similar to the Least Developed Countries (LDCs). “Acute food insecurity” is currently twice as high in countries in conflict than in countries not affected by unrest. The Syrian Arab Republic and Libya are no longer able to cover their needs and are affected by severe food insecurity. A recent FAO warning note (December 2017) identified severe localised food insecurity in Libya, with 6% of people requiring external assistance for food. “The number of people in need of food assistance is estimated at 0.4 million, with refugees, asylum seekers and internally-displaced among the most vulnerable. Food shortages are reported mostly in the South and East where basic food items are in short supply. Access to subsidized food among the affected population is limited.” In the Syrian Arab Republic, violence led to a 67% drop in the Gross Domestic Product (GDP) and has seriously compromised food security. According to FAO estimates, 70% to 80% of Syrians are currently in need of humanitarian aid, with 50% requiring food assistance. The report mentions an exceptional deficit in production and food availability. The ongoing conflict has already placed approximately 6.5 million people in a situation of food insecurity, with an additional 4 million people at risk of food security. Despite international food assistance, Syrian refugees are putting a strain on host communities in neighbouring countries (Lebanon & Turkey).

Food security and instability are interlinked in a vicious circle: food insecurity, the increased price of basic food commodities, and especially bread, is often the source of food riots and unrest, which sometimes leads to political instability. Drought also reduces agricultural production, resulting in higher food prices, which can also be one of the causes of popular rebellions. Conversely, conflicts drastically increase food insecurity, in a region where chronic hunger ordinarily affects less than 5% of the population.

**Finally, climate change is the third factor to take into account in the medium- to long-term.** It has already had an impact on food production in the Mediterranean (see Chapter 2). Agricultural production could fall dramatically due to a global increase in temperatures, prolonged periods of drought and extreme climate events. According to the World Bank report (2014) entitled “Turn down the heat: confronting the new climate normal”, by 2050, cereal yields in Egypt and the region could fall by 30% due to a 1.5°C temperature increase. The stability of food supply is already fragile, and if disturbed, could have very troubling social and political consequences.

In conclusion, it is important to fight on all fronts and all pillars of food security, particularly to strengthen the resilience of the populations most at risk of food insecurity (poor urban households, young unemployed, smallholder farmers and rural residents). Better, more inclusive governance and global, consistent and specific policies need to be implemented to achieve SDG 2 and the Zero Hunger objective by 2030.

## 6.4 Responses and priorities for action

### 6.4.1 Water demand management

Water Demand Management (WDM) aims to encourage better use of existing water supply - through efficient and cost-effective management - before considering an increase in supply. It includes all the interventions and organizational systems intended to increase the technical, social, economic, environmental and institutional efficiency in the different sectors of water use (intra-sectoral efficiency) but also for a better allocation of water between different uses (inter-sectoral efficiency). This concept of WDM was developed in the 1990s in response to water supply development policies in the agricultural sector in particular.

It is based on the implementation of a combination of actions and tools (legislative, institutional, technical, economic, *etc*.) such as the reduction of leaks, the use of water-saving equipment, the establishment of progressive pricing of water, environmental taxes, quotas, water rights or payments for environmental services.

Economic valuation also suggests that WDM measures are often cost-effective and allow for a better allocation of scarce financial resources, when compared to, for example, dam construction, water transfers or desalination in areas facing problems of water scarcity. This underlines the importance of developing the use of cost-benefit or cost-effectiveness analyses comparing several water management options, by internalizing, as much as possible, the cost of the social and environmental impacts of the different options. These analyses represent real tools for decision support.

**Box 5 Examples of progress made toward water efficiency and sensible management of demand in Mediterranean countries** *[Box to be completed]*

In a coastal area such as the Nile Delta, the productivity and efficiency of water in agriculture is being significantly improved using technologies like the construction of raised growing beds facilitating irrigation. This system reduces water inputs by 30%, while improving yield by 25% and efficiency by 72%.

In Tunisia, conservation agriculture trials were conducted with French research services and the French Development agency (AFD) and showed that changes in farming practices can stop erosion and improve resilience to drought. Water does not destroy, but builds because it infiltrates the soil and recharges the water table.

There is no example on a very large scale in the Mediterranean, but it exists elsewhere. In Ethiopia, for example, in twenty years, the water table previously fallen at 30 m depth has been recovered to less than 3 meters. Poverty has been halved simply by better managing all vegetation, soil and water.

### 6.4.2 Integrated Water Resources Management

As presented throughout this chapter, water security entails issues of ecosystem and human health, tackles issues of water quantity and quality, and questions water governance arrangements. However, water security is not a ready-made operational concept yet. A first step in the introduction of this concept in its entirety is the promotion and assessment of integrated water resources management (IWRM). IWRM is defined as “a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment” (GWP 2000). In line with this definition, integrated frameworks were developed to address water resources and demand relationships and their evolution under climatic and anthropogenic changes, and promote dynamic water resources and demands management. These modeling tools evaluate the hydro-climatic conditions of catchments in the first place and then water demands to finally assess water stress or water allocation rates under climatic and anthropogenic changes.

Therefore, regional integrated frameworks are useful to identify the areas that are most likely to be under pressure and to explore the capacity of regional sustainable development strategies to reduce water tensions. However, water management decisions are more often made at the river basin scale. Sub-regional decision support systems were then developed like the models WEAP (Yates *et al.*, 2005), REALM (Perera *et al.*, 2005), Aquatool (Andreu *et al.*, 1996) or the generic method for Mediterranean catchments developed by Plan Bleu in partnership with HydroSciences Montpellier laboratory (Milano *et al.*, 2013b). Developed for catchment-scale studies, these tools provide a detailed spatial and temporal description of water and land use, water supply and demand sites relationships, dam operating systems or even local institutional instruments. They hence provide better insights on local water issues and on the effectiveness of adaptation policies or techniques. They are also useful to identify the most vulnerable regions to climatic and/or anthropogenic pressures as well as sectors and seasons during which water shortage might occur.

The development of integrated approaches on water resources reflects the spatial variety of pressures and availability. It also supports, at a local level, the consideration of which sustainable development strategy to adopt according to the geographical and anthropogenic specific issues of the area.

### 6.4.3 Integration of the WEF nexus

Delivering water, energy and food for all in a sustainable and equitable way, while preserving the health of the natural systems that form the basis of any economic activity, is one of the major challenges that the Mediterranean countries face. Traditionally, these sectors have been dealt with separately in their management and investment planning, with separate strategies, priorities, infrastructure, and regulatory and institutional frameworks to address sector-specific challenges and demands. During the past decade, it is being increasingly realised that in a traditional fragmented approach, attempting to achieve the security in one of these sectors without addressing trade-offs with the other two sectors will endanger their sustainability and security. Overall security can be achieved by creating intelligent synergies and fair trade-offs among them, while providing opportunities for innovation and learning to minimise security risks and enhance resource efficiency and equity.

This rationale led to the "Water-Energy-Food-Ecosystems Nexus approach", moving beyond the traditional sectoral thinking and adopting an integrated approach for the water-energy-food sectors, to assess interlinkages as well as existing or potential synergies and trade-offs among them, with a view to reconciling their interests and resolving conflicts as they compete for the same scarce resources, while respecting environmental constraints as well as human rights, and exploring emerging opportunities. Such an approach requires enhanced technical assessment, policy dialogue, governance improvements, mobilization of financing, replicable applications, collaboration and coordination.

**In order to fully capture the benefits and synergies under a Nexus approach, the development and management choices in the water-energy-food sectors require enhanced integration at the knowledge, policy, legislative and institutional levels/frameworks**.

The current, commonly uncoordinated governance settings and policies, constitute an impediment in addressing issues related to the management and security of the Nexus resources at the national and regional levels. Most governments have separate agencies to oversee water, energy, and agricultural food production, and they set policies and plan for each sector separately. The same is also true, to some extent, of research on these issues: expertise on energy, water and land use is clustered in separate groups, with limited interaction.

However, there are increasingly evident on-going efforts at the governmental level in the Mediterranean Region for the coordination of actions across the water, food, energy and environment sectors and the achievement of integration at the level of planning and implementation of actions, even though some ministries or sectoral institutions often have the stronger leverage and decision-making power.

At the institutional level, Table 7 presents a mapping of the nexus-related competencies of the relevant Ministries in all Mediterranean countries.

**Table 7 Mapping of Nexus-related Ministerial Competencies in the Mediterranean (Source: GWP-Med)**

<table>
<tr><th>Country</th><th>Environment</th><th>Energy</th><th>Water</th><th>Agriculture</th><th>Nexus Integration of Ministerial competencies</th></tr>
<tr><td><b>Spain</b></td><td colspan="3">Ministry for the Ecological Transition</td><td>Ministry of Agriculture, Fisheries and Food</td><td>Environment, Energy, Water</td></tr>
<tr><td><b>France</b></td><td colspan="2">Ministry for the Ecological and Inclusive Transition</td><td><i>Cross-ministerial</i></td><td>Ministry of Agriculture and Food</td><td>Environment & Energy (and partially water)</td></tr>
<tr><td><b>Italy</b></td><td>Ministry for Environment, Land and Sea Protection</td><td>Ministry of Economic Development</td><td>Ministry for Environment, Land and Sea Protection</td><td>Ministry of Agriculture, Food and Forestry Policies</td><td>Environment & Water</td></tr>
<tr><td><b>Slovenia</b></td><td>Ministry of Environment and Spatial Planning</td><td>Ministry of Infrastructure</td><td>Ministry of Environment and Spatial Planning</td><td>Ministry of Agriculture, Forestry and Food</td><td>Environment & Water</td></tr>
<tr><td><b>Croatia</b></td><td colspan="2">Ministry of Environmental Protection and Energy</td><td colspan="2">Ministry of Agriculture</td><td>Environment & Energy; Water & Agriculture</td></tr>
<tr><td><b>Bosnia and Herzegovina</b></td><td>Ministry of Environment and Tourism</td><td>Ministry of Energy, Mining and Industry</td><td colspan="2">Ministry of Agriculture, Water-Management and Forestry</td><td>Agriculture & Water</td></tr>
<tr><td><b>Montenegro</b></td><td colspan="2">Ministry of Sustainable Development and Tourism</td><td colspan="2">Ministry of Agriculture and Rural Development</td><td>Environment & Energy; Water & Agriculture</td></tr>
<tr><td><b>Albania</b></td><td>Ministry of Tourism and Environment</td><td>Ministry of Infrastructure & Energy</td><td>National Water Authority</td><td>Ministry of Agriculture and Rural Development</td><td>-</td></tr>
<tr><td><b>Greece</b></td><td colspan="3">Ministry of Environment and Energy</td><td>Ministry of Agriculture</td><td>Environment, Energy, Water</td></tr>
<tr><td><b>Malta</b></td><td colspan="4">Ministry of Environment, Sustainable Development, and Climate Change</td><td>All</td></tr>
<tr><td><b>Cyprus</b></td><td>Ministry of Agriculture, Rural Development and Environment</td><td>Ministry of Energy, Commerce, Industry and Tourism</td><td colspan="2">Ministry of Agriculture, Rural Development and Environment</td><td>Environment, Water, Agriculture</td></tr>
<tr><td><b>Turkey</b></td><td>Ministry of Environment and Urban Planning</td><td>Ministry of Energy and Natural Resources</td><td colspan="2">Ministry of Agriculture and Forest</td><td>Agriculture & Water</td></tr>
<tr><td><b>Lebanon</b></td><td>Ministry of Environment</td><td colspan="2">Ministry of Energy and Water</td><td>Ministry of Agriculture</td><td>Energy & Water</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| **Israel** | Ministry of Environmental Protection | Ministry of National Infrastructure, Energy and Water Resources | | Ministry of Agriculture and Rural Development | Energy & Water |
| **Palestine** | Environmental Quality Authority | Palestinian Energy and Natural Resources Authority | Palestinian Water Authority | Ministry of Agriculture | - |
| **Egypt** | Ministry of Environment | Ministry of Electricity and Renewable Energy | Ministry of Water Resources and Irrigation | Ministry of Agriculture and Land Reclamation | - |
| **Libya** | Ministry of Health & Environment | Ministry of Electricity & Renewable Energy | Ministry of Water Resources | Ministry of Agriculture, Animal and Marine Wealth | - |
| **Tunisia** | Ministry of Local Affairs and Environment | Ministry of Energy, Mines and renewable Energies | Ministry of Agriculture, Hydraulic Resources and Fisheries | | Agriculture & Water |
| **Algeria** | Ministry of Environment and Renewable Energies | Ministry of Energy | Ministry of Water Resources | Ministry of Agriculture, Rural Development and Fishing | Environment & Energy (only regarding renewables) |
| **Morocco** | Ministry of Energy, Mines and Sustainable Development | | Ministry of Public Works, Transportation, Logistics and Water | Ministry of Agriculture, Maritime fisheries, Rural Development, Water and Forests | Environment & Energy |

**Box 6 Water-Energy-Food nexus: policy recommendations for the Euro-Mediterranean research agenda from the MedSpring project**

The MedSpring Project (Mediterranean Science, Policy, Research & Innovation Gateway, 2013-2017, -www.medspring.eu) – aimed to contribute to the quality of the Euro-Mediterranean research area, with a special focus on bi-regional Euro-Mediterranean Scientific & Technological (S&T) cooperation, Research & Innovation (R&I), policy dialogue and cooperation monitoring. MedSpring has gained insight into the Nexus, based on the involvement of the scientific community and of the civil society, by investigating the relationship between research and innovation and the real needs of the civil society in the frame of the three societal challenges, i.e. water, food, and energy.

Experts have agreed on the following policy recommendations to support the identification of priorities and guide national and EU decision/policy makers in designing ad-hoc initiatives/calls addressing the Nexus:

1. Integrating the Nexus concept in all relevant policies, laws and regulations by:

- Promoting participatory policy making through multilevel and participatory networks/fora;
- Mapping and assessing existing national sectoral policies to develop an integrated Nexus strategy including effective implementation and monitoring plans;
- Promoting the definition and implementation of a Euro-Mediterranean strategy on Nexus.

2. Increasing Nexus awareness and dissemination among relevant stakeholders through:

- Multidisciplinary training and capacity building activities;
- Dissemination of success stories, initiatives, good practices and innovative technologies;
- Including Nexus-related principles and concepts in educational systems;
- Creating a Euro-Mediterranean platform (gathering MedSpring EMEG experts and additional players) for trans-boundary exchange and transfer of best practices.

3. Increasing funding for multidisciplinary and integrated research projects and initiatives, and promoting cooperation between public and private sectors through targeted funds and incentives.

In conclusion, adopting the Nexus approach on a large-scale, system-wide manner is challenging because of the still limited knowledge of how food, water and energy systems operate and interact. National and international policies should go beyond the isolated resource management approach and support deep understanding on how the water-energy-food systems and processes overlap. These steps should be combined with forward-looking policies and regulations encouraging cooperation among citizens, research bodies, governments and industry so that all decisions taken are sustainable and legitimate.

**Box 7 The PRIMA initiative** *[Box to be developed and illustrated]*

The Partnership for Research and Innovation in the Mediterranean Area (PRIMA, 2018-2028) is a joint programme focused on the development and application of solutions for food systems and water resources in the Mediterranean basin. To date, 19 countries committed to the initiative (Algeria, Croatia, Cyprus, Egypt, France, Germany, Greece, Israel, Italy, Jordan, Lebanon, Luxembourg, Malta, Morocco, Portugal, Slovenia, Spain, Tunisia and Turkey). The partnership will be financed through a combination of funding from PRIMA Participating States (currently €274 million), and a €220 million contribution from the EU through Horizon 2020, its research and innovation funding programme (2014 – 2020).

**Box 8 Chrichira case study - The principle of energy economy and recovery of energy lost in water pumping** *[Box to be updated]*

**CHRICHIRA in the Kairouan area, an example in the Water Energy Nexus in Tunisia, with SONEDE and United Nations ESCWA (Economic and Social Commission for Western Asia)**

In all drinking water systems, much energy is spent for pumping, to raise water in water towers and reservoirs on a high point. When the water goes down, the potential energy is not used, and is lost. The aim of this Pilot Initiative of Chrichira was to reduce the electrical energy purchased for pumping and conveying water throughout the municipal water transmission system. For that purpose, SONEDE had devised a preliminary plan to optimize piping layout to improve system efficiency and install a hydroelectric micro turbine to generate electricity from hydraulic energy harnessed due to elevation differences.

ESCWA provided the technical and advisory support needed to assess the proposal suggested by SONEDE from both the technical and financial perspectives and assist in the preparation of technical specifications to initiate the project tender. The main Stakeholders in Tunisia, are: the Ministry of Agriculture, Water Resources and Fisheries; National Water Distribution Utility (SONEDE), and National Agency for Energy Efficiency (ANME). This initiative followed regional priorities related to the Water Energy Nexus of: informing technology choices, ensuring availability and sustainable management of water, promoting renewable energy and increasing efficiency.

The Kairouan region is located at the center of Tunisia, 150 km southwest of Tunis. The study area includes an elaborate water extraction and conveyance system supplied by water from two main aquifers, the Chrichira and the Bouhafna. The collection network consists of 27 boreholes along with a transmission network of about 226 km of pipes of different diameters, allowing the production and transmission of nearly 1000 l/s (year 2015) for drinking water supply in the governorates of Kairouan, Sousse, Monastir and Mahdia. Water pumped from boreholes is collected in reservoirs and redirected to load breakers to dissipate excess energy in the piped network.

**Figure 37 Water pressure dissipation using a load breaker**

The financial assessment proved the proposed micro-hydro system feasible with a reduction in electrical energy purchased, and a return on investment for the envisaged project achieved in less than 3 years. Based on assessment outcomes, installing hydroelectric micro turbines in water transmission systems of favorable technical conditions may present a very promising energy resource within the context of the water-energy nexus. From the study conducted for the case of Chrichira, conclusions and general recommendations are to be drawn for other projects in drinking water networks:

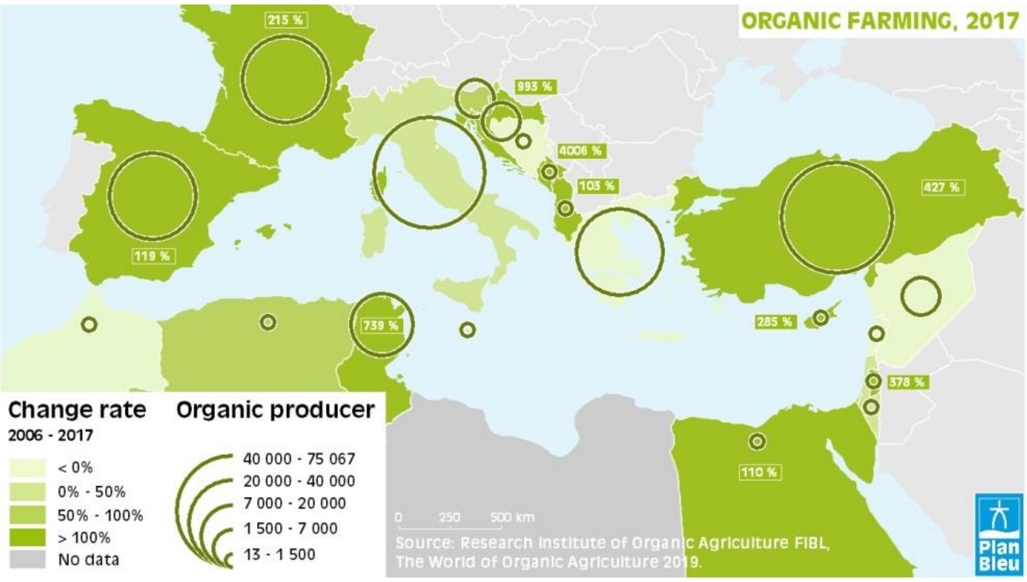
- There is no unique solution, one must adapt to each context and each situation.
- First look for energy savings on pumping, by hunting for the least useful expenses. Do not pump unnecessarily to excessive and unnecessary heights, Avoid over-sizing pumps.
- Research the technical variants best adapted to each situation, a first choice of technical solution, followed by a thorough optimization in dialogue with the suppliers of the equipment, (eg. fixed flow, variable flow, or combination of two turbines or PaT).
- After having chosen a turbine or pump according to the data of the studied site (height of fall and flow), do not hesitate to **make a second phase of optimization** according to the available equipment (adaptation of the flow of water in exploitation to a specific pump, to aim the optimum of operation if it is possible).
- **In the choice of equipment, take into account the human dimension and corporate culture** (for the know-how in operation and maintenance, the needs in capacity building and training). For example, "pump as turbines" are well adapted to the case of SONEDE, which already manages a large number of pumps.

### 6.4.4 Agroecological transition and sustainable agriculture

*[Section to be completed including examples of soil and water conservation practices implemented in the Mediterranean]*

Considering agriculture as a producer of various services – besides food production only – would facilitate the transition towards a more sustainable agriculture.

Target 2.4 calls for the development of sustainable food production systems and implementation of resilient agricultural practices that increase the productivity and production, help maintain ecosystems, strengthen the capacity for climate change adaptation and progressively improve land and soil quality. This should be measured based on the proportion of agricultural area under productive and sustainable agriculture, considering the three dimensions of sustainability - environmental, economic and social. Between 2006 and 2017, the number of organic farms has highly increased in Croatia, Egypt, France, Slovenia, Spain, Tunisia and Turkey (Figure 38).



Source: Research Institute of Organic Agriculture FIBL, The World of Organic Agriculture 2019.

**Figure 38 Change in the number of organic farms in the Mediterranean countries** *[Figure to be revised]*

Better soil management would result in their enrichment in organic matter, through agroecology, irrigation and land protection *[paragraph on soil conservation to be completed]*.

## 6.4.5 Rural development and smallholder farming

*[Section to be completed]*

**The development of decent living conditions for residents in rural areas remains a necessary condition to ensure food security and even security itself.** It is no longer enough to increase agricultural productivity to improve food availability, or to bring in foreign currency through exports to solve the problem of food security. Instead, opportunities for decent jobs and incomes need to be provided to millions of people to avoid internal and external migration, despair, radicalisation and conflicts. Collective organisations (rural markets, farmer organisations, local value chains, infrastructure, distribution, new services) need to be developed with new initiatives from citizens.

**The link between food quality and the geographical location of farmland has been studied closely for the past thirty years.** For example, the development of geographical indicators for farmland and local know-how has shown how local development can support food security. Capitalising on local food experience can be a development strategy via tourism, local value chains and the promotion of distinctive high-quality products on niche markets. This would generate income in rural areas, and help preserving biodiversity and conserving traditional processes, agricultural practices and know-how in order to preserve recipes and products in accordance with the dietary preferences of populations and their identity.

**Although** the role of women in eating habits in Mediterranean households is recognised, and improving agricultural practices and production can help improve the nutrition of family members, including children, the causal link is not currently systematically virtuous (Dury *et al.*, 2015). **The involvement of women is important as "they are the nucleus of the Mediterranean family unit**, making them the best educators in terms of food and health" (Agropolis Fondation, 2011: CIHEAM, 2018). Food policies to achieve food and nutrition security for children, that link schools and organisations of women representing their double function of producers and mothers, should be tested as they may bring about progress. Many women now work in the production, processing and sale of local products, working within women cooperatives, such as in Algeria or Lebanon. The number of businesses led by women who produce and sell traditional food has increased significantly in the past twenty years in Algeria, Egypt, Lebanon, Morocco, and Syrian Arab Republic (Hachem *et* *al.*, 2016). **Supporting the emancipation of women therefore benefits both the local economy and food and nutrition security, especially for children.**

### 6.4.6 Climate change adaptation

*[Section to be completed with info on centralisation vs. decentralisation, adapted financial services, crisis management and prevention, enhancing resilience]*

MENA countries have acceded to international conventions and created institutions dedicated to climate change management. Various measures have been planned/demonstrated in terms of water saving, such as construction of dams and hollows, adaptation of itineraries, introduction of new techniques, systems of production conversion, combating desertification and drought, basin management, diversification of activity in rural areas, management of forest areas and development of insurance against climate risk. Another proposed measure is to mobilize the civil society to contribute to environmental management. In priority 4 of its strategic orientations, the Mediterranean Commission on Sustainable Development (MCSD) has included climate change. As such, important actions will be taken to address common adaptation and mitigation challenges.

At the national level, warning and surveillance tools, even if they exist, are not sufficiently mobilized, notably the tools developed by regional institutions. There is also no system for monitoring or evaluating these measures.

At the regional level, research programs are functioning, but there is no sufficient exchange or cooperation between countries around the issues of knowledge and means of action against climate change. Regional cooperation and coordination efforts should be developed through knowledge sharing platforms.

Finally, funding should be put at the service of climate change adaptation strategies. Financial instruments and international cooperation would improve the negotiating capacity of States in international institutions. Thus, countries could mobilize climate-friendly investments.

Some recommendations can already be made:

- Structural reforms are needed to support family/smallholder farming,
- The gradual withdrawal of agriculture, or of certain crops, from the growing inadaptability to the bioclimatic environment should be organized,
- Equity financing measures, pricing policies, targeted subsidies, concessional interest rates, tax measures (eco-taxes), special "green" funds, etc. would be useful,
- It would be useful to develop economic and social incentives to locate non-agricultural activities in rural areas and / or to organize progress.
- Investment in human capital will provide a dignified living environment for rural populations.

**Box 9 Climate change adaptation framework example in France**

Since 2014, the 7 major French river basins have progressively committed themselves to climate change adaptation plans. They identify the phenomena for which there is a need to be prepared and define the strategic framework and the concrete actions to act in the face of climate change.

Regarding the water sector, the challenge is fairly broadly shared and valid everywhere: increased temperatures and soil desiccation, increased extreme events and frequency of heavy rains, lower groundwater levels and surface water flows. The intensity of these phenomena is nevertheless variable according to the territories and remains subject to uncertainties with which it is necessary to act.

Recommended solutions concern the efficiency in the use of available resources, the equitable share of water between users, converging towards more solidarity, the fight against waste or the development of more sober uses of water and thereby less vulnerable to hazards. The plans also call for preserving or restoring the proper functioning of aquatic, wetland or littoral environments in order to promote biodiversity and restore the services provided by the aquatic environment in terms of flood regulation.

Numerous actions of this type are already carried out, within the framework of Schémas Directeurs de la Gestion des Eaux (SDAGE), to recover the good status of water bodies and habitats. Climate change adds urgency or additional level of effort in their implementation. Given the generalized vulnerability of the territories for the availability of water, the question is no longer whether or not to act, but rather to identify where and on what priority issue to invest for carrying the effort. To scale up this effort, the Rhône-Méditerranée (2014) and Corsica (2018) adaptation basin plans produced vulnerability maps that identify priority sectors.

In addition, adaptation strategies prioritize actions that are beneficial regardless of the magnitude of climate change. They allow actors to invest in adaptation without regret and avoiding maladaptation.

From now on, the initiatives multiply to act locally on what makes the vulnerability of a territory or a sector of economic activity. The water managers specify the diagnosis in order to identify the different sectors, structures and natural environments that would be very vulnerable to the phenomena induced by climate change. This work may include, for example, drinking water supply schemes, irrigated agricultural sectors or remarkable natural environments. Thus, investment priorities are identified to act faster or stronger in the face of climate change.

### 6.4.7 Knowledge and data gaps

*[Section to be completed]*

The lack of data is a recurring problem in Mediterranean states. Countries lack homogeneous data and common indicators. Scientific research is carried out, but national reports contain official data that are not always consistent. Data are lacking, at the level of coastal areas or coastal watershed that could often be the most relevant scale of analysis in the context of the Barcelona Convention.

Monitoring the impact of tourism on water resources is one of the key area of data gaps. Only cities are covered by monitoring systems on the impact of tourism on water resources and their seasonal variations. There is no general data on this topic in the Mediterranean.

A Millenium Ecosystem Assessment vision could help develop an expanded agroecosystem vision of the watershed, including water, agricultural ecosystems, and hydro and marine ecosystems. Through a broader understanding of ecosystem services, agriculture could be managed as a producer of a wide range of goods and services, including carbon storage, water infiltration, flood and flood prevention, and coastal protection.

#### 6.4.7.1 Trends in food production

*[Section to be re-worked or moved, as not focusing on responses and priorities for action]*

The demand for livestock products is expected to grow in the next decades but there are significant challenges for livestock systems under changing climate and social conditions (Herrero *et al*, 2013b). In 2014, animal food and feed import represented around 32 % of total food import (Weindl *et al*, 2015). The impacts of climate change on local production potential, combined with the growing demand of animal products due to demographic growth and changing consumption habits changes will increase the food dependence of the south Mediterranean countries in the coming decades (estimated at around 50 % for all food products in the Maghreb (FAO 2016). Human population growth and increased affluence in some regions, along with changing diets will lead to higher demand for food products, while crop and livestock yields are projected to decline in many areas due to climatic and other stress factors.

Extreme events such as drought, heat waves and heavy rainfall occurring in critical phenological stages could bring unexpected losses and increase crop yield variability (Barbagallo *et al*, 2013; Fitzgerald *et al.*, 2016; Fernando *et al.*, 2016). Pests and diseases as well as mycotoxins could also represent a serious threat under unfavorable climate conditions (Bernues *et al*, 2011). Sea-level rise, combined with land subsidence, may significantly reduce the area available for agriculture. The effects of sea level rise in North Africa, especially on the coast of the Delta region of Egypt, would impose additional constraints to the agricultural land (Herrero *et al*, 2013a).
Yields for many winter and spring crops are expected to decrease due to climate change, especially in the South. By 2050 reduction by 40% for legume production in Egypt, 12% for sunflowers and 14% for tuber crops in Southern Europe have been estimated. Warming will also affect olive production

by increasing the irrigation requirement (Tanasijevic *et al*, 2014), the risk of heat stress around flowering and the lack of chilling accumulation (Gabaldon-Leal *et al*, 2017), and by altering fly infestation risk (Ponti *et al*, 2014). Although the impact is not projected to be large for aggregated productions, local and regional disparities will emerge (Ponti *et al*, 2014). Changes in the phenological cycle towards shorter duration and anticipated flowering are projected for grapevines, with associated increase in the exposure to extreme events and increase in water stress (Fraga *et al*, 2016). These conditions could also affect the quality. Anticipated flowering and insufficient time with cold weather (chilling accumulation) are expected to impact yields from fruit trees as well (Funes *et al* 2016). For vegetables such as tomatoes, reduced water availability will be the main yield limiting factor (Arbex de Castro Vilas Boas *et al*, 2017), although water-saving strategies to enhance the quality and nutritional aspects while keeping satisfactory yield levels could be developed (Barbagallo *et al*, 2013). In some crops, yield increases may occur, due to CO2-fertilization effects which could increase water use efficiency and biomass productivity (Deryng *et al.* 2016 ; Fraga *et al*, 2016), although the complex interactions among the various factors and current knowledge gaps imply high uncertainties (Fitzgerald *et al*, 2016 ; Link *et al*, 2012). Furthermore, these yield increases are expected to be combined with decreased quality (e.g. lower protein content in cereals) (Fernando *et al.*, 2015).

Fisheries and aquaculture are currently impacted mostly by overfishing and coastal development, but climate change and acidification may play a important role in the future. Mediterranean countries import more fish products than they export, as a result of the increasing demand for seafood. Despite being major exporters, France, Spain and Italy are the countries with the highest trade deficits for seafood. There are no quantitative estimates of the impact of climate change on future seafood production in the Mediterranean region, but ocean acidification and warming will very likely impact an already-stressed fish sector. By 2040–2059 relative to 1991-2010, more than 20 % of exploited fishes and invertebrates currently occurring in eastern Mediterranean are projected to become locally extinct under the most pessimistic scenario (RCP 8.5) (Jones & Cheung, 2015; Cheung *et al*, 2016). By 2070–2099, 45 species are expected to qualify for the IUCN Red List whereas 14 are expected to become extinct (Ben Rais Lasram *et al*, 2010). The maximum catch potential on the southern coast of the Mediterranean Sea is projected to decline by more than 20 % by the 2050s relative to the 1990s under RCP 8.5 (Cheung *et al*, 2016). The expected migration of species to cooler areas as the ocean warms up (Poloczanska *et al*, 2016) is eventually limited in enclosed seas and the Mediterranean Sea has been described as a ‘sans issue’ (no exit) for endemic fishes, including commercial species, facing climate change (Ben Rais Lasram *et al*, 2010).

#### 6.4.7.2 Agricultural and aquatic ecosystem services and their value

*[Section to be completed]*

#### 6.4.7.3 Cumulative impacts of multiple stressors

*[Section to be completed]*

### 6.4.8 Priorities for actions (data based, according to current status and trends in regards to the policy objectives)

*[Section to be completed]*

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