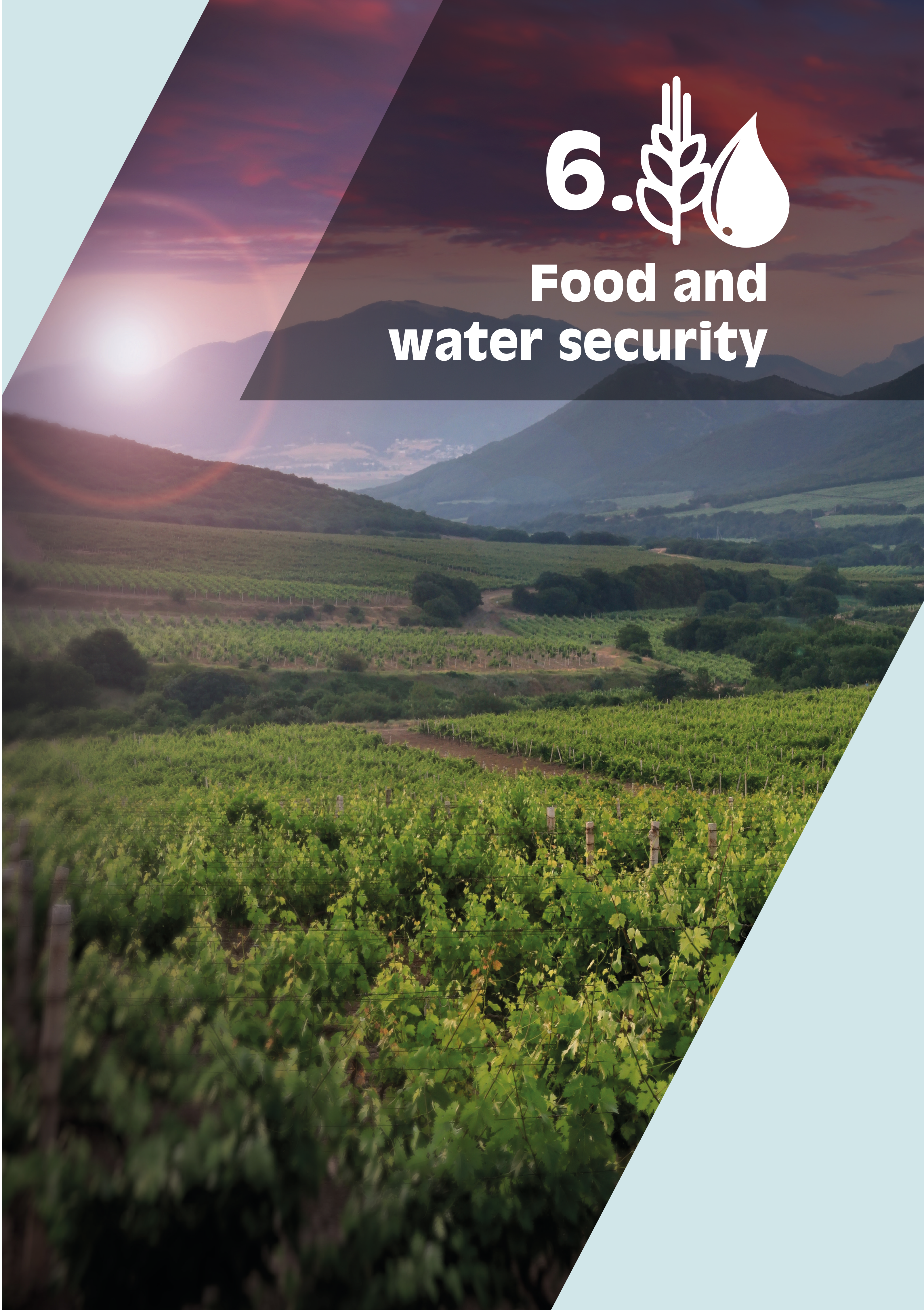
6. Food and water security



Food security and water security in the Mediterranean are intrinsically linked and are facing similar challenges. Food security is threatened mainly by the high dependency of Mediterranean countries on food imports, making them vulnerable to external pressures such as volatile food prices. From a nutritional standpoint, the number of overweight and obese people has increased as a result of the traditional Mediterranean diet being abandoned. Water security has degenerated due to the deterioration of internal freshwater resources, both in terms of water quantity and quality, with a high dependency on external water resources, higher regional water footprints than the global average, increasing scarcity of renewable water resources, an increased number and capacity of dams exerting pressure on freshwater ecosystems, and a growing risk of conflicts between water users and countries. Access to water and sanitation remains a major challenge in the region. Territorial divisions separating coastal urban and remote rural areas are growing stronger, making isolated populations such as smallholder farmers particularly at risk of food and water insecurity. With climate change, precipitation is expected to decrease and temperatures to rise in the region, which will affect water supply (and thereby energy and food supply). It will also directly affect soil moisture and crop growth, thereby further increasing irrigation water needs.

There are clear but difficult to measure interactions between the water, energy and agricultural sectors, as they are all interdependent, which calls for integrated policies and management. Agriculture being the largest water user in the region, further efforts need to be made to promote the use of non-conventional water resources. The conservation and restoration of Mediterranean agro-ecosystems is key to ensuring sustainable development. This requires better management of continuing arable land loss, land use intensification, and soil erosion and salinization. Integrated Water Resources Management and Water Demand Management (WDM) provide guidelines for achieving better water efficiency and reducing conflicts between users.

6.1 Introduction

Water, energy and food are essential to human well-being, poverty reduction and sustainable development. These strategic resources share many similar characteristics: i) billions of people do not have safe access to them; ii) global demand is rapidly growing; iii) all are 'global goods' that involve 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). Several of the UN Sustainable Development Goals (SDGs) focus on food and water security, in particular SDG 1, no poverty; SDG 2, zero hunger; SDG 6 clean water and sanitation; and SDG 15, which concerns the protection and sustainable use of terrestrial ecosystems, highlighting the fact that food and water security are an essential component of sustainable and inclusive development.

Food security[92] exists 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 to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture".

The status of food security and challenges vary across Mediterranean countries. At the regional level, **food availability** is dependent on imports, with a regional agricultural trade deficit of USD 36.6 billion in 2017 (WTO, 2017). Only France and Spain produce an agricultural surplus. Mediterranean countries account for one-third of global cereal imports, for only 7% of the global population. Import dependency ratios for cereals in the Mediterranean (import over consumption ratio) are very high (86% in Lebanon, 72% in Algeria, 60% in Tunisia, 42% in Egypt) (FAO et al. 2018). Importing countries are thus very sensitive to the volatility of international prices, and were strongly hit by the food crisis of 2007-2008. Egypt and Algeria are among the world largest cereal importers.

Beyond food availability, **access to food** depends on multiple factors, including purchasing power and the state of infrastructure. In many Mediterranean areas, territorial divisions 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 can exist.

From a **nutritional** standpoint, increasing overweight and obesity rates are reaching an alarming level in all Mediterranean countries (e.g. 30% of adults in Eastern Mediterranean countries are obese), and a high prevalence of anaemia affects women of childbearing age.

Factors that may affect food security in the region include dependency on imports, political instability and conflicts, global warming, and erosion of natural resources (soil, biodiversity). Rising water insecurity is a key factor because water and food are closely 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 socioeconomic 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,

[92] Data on global food security 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.

2013). Water resources are unevenly distributed across the Mediterranean basin, with critical limitations in southern countries, which hold only 10% of the total renewable water resources in the region. Six Mediterranean countries experience absolute water scarcity (less than 500 m^3 per capita per year) and another five are under the water scarcity threshold of 1000 m^3 per capita per year (FAO, 2016a). Most Northern Mediterranean countries (NMCs) are water-secure with over 1,700 m^3 per capita per year.
In North Africa and the Middle East, shared aquifers are the largest source of freshwater (Aureli, Ganoulis & Margat, 2008). Satisfying the simultaneous needs for high quality drinking water and high demand for irrigation water is a particularly complex problem. Water scarcity causes tensions and potential conflicts between groundwater users and land owners, and between countries. Tensions are exacerbated by increasing water demand for irrigated agriculture in a context of demographic growth. In numerous areas in the Mediterranean, groundwater quality is also under threat from pollution, sea water intrusion and overexploitation.

As pre-existing water scarcity in the Mediterranean region is being aggravated by population growth, urbanization, growing food and energy demands, pollution, and climate change, ensuring water security will require inclusive approaches and coordinated cross-sector solutions. The **Water-Energy-Food Nexus** has emerged as a useful concept to describe and address the complex and interdependent nature of these three resources *(Figure 146)*, on which we depend to achieve a range of social, economic and environmental goals (FAO, 2014b).

Since 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, in emerging technologies such as fracking for oil and gas, and

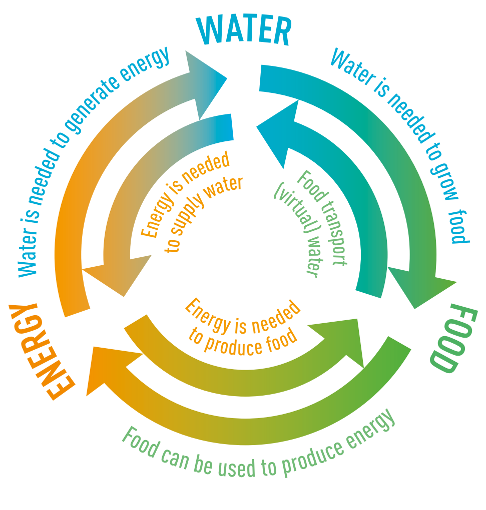


Figure 146 - The Water-Energy-Food Nexus
(Source: UN-Water, 2013 - adapted from IBM, 2009)

concentrated solar power). Energy is required to process and distribute water, treat wastewater, pump groundwater, and desalinate sea water. Water is the keystone for the entire agrifood supply chain, while intensified agriculture impacts water quality. Energy is also an essential input across the agrifood supply chain, from pumping to processing and transportation.

Non-conventional water resources such as wastewater recycling and reuse, rainwater and storm water capture, and desalination, are expected to be increasingly used in the forthcoming decades to meet growing demands. **Desalination** is a key Nexus interlinkage with energy consumed to increase water supply. The production of desalinated seawater in the Middle East and North Africa (MENA) region is projected to be thirteen times higher in 2040 than 2014. Currently, desalination for municipal use is already gaining importance on islands and in coastal cities with limited water resources. In absolute terms, the Mediterranean's largest producers of freshwater through desalination are Algeria (615 million m^3/year), Egypt (200 million m^3/year), Israel (140 million m^3/year), and Italy and Spain (both 100 million m^3/year) (FAO, 2016b). In relative terms, Malta is the desalination leader, with more than half of its drinking water supply produced via 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 salt water 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 wastewater treatment by-products, such as biogas and sludge for energy generation, thus reducing emissions from the water sector and overall energy demand. However, around 80% of the MENA region's wastewater is still being discharged into the environment without being reused (World Bank, 2018).

Agriculture accounts for two-thirds of the increase in water withdrawals in the Mediterranean basin. Growing water scarcity in the southern and eastern Mediterranean is 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 with demand from urban areas and the industrial sector. Growing water scarcity and the resulting decline in agricultural production are also expected to accelerate migration, especially in the most agriculture-dependent economies, and increase food trade.

In the MENA 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 all 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 electricity produced domestically respectively), while in Bosnia and Herzegovina, hydropower represents about a third of energy production. In both Montenegro and Bosnia and Herzegovina, the rest of the domestic electricity generation comes exclusively from coal (IEA statistics). All countries in the EU or in the EU accession process have adopted renewable energy targets for 2020 (e.g. 38% for Albania, 40% for Bosnia and Herzegovina and 33% for Montenegro; all three countries are 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 emissions. 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 for 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[93].

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

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

6.2 Water resources and water security

6.2.1 Precipitation and soil moisture

The Mediterranean climate is generally characterized by mild and wet winters, and dry, hot summers. Precipitation strongly differs between subregions, especially in winter. Long-term average precipitation[94] ranges from 33 mm per year in Egypt to 1,325 mm per year in Slovenia, i.e. 40 times more (*Table 26* and *Figure 147*), with a clear North/South divide. Variations within countries are particularly associated with the orography of continental regions, with higher precipitation in mountainous areas than plains[95].

Precipitation over the Mediterranean region is critical to the availability of water resources. It provides the water

Countries	Precipitation (mm)	Countries	Precipitation (mm)
North		South	
Albania	981	**Algeria**	83
Bosnia and Herzegovina	1,072	**Egypt**	33
Croatia	1,066	**Libya**	44
Cyprus	468	**Morocco**	315
France	841	**Tunisia**	271
Greece	649	East	
Italy	927	**Israel**	258
Malta	428	**Lebanon**	565
Montenegro	1,135	**State of Palestine**	413
Portugal	839	**Syrian Arab Republic**	289
Slovenia	1,326	**Turkey**	568
Spain	610		

Table 26 - Long-term average annual precipitation by country, 1961-2015
(Source: World Bank, 2016[96])

[93] According to their National Renewable Energy Action Plans for 2020, compared to 2016, Albania plans to increase its hydro capacity from 1,838 Megawatt (MW) to 2,324 MW, Bosnia and Herzegovina from 2,180 MW to 2,700 MW and Montenegro from 674 MW to 826 MW.
[94] From 1961–2015.
[95] Maximum precipitation levels are recorded over the Alps and Dinaric Alps with over 1,500 mm per year. Minimum precipitation levels are recorded over the Southern Mediterranean with high precipitation in the Atlas Mountains in Algeria and Morocco.
[96] Calculated as the average annual precipitation between 1961 and 2015.

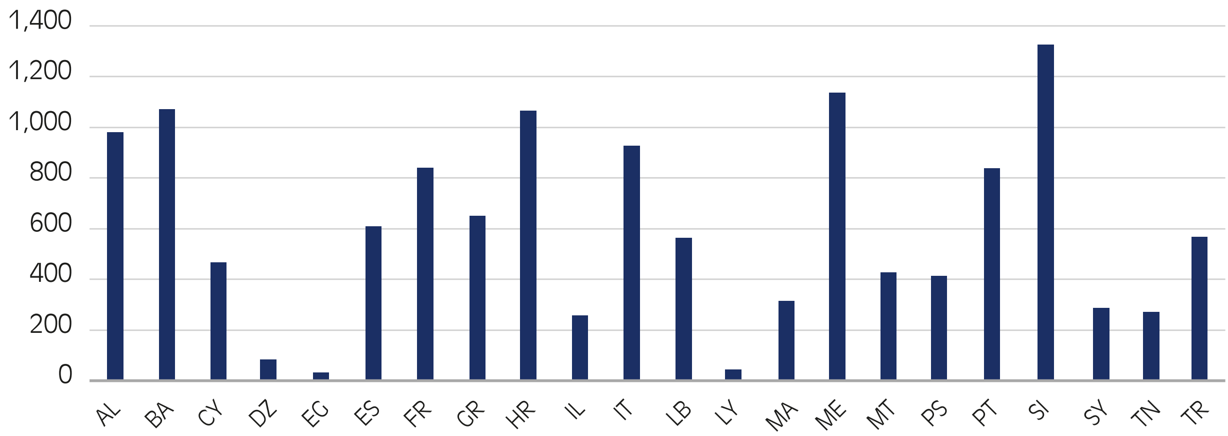


Figure 147 - Long-term average annual precipitation by country (1961-2015)
(Source: World Bank, 2016)

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 surfaces and the atmosphere, which impacts rainfall-runoff processes. Thus, soil moisture is vital for the ecosystem and agricultural outputs (food security). In the Southern and Eastern Mediterranean, soil moisture is very low due to low precipitation and high temperatures, limiting the possibility of rainfed agriculture. Since precipitation is considerably less than potential evaporation in these parts of the Mediterranean region, any future decrease in precipitation will often cause a decrease in soil moisture.

The Mediterranean region has been recognized as one of most vulnerable regions to climate change, including projected decreases of precipitation and increases of evapotranspiration.

6.2.2 Freshwater availability

The ten largest Mediterranean river basins are the Nile (Egypt), Rhone (France), Ebro (Spain), Po (Italia), Moulouya (Morocco), Meric/Evros (Greece, Turkey), Chelif (Algeria), Büyük Menderes (Turkey), Axios/Vardar (Greece) and Orontes/Asi (Turkey). River inflow into the Mediterranean represents approximately 340 km^3 (Montreuil & Ludwig, 2013). A general decline in water discharge from rivers in the last 50 years has been observed. This decline results from the impact of multiple stressors, namely decreasing precipitation, an increasing number of reservoirs and increasing irrigated areas.

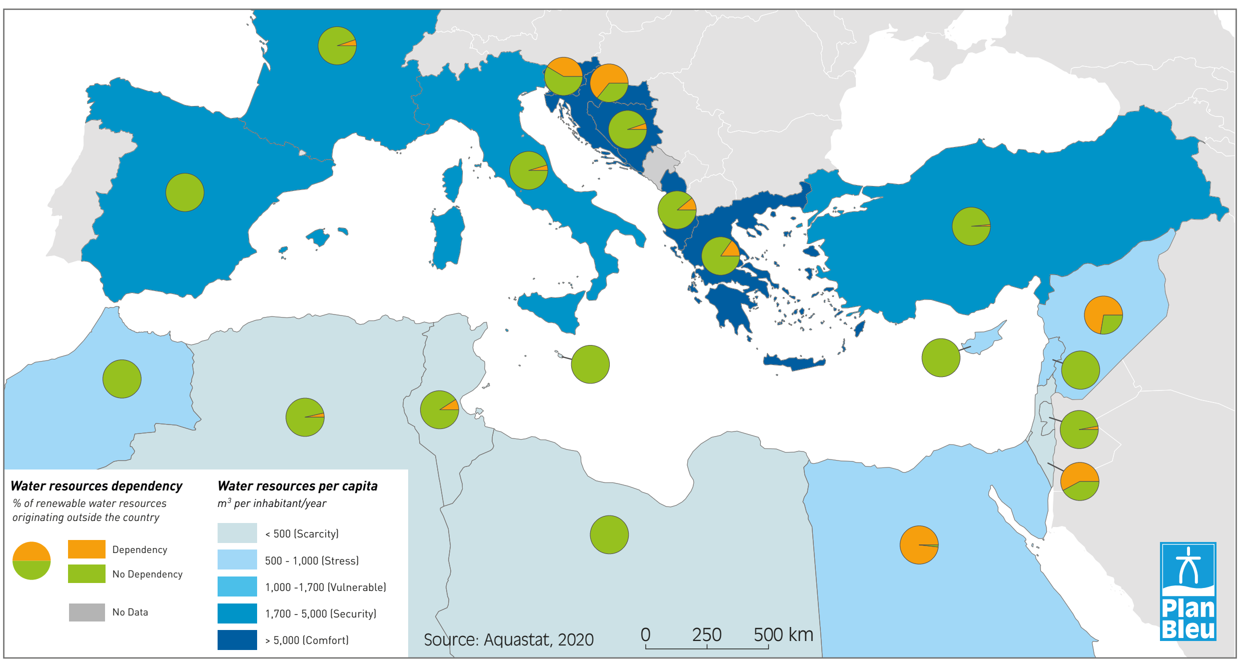


Figure 148 - Total renewable water resources per capita in the Mediterranean, 2017
(Source: FAO, 2020)

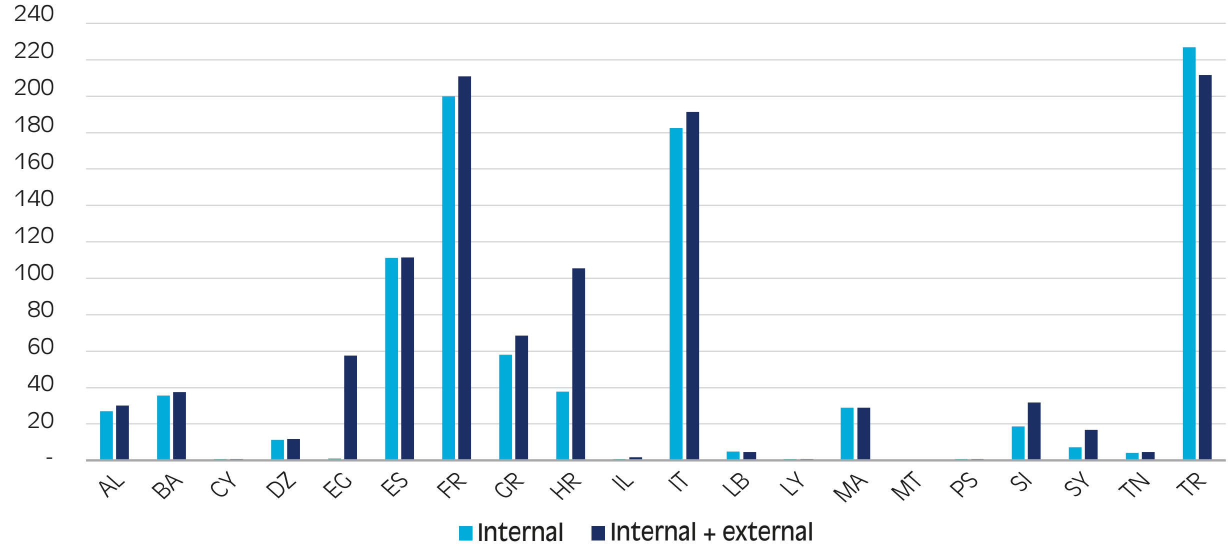


Figure 149 - Internal and external total renewable water resources in the Mediterranean (109 m³/year), 2017
(Source: FAO, 2020) - Note: No data for MC and ME.

6.2.2.1 Total Renewable Water Resources

Total Renewable Water Resources (TRWR[97]) are unevenly distributed across Mediterranean subregions: 67% are located in the North, 10% in the South, and 23% in the East, over 20.5% are in Turkey (FAO, 2016a). These heterogeneities are further emphasized by uneven population growth, as population is stagnating in the water rich North and continues to grow in the water poor South *(Figure 148)*. 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 1,000 m^3 per capita per year, Cyprus, Egypt, Lebanon, Morocco and the Syrian Arab Republic are water scarce (FAO, 2016a). Most of the NMC population is water-secure, with some countries considered as living in the comfort of water abundance, such as the Balkans.

Figure 149 shows the total renewable water resources (i.e. the sum of internal and external resources), which can mask the dependency of some countries on external water resources, i.e. water originating from outside of their borders. For instance, Egypt depends on external water for 98% of its freshwater resources, the Syrian Arab Republic

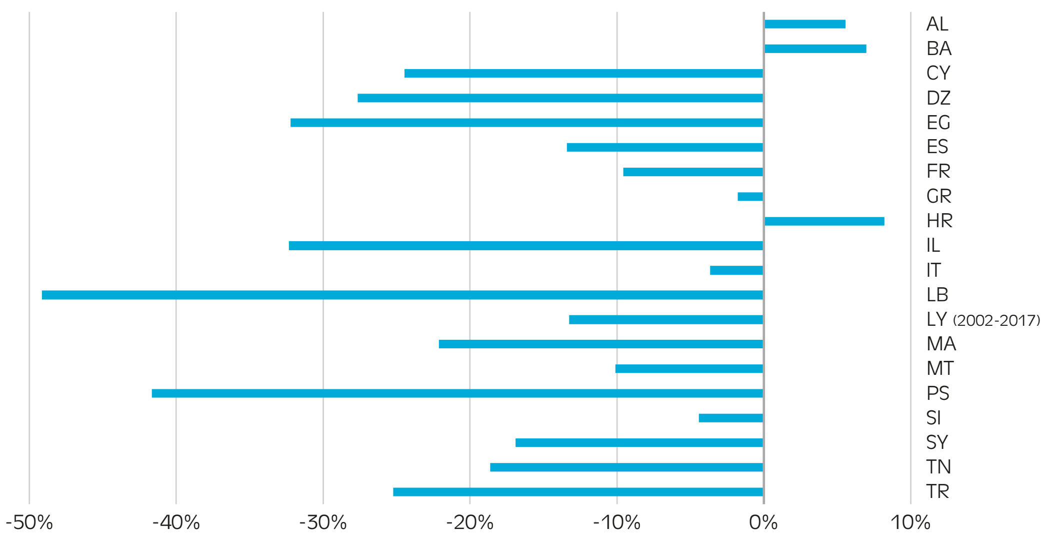


Figure 150 - Changes to internal renewable water resources per capita between 1997 and 2017, variations in %
(Source: FAO, 2020) - Note: No data for MC and ME.

[97] 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: AQUASTAT, Glossary (FAO, 2016a).

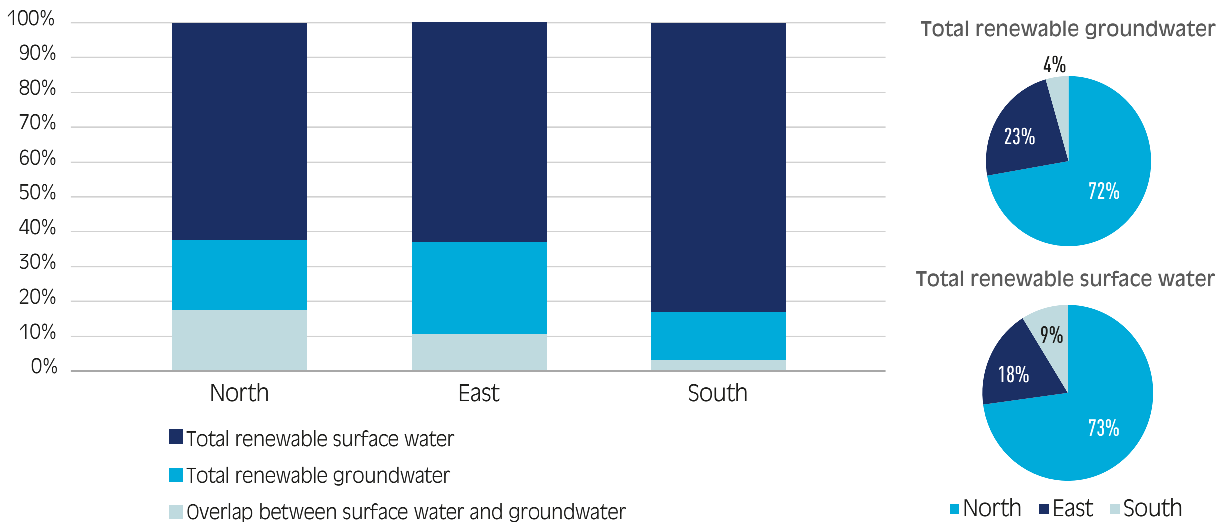


Figure 151 - Surface and Groundwater Renewable Water Resources by subregion, 2017
(Source: FAO, 2020[98])

for 58% and Israel for 58% *(Figure 149)*. Total renewable water resources in the Mediterranean Region amount to 1,127 km^3 (FAO, 2020).

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

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 aquifer depletion (Dalin et al. 2017), threatening the sustainability of food production, and inducing significant environmental damage, such as land subsidence and seawater intrusion (Calò et al. 2017; Custodio, 2018). It also contributes to the major cross-border challenges affecting the Mediterranean region (UNEP/MAP & UNESCO-IHP, 2015).

In terms of Mediterranean groundwater resources, 72% are located in the North, 23% in the Middle East and only 5% in the South. For surface water, 73% is located in the North, 18% in the East and 9% in the South *(Figure 151)*. In the southern subregion, surface water represents 85% of water resources, and up to 97% in Egypt (*Figure 151* and *Figure 152*).

Algeria, Morocco and Tunisia rely on both surface and groundwater for their freshwater withdrawals. Malta relies entirely on groundwater. Groundwater accounts for over or around 70% of freshwater withdrawals for Croatia, Cyprus, Libya and Tunisia. Most islands in the subregion 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 the mainland to deal with structural shortages (Greek islands, Croatian islands) or during droughts (MED-EUWI WG, 2007). In the eastern subregion, the State of Palestine and Israel rely mostly on groundwater, while 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.

As a consequence of irrigation, aquifers with declining groundwater levels are common in the Mediterranean region, in particular in the southern and eastern subregions 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, van Beek & Bierkens (2012) as the Mediterranean country with the most rapid groundwater depletion. Overexploitation 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 high additional demand in coastal areas during peak seasons that in most cases coincide with the dry season. This can put a considerable strain on available water resources

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

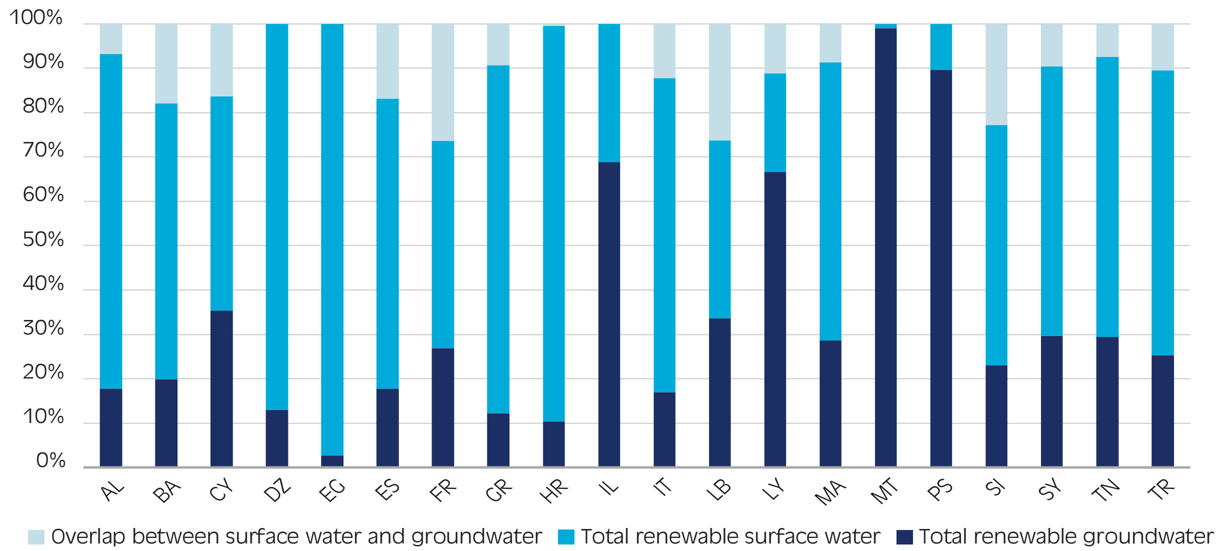


Figure 152 -Surface and Groundwater Renewable Water Resources by country, in % of total renewable water resources, 2017
(Source: FAO, 2020)

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 153)*.
The North-Western Sahara aquifer system has a renewal rate of only 40% of the withdrawals (Goncalvès 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 153* shows the critical aquifers in the region with very low recharge. Sustainable use of these aquifers is essential to protect this valuable resource.

6.2.2.3 Climate change influence on freshwater availability

Water availability in the Mediterranean Basin is expected to further decline in the coming decades as a consequence of (i) decreased precipitation, (ii) rising temperatures, and (iii) population growth, especially in the countries already short in water supply. Water quality is also expected to decrease due to pollution and salt intrusion in coastal areas. Both phenomena may increase conflicts over freshwater use. Overall, there is a high level of certainty that a 1.5°C to 2°C increase in global warming will cause strong increases in dryness and decrease water availability in the Mediterranean and southern Europe.

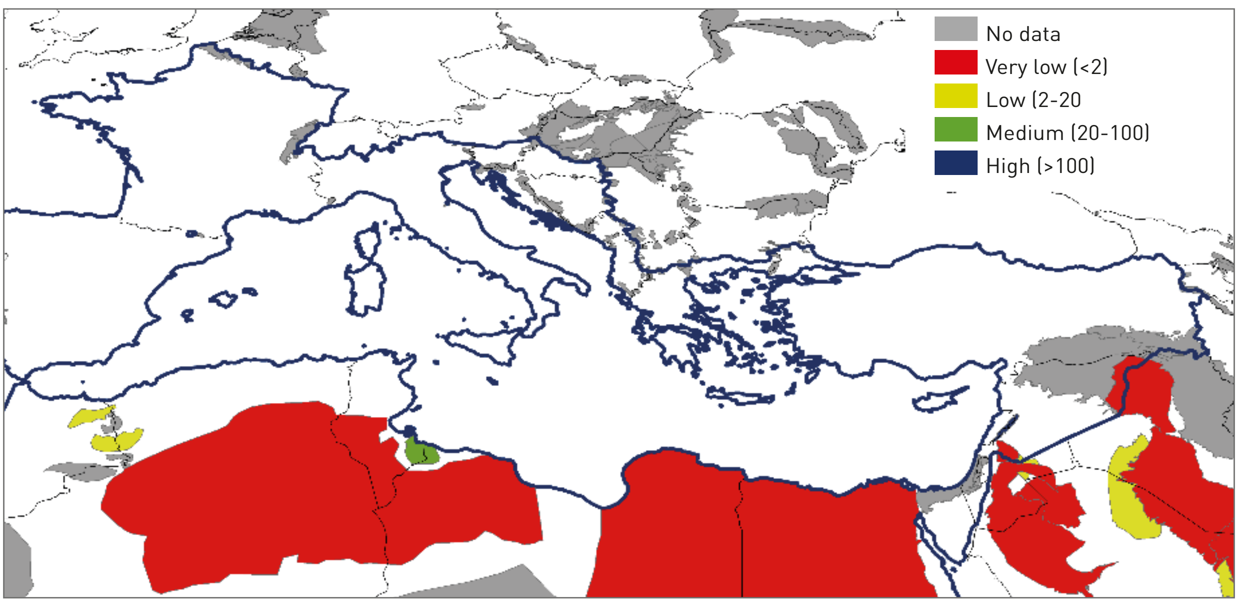


Figure 153 - Transboundary aquifers (Source: layer extracted from IGRAC-UNESCO-IHP, 2015) and mean annual groundwater recharge (mm/year)
(Source: layer extracted from UNESCO-IGRAC, 2016)

Compared to 1960-1990, annual precipitation is projected to decrease in 2040-2070 by around 15% in Southern Mediterranean countries and the Middle East (García-Ruiz et al. 2011), while this decrease is expected to be around 10% in South Italy, Greece and Southern Turkey. It is projected that Southern and Eastern Mediterranean Countries (SEMCs), as well as southern Spain, will experience a decrease in winter precipitation, the highest decrease in the Mediterranean region.

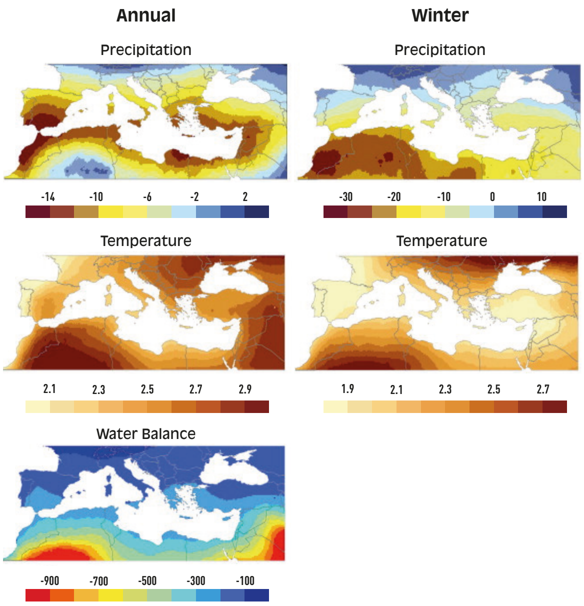


Figure 154 - Mean annual and winter climate changes precipitation (P, %), temperature (T, °C) and water balance (P–T, mm) projected for the Mediterranean region between 2040 and 2070 in comparison to 1960-1990 by nine general circulation models.
(Source: García-Ruiz et al. 2011)

Due to climate change (enhanced evapotranspiration and reduced rainfall), freshwater availability is likely to decrease substantially (by 2 to 15% for 2°C warming), among the most significant decreases in the world (Jiménez Cisneros et al. 2014; Gudmundsson & Seneviratne, 2016; Gudmundsson, Seneviratne & Zhang, 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 high uncertainty. With an 18% reduction in TRWR availability in Crete under a +2°C scenario, only 6% is due to the precipitation reduction and 12% to the evapotranspiration increase (Koutroulis et al. 2016). In Greece and Turkey, water availability may fall below 1000 m³ per capita and per year for the first time in 2030 (Ludwig et al. 2010). In South-Eastern Spain and on the southern shores, water availability may drop to below 500 m³ per capita per year[99]. Particularly in the Middle East and Near East, people 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). Impacts on wheat and barley production are expected to hit hardest in the Syrian Arab Republic and neighbouring countries. The importance of covering environmental flow requirements for assuring the healthy functioning of aquatic ecosystems means that certain amount of water will need to be maintained in the systems, further limiting availability for human uses (Hermoso & Clavero, 2011).

Under climate change scenarios, river flow is generally reduced, particularly in the Southern and Eastern Mediterranean, where water is in critically short supply (Forzieri et al. 2014). As a result of decreased precipitation, 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 highly likely to change, with earlier declines of high flows from snow melt in spring, intensified low flows in summer and g reater 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, 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. Groundwater recharging will be diminished, affecting most of the region. Water requirements for irrigation in the Mediterranean region are projected to increase by 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).

6.2.3 Status and trends of water use and demand: breakdown by sector and categories of users, efficiency of water use

6.2.3.1 Water demand

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

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

Demand in Mediterranean watersheds. While watershed (i.e. catchment area) data is crucial in the Mediterranean, no recent data is available on this geographical scale for the entire region. Total water demand[100] in Mediterranean watersheds was last estimated at 119.5 billion m³/year (according to Margat & Treyer, 2004 and Milano et al. 2012). Irrigated agriculture was the most water demanding sector with 66 billion m³/year (55%), mainly for the production of cereals, vegetables and citrus. The other main sectors were the energy and domestic sector, with water demand accounting for 21.8 billion m³/year (19%) and 19.5 billion m³/year (16%), respectively. Water demand for industries not connected to the municipal water network amounted to 12.2 billion m³/year (10%). Significant differences in the proportion of water demand existed between catchment areas. Water demand for irrigation purposes represents more than half of the total water demand for all catchment areas, except in France and Italy, where water demand for energy and industrial purposes prevail, and in Slovenia and Croatia, where domestic water demands prevail.

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

Withdrawal[101] in Mediterranean countries. In Mediterranean countries, total water withdrawal from all sectors is 290 billion m³ per year (FAO, 2019a), but distribution is uneven between the three main sectors: irrigated agriculture, industry and services *(Figure 155)*.

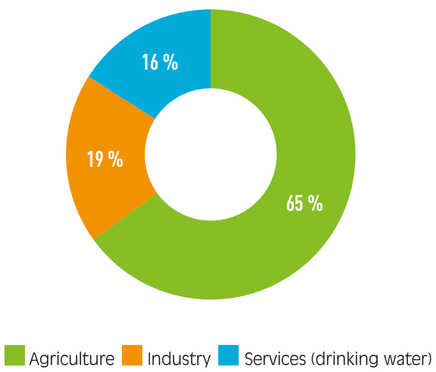


Figure 155 - Distribution of total water withdrawals between the three main sectors of water use in the Mediterranean region
(Source: FAO Aquastat, 2018)

In the North, 51% of water withdrawals are used for agriculture. The agricultural sector represents a greater proportion of water withdrawals in the South and East with 84% and 81% of the total freshwater withdrawals (blue water), respectively.

This finding emphasizes the importance of rainfall agriculture (using green water[102]), 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 erosion and silting downstream.

By 2050, under a business-as-usual water-use scenario, water withdrawals are projected to double or even triple in catchment areas in the Southern and Eastern Mediterranean 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 on new irrigated land (mainly maize and alfalfa) have higher water needs than traditional Mediterranean crops (cereals, olives, grapes). In the Northern Mediterranean, agricultural water demands for irrigation are projected to increase mainly in the Ebro catchment area (Spain) and in Greece due to warmer and drier conditions affecting crop water needs (Milano et al. 2012). Domestic water demand in the Northern Mediterranean should remain constant or decrease as population is projected to stabilize in the medium term.

6.2.3.2 Water stress

Level of water stress (SDG 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).

The renewable freshwater resources of the Mediterranean region amount to 1,123 billion m³ per year (FAO, 2015). 84% of average long-term flows are generated by precipitation within the countries, and 16% is from water entering the countries, considering flows reserved for upstream and downstream by agreements or treaties. Total freshwater withdrawals, defined by the volume of freshwater extracted from rivers, lakes, or aquifers for the needs of agriculture, industry and municipalities, is evaluated at 290 billion m³ per year (FAO, 2015). Exploitation is therefore estimated at 37%, which remains well below the 70% threshold indicating severe water stress and potential water shortage. The level of water stress differs across countries with three groups:

[100] 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.).
[101] Water withdrawal describes the total amount of water withdrawn from a surface water or groundwater source. Measurements of this withdrawn water help evaluate demand from domestic, industrial and agricultural users. Water consumption is the portion of the withdrawn water permanently lost from its source.
[102] Green water is the soil moisture from precipitation, used by plants via evapotranspiration.

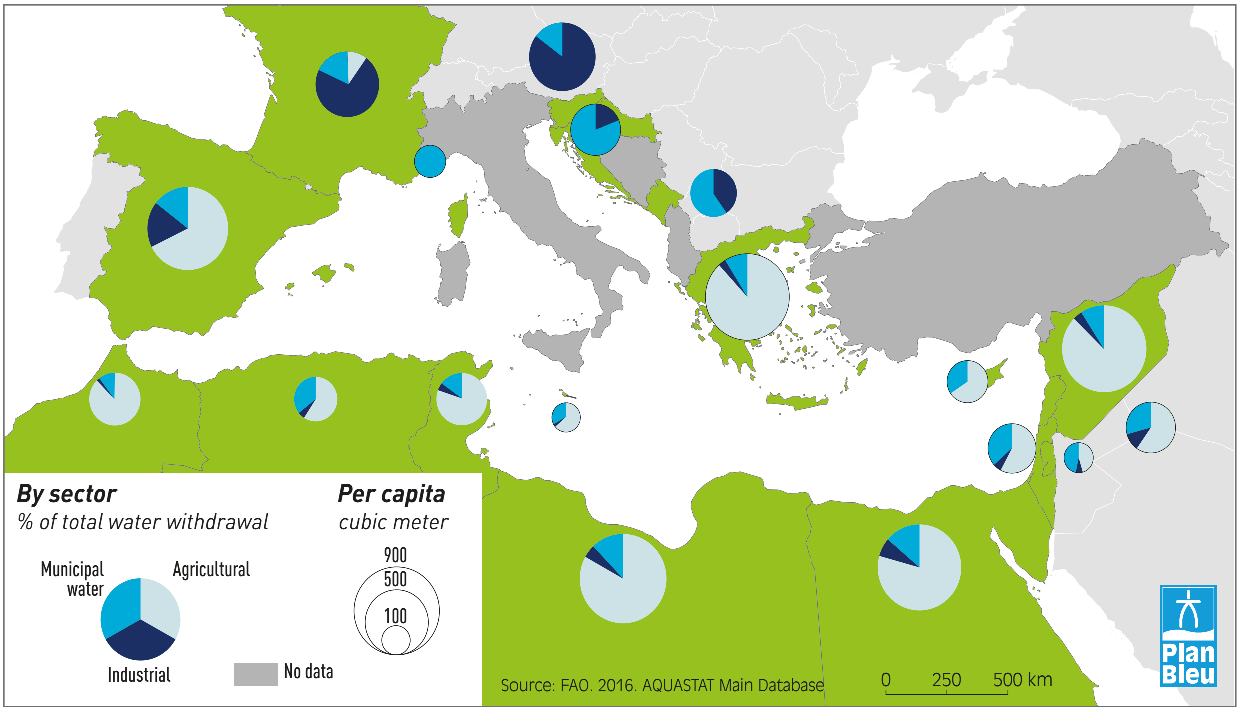


Figure 156 - Water withdrawal by sector and per capita in Mediterranean countries in 2016
(Source: FAO Aquastat, 2019)

- Algeria, Egypt, Israel, Libya, the Syrian Arab Republic and Tunisia exploit more than 80% of their available renewable water resources and their level of water stress tends towards serious water shortage;
- Cyprus, Lebanon, Malta, Morocco, Spain and the State of Palestine with exploitation approaching 50% form a group of countries with a risk of water shortage in the future;
- Albania, Bosnia and Herzegovina, Croatia, France, Greece, Italy, Slovenia and Turkey exploit less than 30% of their available renewable water resources, with local (sub-national) disparities.

A regional-scale investigation was conducted for the Mediterranean basin (Milano et al. 2013a). It highlighted that 112 million people experience 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 are expected to be living under water shortage. 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 be trimmed down to 228 million. Severe

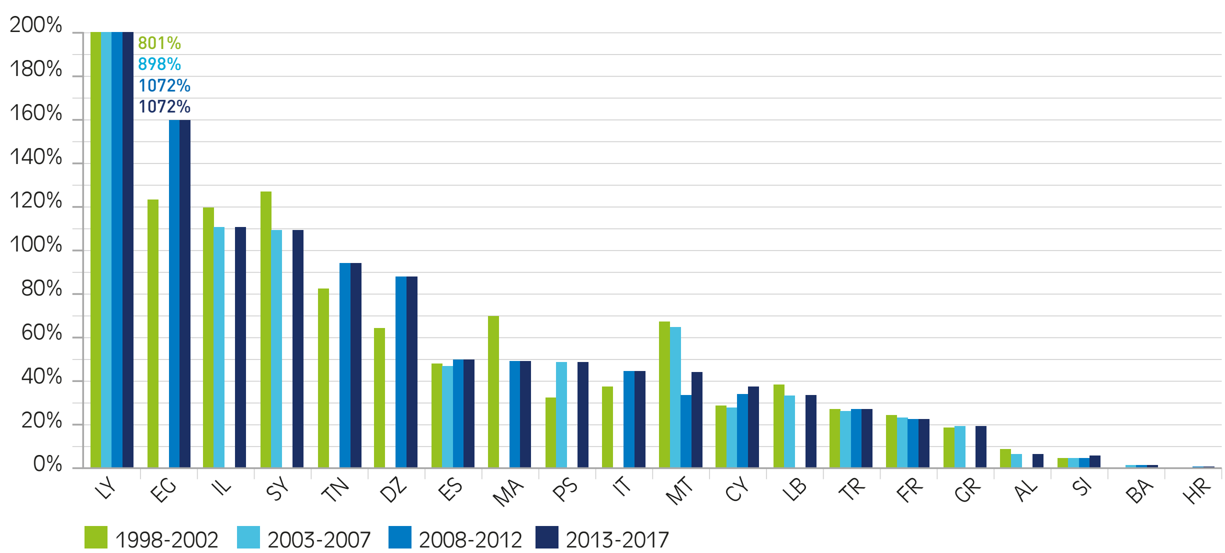


Figure 157 - Freshwater withdrawal as a proportion of available freshwater resources in Mediterranean countries
(Source: FAO and UNSTATS, 2018)

water stress situations could be mitigated in Albania, Greece and Turkey but efficiency improvements alone would not be able to reduce water stress in Spain and the Southern Mediterranean.

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

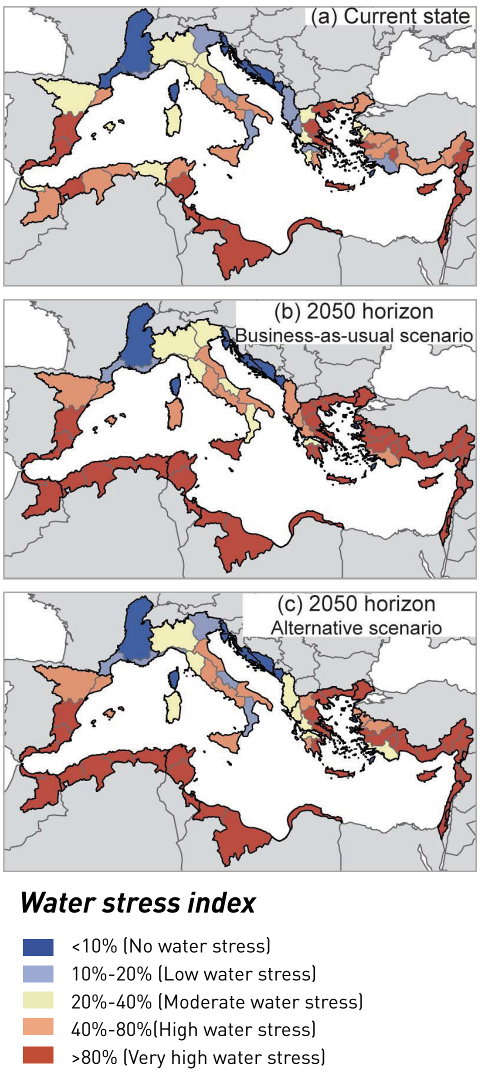


Figure 158 - Water stress changes in the Mediterranean
Current water stress over the Mediterranean basin (a) and changes by 2050 according to a business-as-usual scenario (b) and an alternative scenario (c).
(Source: Milano et al. 2013a; Milano et al. 2013b)

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 (SDG indicator 6.4.1) is defined as the value added by quantity of water withdrawn, expressed as USD /m³ for a given sector[103]. In the Mediterranean, estimations range between USD 3 /m³ and USD 185 /m³ (FAOSTAT, 2018). As this is a new indicator, it is impossible to define a specific target for its value. But the indicator should, at least, follow the same path as the country's economic growth.

Economic efficiency is also unevenly distributed among sectors. In the Mediterranean, irrigated agriculture uses 189 billion m³, or 65% of total water demand (global average: 69% (FAO, 2016b)), considered as the most water-consuming sector. Water use efficiency in this sector is typically much lower than in the industrial and services sector. In Europe, for example, water use efficiency of the agricultural sector is around 50 times lower than in the industrial and 70 times lower than in the services sector. A general rule of thumb leads to lower agricultural water use efficiency in countries with lower GDP per capita and higher contribution of agriculture to GDP and to total water use (Rossi, Biancalani & Chocholata, 2019). Therefore, similar, or even more divergent rates of agricultural water use efficiency compared to other sectors' water use efficiency can be expected in the Mediterranean. Considerable water losses undermine water efficiency in the agricultural sector, which calls for modernization of irrigation systems and awareness raising programmes on water saving practices for farmers.

6.2.3.4 Environmental flows

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 coastal and marine ecosystems. Environmental flows, or environmental water requirements, describe "the quantity, timing, and quality of

[103] 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 each sector compared to total withdrawals. Only runoff water (blue water) is taken into account when calculating the indicator. Agricultural production generated by rainfed agriculture in particular should be subtracted from the overall sectoral value added.

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

WUE = Water-use efficiency

Awe = Efficiency of water used in irrigated agriculture [Value added of irrigated agriculture in USD/ quantity of freshwater used in m³]

Iwe = Efficiency of water used in industries [USD/ m³]

Swe = Efficiency of water used in services [USD/ m³]

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

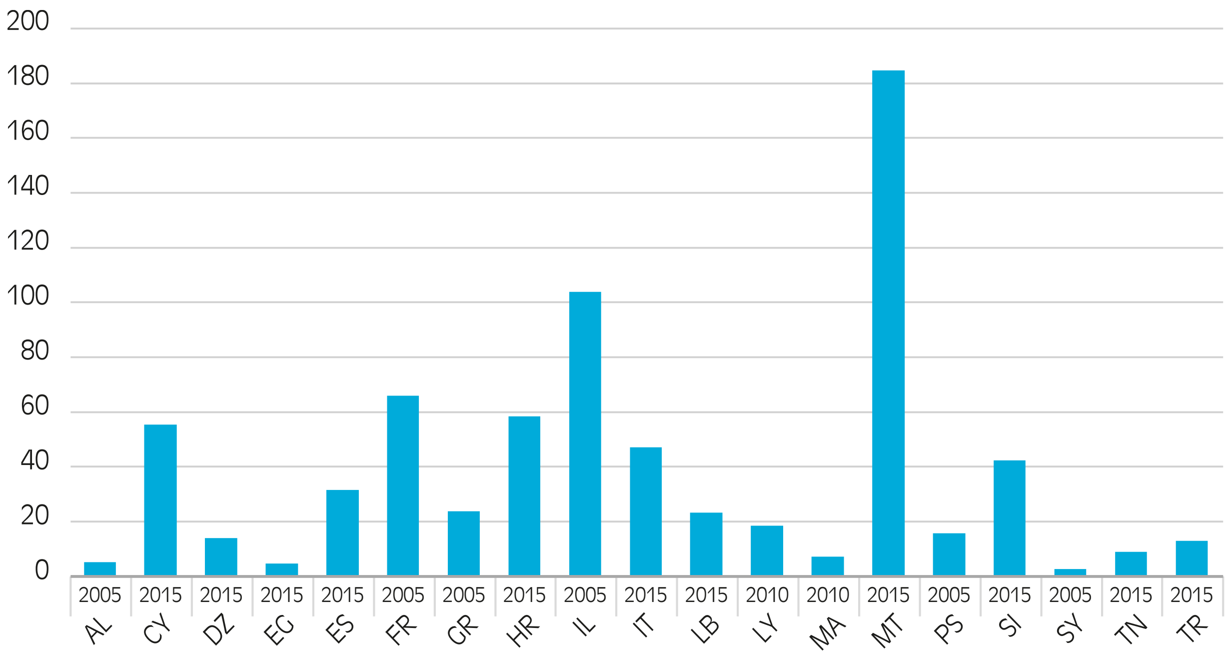


Figure 159 - Water use efficiency calculated for the Mediterranean countries, no data for BA, MC, ME
(Source: FAOSTAT, 2019)

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 Plans and Water Allocation Plans. FAO recently launched new guidelines for incorporating environmental flows into SDG indicator 6.4.2 "level of water stress" to help countries 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 EU 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).

Reservoir dams are designed to regulate river flow and provide continuous irrigation. Mediterranean dams mainly serve irrigation and hydroelectricity generation. There are 398 dams identified in the Mediterranean basin (Plan Bleu calculations based on the Global Reservoir and Dam Database (GRanD) v1.3, Lehner et al. 2011). Twenty-four were built between 2009 and 2016, mostly in Turkey (more than half) and Algeria. The High Aswan dam in Egypt has by far the largest reservoir surface area (5,385 km^2), and is followed by the Miorina Dam in Italy (208 km^2), Nechma Dam in Tunisia (87 km^2) and the Catalan and Kremasta Dams in Turkey and Greece respectively (62 km^2). The Ermenek Dam in Turkey and Vajont Dam in Italy are the highest in height.

The increase in the number and capacity of dams in Mediterranean countries *(Figure 160)*, as well as changing land covers, and increasing pollution, have considerable impacts on downstream ecosystems and the services they provide. Flow regulation infrastructures affecting land-sea interactions (especially ecological connectivity) are often related to agricultural developments, energy, and water supply, therefore requiring integrated management.

Water demand in coastal areas of the Mediterranean region is 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 within the Mediterranean basin 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 a significant impact on neighbouring ecosystems.

Over the past three decades, despite geographical disparities, Mediterranean countries as a whole have experienced strong population growth accompanied by a substantial increase in cultivated area (around 1.6% average annual increase between 1992 and 2015) and open water areas (approximately 12.3% between 1984 and 2015). The latter seems to correlate with the number and capacity of water infrastructure, especially dams for agriculture (Pekel et al. 2016). The vast majority of this infrastructure is related to agricultural projects. There is therefore a link

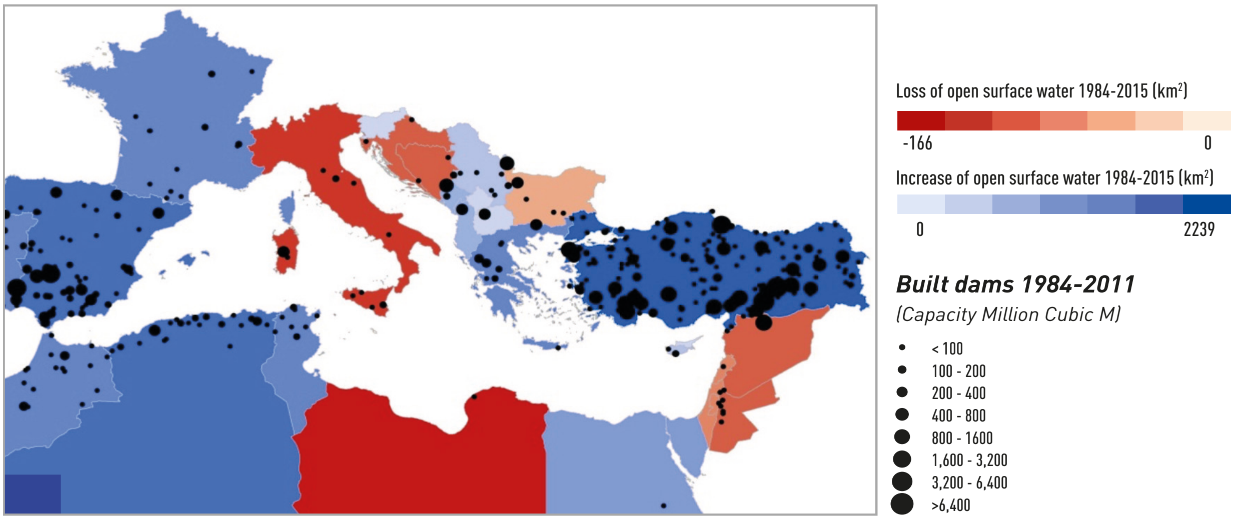


Figure 160 - Loss and increase of open surface water area and number and capacity of dams
(Source: Global Surface Water Explorer (European Commission, 2019) and Global Reservoirs and Dams database (Global Water System Project, 2019))

between agriculture, the development of surface water infrastructure, water dynamics and natural wetlands, many of which directly depend on inflow from upstream freshwater bodies. This profoundly modifies and alters ecological processes and in certain cases, could lead, to their gradual drying up or even complete disappearance. It is therefore recommended that the agricultural development models of Mediterranean countries be partially or entirely re-examined, so that agriculture, a key economic sector, does not enter into conflict with the conservation of natural wetlands and the services they provide (surface water purification, groundwater recharge, flood regulation, drought mitigation, biodiversity conservation, etc.).

6.2.3.5 Water footprint in the Mediterranean

In the Mediterranean region, trade in raw materials and manufactured products induces virtual water transfers that impact water resource management at different scales. According to the Water Footprint Network, the water footprint[104] has three components: green, blue and grey (Hoekstra, Chapagain & Mekonnen, 2011). The blue water footprint refers to the consumption of blue water resources[105]. The green water footprint is the volume of green water[106] 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. 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 through the goods and services consumed.

Mediterranean people use lots of water for drinking, cooking and washing, but even more for producing food, paper, cotton clothes, etc. In the Mediterranean region, when the water footprint and available water resources are compared among countries, two situations emerge:

- One group, mostly composed of NMCs, has a water footprint that is smaller than available water resources[107];
- In a second group, especially the SEMCs, the water footprint exceeds available water resources[108].

[104] 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).
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 consumption of industrial goods also accounts 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.

[105] Fresh surface and groundwater, i.e., the water in freshwater lakes, rivers and aquifers.

[106] 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..

[107] Turkey, France, Italy, Spain, Croatia, Albania, Bosnia and Herzegovina, Slovenia.

[108] Egypt, Morocco, Syrian Arab Republic, Algeria, Lebanon, Tunisia, Israel, Cyprus, Libya, Montenegro.

BOX 71 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 fair sharing among water users while ensuring water preservation and improving water quality. Through a variety of laws and texts, Spanish legislation 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

The Jucar River Basin Authority (JRBA) applied an E-flow assessment methodology for the first time with the publication of the Public Order of 13 August 1999. Since then, one of the basic components of E-flows, i.e. the minimum flow, has been assigned and approved in the RBMP. The first minimum flow 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 planning cycles (2015 - 2021). However, while some of the E-flow studies have improved the E-Flows with the aim of improving ecological conditions, some 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 obtained during the 1st and 2nd hydrological planning cycles, respectively. *Figure 161* 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 compared to its Mean Annual Flow (MAF) in water bodies regularly monitored, for the first and second planning cycles.

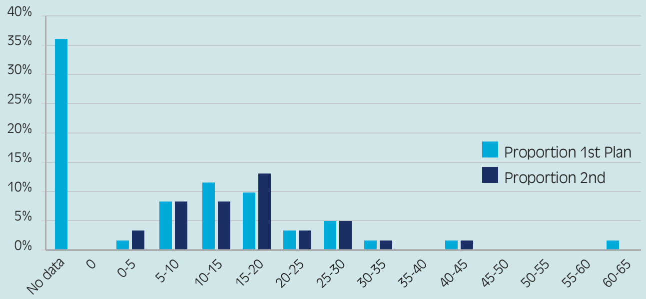


Figure 161 - Proportion of minimum flow values compared to the natural mean annual flow (MAF)
1st and 2nd Hydrological Planning Cycles are compared.

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 that progress has been made in the assessment and implementation of some components of Environmental Flows in the Jucar River Basin for the last decade. Some fundamental components such as 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 challenges where significant improvements are necessary. Furthermore, considerable efforts still need to be made by the JRBA because the percentage of water bodies without regular flow monitoring is still very high (253 out of 314).

Figure 161 shows the proportion of water bodies where the minimum flow in the 10-15% range has decreased by the 2nd period from 11% down to 8%, while the proportion in the 15-20% range has increased. From a historical perspective, the number of sites with minimum flows below 10% has slightly increased, which suggests that the improvement of the ecological status in some areas has been overlooked for prioritizing other water uses.

Jucar river basin E-flow related indicators

Besides the minimum flow values, three other components of the E-flows must be considered in Spain under the legal framework of hydrological planning: the maximum flows in regular operation or management (Qmax), the limitation to the rate of change, and the high flows or small floods; in addition, temporal variability should be considered for the four components. *Figure 162* shows the percentage of water bodies where maximum flows and ratio of change were approved, the percentage of water bodies where minimum flow is controlled; and the percentage of water bodies where minimum flow was achieved.

Minimum flow is legally approved in an incremental number of water bodies (up to 61%). Two other components, i.e. the maximum flow and rate of change began to be monitored in the 2nd 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 achieve the minimum flow.

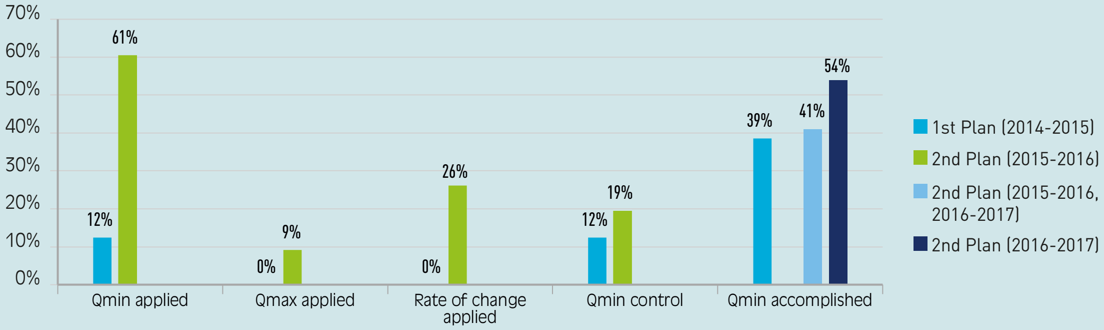


Figure 162 - Comparison of five indicators for legal forcing and accomplishment of environmental flows in the Jucar River Basin
for the 1st vs. 2nd cycle of hydrological planning. Percentage (%) of water bodies where minimum flow is approved, and similar % for maximum flow (Qmax) and rate of change. And, % of water bodies with E-flow gauging, and of water bodies where minimum flow was actually achieved.

BOX 72

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 the number of incoming/outgoing tourists, tourism revenue, consumption patterns, income and welfare.

In Roson & Sartori (2014), the economic impact of variations in tourism flows for some Mediterranean countries, possibly induced by 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 beach tourism. As it is well known that the per capita water consumption of an average tourist is far higher than that of a local, it can be concluded that increased tourism activity would bring about higher pressure on scarce water resources.

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 accounts for about two-thirds of total water consumption in the Mediterranean, meaning that even a modest decline in agriculture could more than compensate for the increased demand from tourists. However, not all water savings obtained in agriculture could be redirected to supply water for tourists. 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 defined instead as "blue water".

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% likelihood 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. This is not a coincidence as relatively arid countries rely more on irrigation in agriculture, so any decline in agricultural production would free surface water, which then becomes available for the tourism industry or other uses.

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, tourism development policies should be geared towards making tourism flows more continuous over the year, reducing seasonal peaks (thereby reinforcing the effect induced by climate change itself). They should also avoid further development in overexploited areas. One way to provide efficient access is to allow water trading where feasible in terms of engineering.

The average water footprint of the Mediterranean countries (1,859 m³/capita/year) is higher than the global average (1,385 m³/capita/year) (Mekonnen & Hoekstra, 2011).

Figure 163 shows that in the range of relatively large water footprints per capita there are both industrialized and developing countries. The latter generally have large water footprints not because of their relatively large consumption - although relatively large meat consumption can play a role - but because of their low water/productivity rates, i.e. large water footprints per ton of product consumed[109].

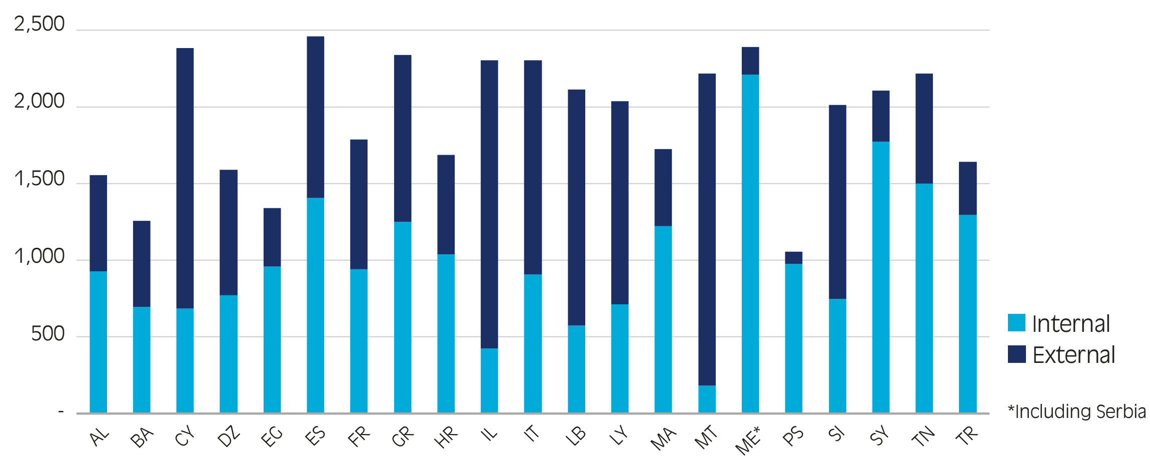


Figure 163 - Water footprint of Mediterranean countries (1996-2005)

In m³ per year per capita, internal share (volume of domestic freshwater used to produce the goods and services consumed by the country) and external share (volume of freshwater used to produce the goods and services consumed by the country originating outside of the country)
(Source: Mekonnen & Hoekstra, 2011)

[109] With the disclaimer that the extreme values can also partially relate to weak basic data on consumption and water productivity, the differences can be traced back to differences in consumption patterns, and differences in the water footprints of the products consumed.

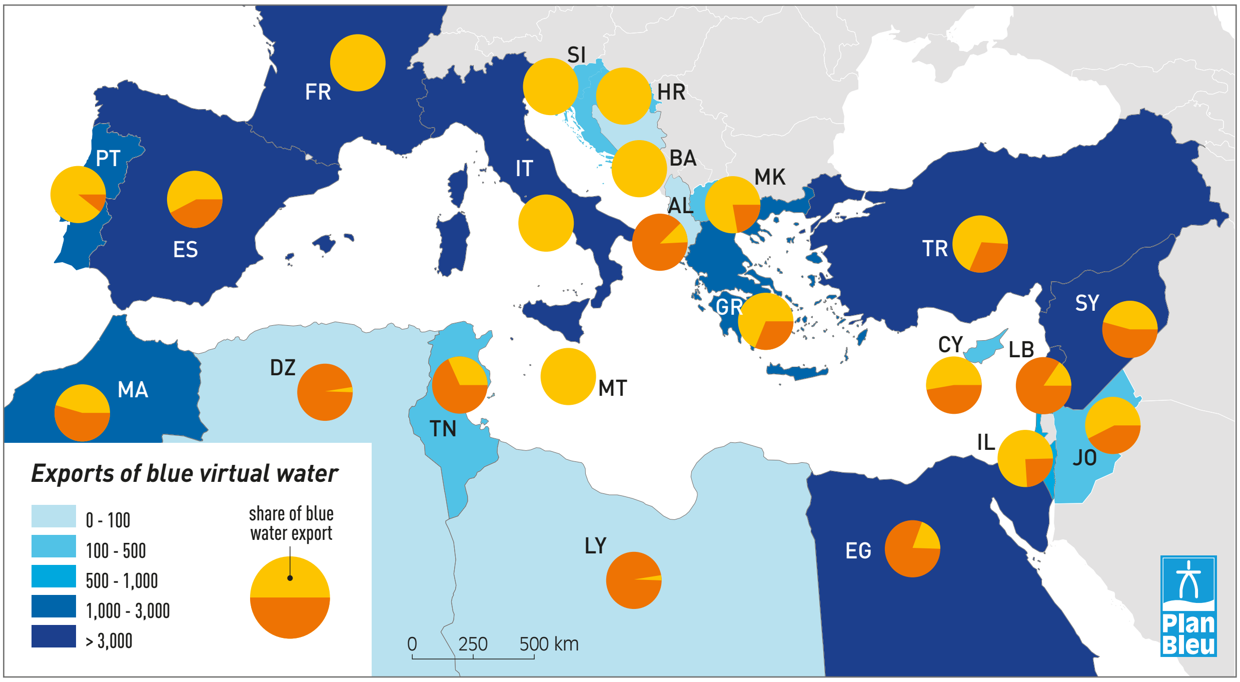


Figure 164 - Share of virtual blue water exported from the Mediterranean countries, 1996-2005 (in percentage of the total blue water consumed in the country)
(Source: Mekonnen & Hoekstra, 2011)

The 'water self-sufficiency' of a country or region is defined as the ratio of its internal water footprint to its total water footprint (Hoekstra et al. 2011). It denotes the capacity to supply the water needed for the production of the domestic demand for goods and services. The 'dependency rate' of a country or region is defined as the ratio of its external water footprint to its total water footprint[110].

Water-scarce countries with high external water dependency include Malta (92% dependency), Israel (82%), Lebanon (73%) and Cyprus (71%). Not all countries with a large external water footprint are water scarce. In this category are Northern European countries like Slovenia. They depend upon freshwater resources elsewhere, but their high dependency is not associated with their lack of water resources. These countries have ample room for expanding agricultural production and thus reducing their external water dependency (Mekonnen & Hoekstra, 2011).

A number of Mediterranean countries reduce the use of their national water resources (blue water) by importing agricultural and industrial products that are water-intensive in their production. Imports of virtual water associated with international trade of agricultural products or other water uses can help cope with water crises and shortages.

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 (Fernandez, 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 thus impact virtual water flows and water uses.

In NMCs, Cyprus, Greece and Spain are net virtual blue water exporters[111]. Spain in particular exports large quantities of blue virtual water, due to crop products (Mekonnen & Hoekstra, 2011). When considering overall virtual water, including blue, green and grey waters, Cyprus, Greece and Spain are generally net importers.

[110] The virtual-water export of a country is the volume of virtual water associated with the export of goods or services from the country (i.e. the total volume of water required to produce 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 (i.e. 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).All external water footprints of Mediterranean countries together constitute 43% of the total overall water footprint (Plan Bleu, 2011). The share of external water footprint, however, varies from country to country. Some Northern Mediterranean countries, such as Malta, Cyprus, Slovenia and Italy have external water footprints that contribute 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.

[111] With respectively 150 hm^3, 2,800 hm^3 and 9,050 hm^3 of blue water exported per year.

In the Eastern Mediterranean, Turkey is a net blue water exporter and the leading exporter of virtual blue water in the Mediterranean region. In the Southern Mediterranean, Egypt and Morocco are the countries that export the most virtual blue water[112], both also being net virtual blue water exporters (Mekonnen & Hoekstra, 2011).

The inter-Mediterranean trade of virtual water is low when compared to trade with the rest of the world. The Mediterranean region is the world's largest importer of cereals. The dependency on imports is a major hazard for food security.

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. 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 subregions, as 44% of wastewater is produced in the North, 33% in the South and 23% in the East *(Figure 165)*. While positive experiences in the region demonstrate that wastewater can be safely recycled for irrigation or aquifer recharge, about 80% of wastewater in the MENA region is released into the environment without being reused (World Bank, 2017).

The total wastewater treated in the Mediterranean 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). 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 the Syrian Arab Republic directly use 2.7 and 2.3 million m^3 of agricultural drainage water, respectively. Particular attention to degradation of drainage water quality should be paid. Israel is the reuse leader among 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 only reuses 0.2% of its wastewater (IPEMED, 2019).

First developed in situations of island isolation (Balearic Islands, Cyclades, Cyprus, Dalmatia, Malta, etc.) and in

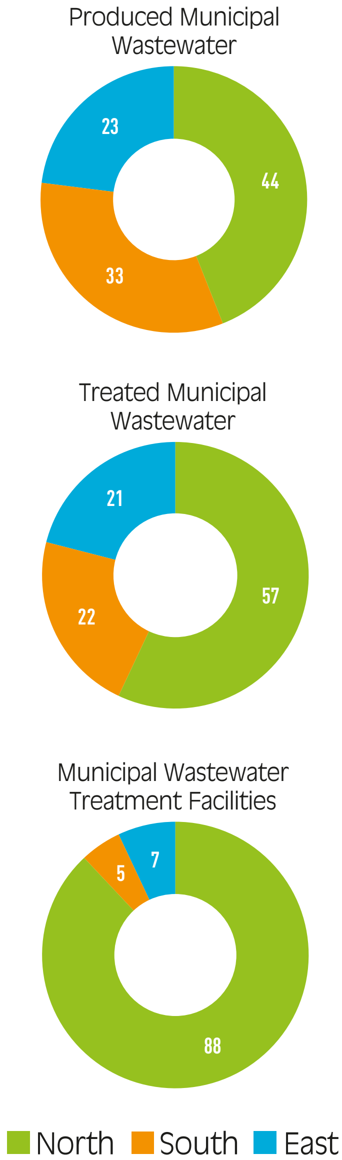


Figure 165 - Distribution of municipal wastewater produced and treated, in reference to total wastewater in the Mediterranean
(Source: FAO, 2016a)

coastal areas 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 166)*. 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 built 11 desalination plants since 2003, and plans to build two new

[112] Turkey, Egypt and Morocco export 11,370; 6,800 and 2,400 hm^3 of blue water per year respectively.

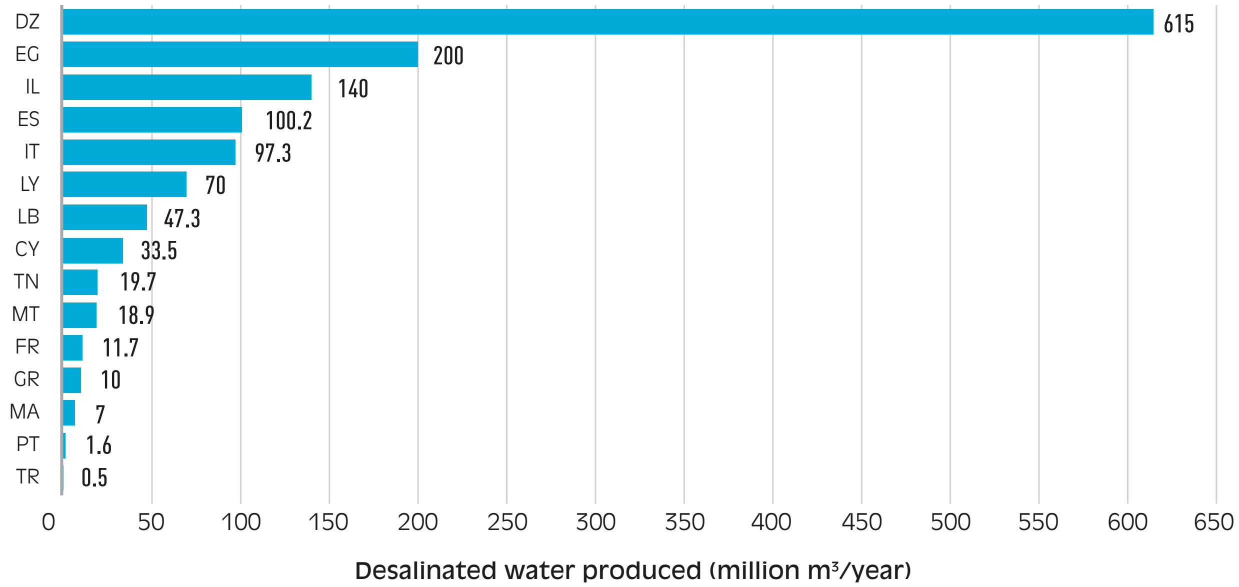


Figure 166 - Production of desalinated water in the Mediterranean
(Source: FAO, 2016a)

desalination plants, each with capacity of 300,000 m^3 per day. This is part of a plan to have 13 facilities and a total capacity of 2.31 million m^3 per day. The two new plants will increase desalinated water to 25% of the national drinking water supply, 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 and food security[113].

Large-scale desalination remains a costly option that consumes large amounts of energy and emits greenhouse

BOX 73 Trade-offs between desalination and recycled water: The Israeli experience

In Israel, desalination produces half of the water supply, and more than 85% of wastewater is recycled. The high percentage of recycled water used in agriculture has led to a demand for salinity rates in desalinated water ranging from 20 to 80 mg/l Cl-. This rate is lower than the salinity rate accepted in most places in the world and lower than the mandatory rate defined by the Israeli drinking water quality law (400 mg/l Cl-). This allows recycled water to be used for any crop without limitations and protects the soil and the aquifers. The price of this low salinity desalinated water is relatively high. However, the low salinity improves the recycled water's quality and reduces the amount of water needed to irrigate each crop (improves utility water consumption), increases agricultural production (raises profits) and reduces the costs of treating salted soil and aquifers. Overall, there are more benefits than costs.

The increase in water desalination reduces water withdrawals from the country's overdrawn natural drinking water storage bodies, the Sea of Galilee and the two main aquifers. It also helps avoid their further degradation by saline water intrusion and can raise their levels to hydrologically safe values and renew natural water levels in rivers and springs. The rehabilitation of the natural drinking water storage bodies is implemented in spite of the loss of fresh water into the sea through rivers and underground flows from the shore aquifer.

The wide use of recycled water in agriculture raises questions about the presence of medical waste in the irrigation water and its impacts on underground water quality (and on crops and soil). These questions are still being studied (Chapter 7).

A potential trade-off between desalination and recycled water can arise from the use of recycled water as an alternative to water from rivers while transferring the original freshwater to other uses. The aim of this type of policy is to achieve two objectives at the same time: conserving aquatic ecosystems and using freshwater more efficiently. However, this may potentially pollute the desalination water source in a disruptive way. Such disruption may also occur in unintended cases of spills into the sea or rivers. According to Israeli experience, it has been found that there were very few occasions when treated wastewater streams caused the shutdown of desalination plants. It more commonly forced authorities to increase the number and frequency of laboratory testing to assess water quality. It should be noted that the Israeli experience is not sufficient to generalize the existence of this trade-off; (because there is almost no wastewater or recycled water in Israeli rivers and coastal areas due to the high percentage of wastewater directed to recycling and then to agriculture). Precautionary measures to avoid potential trade-offs between desalination and recycled water can include building new desalination plants as far away as possible from wastewater flows.

[113] In the Mediterranean, desalination production in 2008 was at 10 Mm^3 per year and could multiply several times over the next decade.

gases. The cost of water produced by desalination of seawater is around 0.4 to 0.6 Euro 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. In addition, desalination has negative impacts on the environment, related to the development of coastal infrastructure but also to the discharge of brines. Energy-efficient desalination systems with relatively low CO_2 emissions are possible and need to be implemented. This includes 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 financing and competitiveness issues.

A limiting factor for desalination plants can be the quality of the sea water or brackish water used. In fact, cases of intermittent closures of desalination plants have been reported in the Mediterranean due to contamination of seawater by land-based sewage, including discharges into streams that flow into the sea. The proximity of seawater inlets to infrastructure, such as oil terminals and ports, can also potentially lead to closures, when oil is released into the Mediterranean (Tal, 2018).

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 when it comes to achieving the Sustainable Development Goals by 2030 in order 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. 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 the water point. Target 6.2 on sanitation and hygiene and Target 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 "improved" level, which was used in the MDG indicators. The previously used "improved" level corresponds to what is now called "at least basic" level, including the "basic" and "safely managed" water levels.

In 2015, around 18 million Mediterranean people did not yet have access to an improved drinking water supply (WHO & UNICEF, 2017), i.e. 3.6% of the total population of the Mediterranean region, 89% of which come from Southern and Eastern Mediterranean Countries (SEMC). Countries in the region recorded an average rate of access to improved water of 96%, which is higher than the global average of 91% (World Bank, 2019). 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 sustainable access to water directly impacts the living conditions of women, who can spend hours fetching water, and improves school attendance for girls.

In 2015, around 23 million people, with disparities between countries, did not yet have sustainable access to adequate sanitation (WHO & UNICEF, 2017), i.e. 5% of the total population of the Mediterranean region, 80% of which are from SEMCs.

As for access to water, SEMCs have also made very encouraging progress, with an average sanitation access rate of 91%, which is higher than the global average of 68% (World Bank, 2019). When it comes to access to safely managed sanitation services (as defined in SDG 6, i.e. improved sanitation facilities that are not shared with other households and where excreta are safely disposed of in situ or offsite), 182 million Mediterranean people still lack these services. Enormous efforts still remain to be made, specifically in the sanitation sector.

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

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 government budget. Between 2000 and 2015, the amount of public aid for development related to water and sanitation

Figure 167 - The Sustainable Development Goals for Water and Sanitation Services; Interpreting the Targets and Indicators
(Source: Ps-EAU, 2018)

allocated to North Africa (Algeria, Egypt, Libya, Morocco and Tunisia) rose from USD 455 million to USD 777 million (UNSD, 2015), representing a growth rate of 71% unequally distributed among the 5 countries. Disparities are significant between countries, with a minimum of USD 430,000 recorded for Libya and a maximum of USD 404 million for Morocco.

This increase in official development assistance (ODA) devoted to water and sanitation can explain 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 91% respectively; WHO & UNICEF, 2017).

6.2.6 Status and trends of water quality

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".

There is a lack of integrated historical data for the Mediterranean region on the status and trends of water quality parameters. The number of existing contaminants, as well as their spatial and temporal variations, amplify the difficulty of monitoring.

The main water quality environmental impacts in the Mediterranean, which have been recently reported in relation to the water framework directive (WFD), are seawater intrusion, eutrophication, heavy metal, pesticides from agricultural runoff, pharmaceuticals and persistent chlorinated hydrocarbon pollution (Nikolaidis et al. 2014). Considering the 16 River Basin Districts monitored for surface water pollution and habitat degradation along the Mediterranean coastline, 49% of water bodies on average are failing to achieve Good Environmental Status, the highest proportion of which are in Sicily, Italy, and lowest in Corsica, France (EEA, 2018).

Nitrate concentrations and loads increased steadily from the 1970s in the Rhone, Po and Ebro rivers, and have remained relatively constant since the 90s (Ludwig & Montreuil, 2013). Over the past decade, progress has been made to treat urban wastewater and reduce total nitrogen and total phosphorus loads, yet there is a need for further efforts to accommodate the increasing volumes of wastewater resulting from population growth and fluctuations from tourism. Nitrogen and Phosphorus are essential for maintaining biological productivity at sea and are strongly associated with water fluxes. They are therefore strongly affected by dams and river discharge alterations.

The Water-Food connection is clear when looking at nutrient loads as agriculture and wastewater treatment plants are the most significant sources of TN and TP (Malagò & Bouraoui, 2017).

Increasing water temperatures and decreasing dissolved oxygen levels are caused by air temperature increases in the Ebro (Spain) and Adige (Italy) river basins (Diamantini et al. 2018). Agricultural practices and population density have had some influence on chloride, Biochemical oxygen demand (BOD) and phosphate contents in the Sava (Slovenia) and Ebro river basins.

6.2.7 Stability and 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, Borgomeo & De Waal, 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.

The concept of water security is located at the nexus between environmental, socioeconomic and political factors. In its absence, short- to long-term processes leading to political instability, loss of livelihood, ecosystem degradation and population displacement may arise. 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, Borgomeo & De Waal, 2017).

Water, Instability and Population Displacement

One of the manifestations of this vicious cycle can potentially be population displacement. Recent phenomena in the Mediterranean region, such as the Syrian refugee crisis and the ongoing flow of migrants crossing the Mediterranean to reach its northern shores bring about questions concerning possible links 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 ability of populations to ensure their livelihoods (notably through agriculture) is strongly impacted, which can lead to conflicts and potentially migration due to competition for resources, as well as increased pressure on resource governance in host communities. Nonetheless, it is widely agreed that it is not possible to simply "blame the drought", namely environmental factors such as climate change: Water scarcity or water-related factors rarely figure in migrants' and refugees' decisions to flee their homes (Jobbins, Langdown & Bernard, 2018). Rather, the water insecurity and fragility dynamics play out in the mid- to long-term, feeding into processes of rising instability that may lead up to forced displacement or voluntary migration. Initially, 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, or failure to preserve surface and ground water resources (Sadoff, Borgomeo & De Waal, 2017).

These policy failures can threaten social cohesion while increasing tensions between governments/policymakers and citizens, and can either be partly caused or exacerbated by long-term environmental factors, such as the numerous effects of climate change. Linking the wave of rural to urban migration and the ensuing broader crisis and conflict to the severe drought which struck the Syrian Arab Republic starting in 2005 is controversial. They are also associated with broad governance failures (De Châtel, 2014). The drought did not lead to widespread migratory phenomena from rural to urban areas in other neighbouring countries that were also affected, such as Iraq, Turkey, Lebanon and Jordan (Weinthal, Zawahri & 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 migration (Jobbins, Langdown & Bernard, 2018). Nonetheless, while water resources and water, sanitation and hygiene (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 & Swain, 2016).

Emerging from the "vicious cycle" of water security 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 & Swain, 2016). Profound social instability is one of the main factors that prevent integrated water strategies from taking 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 essential resource and deprived of their capacity to access clean drinking water, proper sanitation, and to produce food to ensure their subsistence and income. Food crises can be directly related to water shortages or water supply inefficiencies. Food is essentially water that humans "eat". When water is lacking due to environmental or human factors, food production is directly impacted further down the chain. Unable to feed themselves or to obtain sufficient income from their agricultural production, 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' 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 & World Bank, 2018). This long-term, regional and collaborative approach is instrumental in building regional resilience to human or environmental disasters such as conflict, forced displacement and extreme weather events and ongoing environmental degradation.

6.3 Agroecosystems, soils and food security

6.3.1 Agroecosystems

Agroecosystems are generally defined by a dominant agricultural activity influencing the living and non-living components interacting in an ecosystem. Research increasingly considers socio-agroecosystems to take into account the human component, most relevant in the Mediterranean region, where ancient traditions and consumption habits have shaped many agricultural activities and landscapes.

The Mediterranean region hosts a variety of contrasting agroecosystems, including traditional and technologically intensive irrigated agriculture, rainfed agriculture, in particular permanent crops, pastoral and agro-sylvo-pastoral systems, coastal fisheries and aquaculture.

Permanent crops most typical of Mediterranean agroecosystems include olives, grapes, citrus and nuts. Due to their historical relevance, these agricultural products have acquired a significant share of the global food market, including organic markets. They are increasingly labelled and sold under a mark of origin label, adding value to local productions. While such profitable development is expanding in the North of the Mediterranean Basin, opportunities can be further taken advantage of in SEMCs. This would involve support to farmers' organization around local value chains, branding traditional knowledge and "terroirs", connections with local markets (in particular in touristic areas), and international export on markets for recognized quality products.

In addition to these typical crops, there is a strong presence of legumes, fresh vegetables, wheat, often complemented by a more extensive presence of livestock, mostly sheep and goats.

The Mediterranean agroecosystem can schematically be divided into two categories:

- In "fertile" areas, large irrigation systems and rainfall agroecosystems occur. These areas are said to be favourable because they receive more than 400 mm in annual rainfall. They are limited spatially by resource availability (water and land).
- "Disadvantaged/marginal" areas are characterized by mountains and semi-arid, non-irrigated fields, where agriculture is often marginal and interferes with the pastoral economy, the latter becoming dominant in the steppes. The agricultural economy in these areas can be considered "agro-sylvo-pastoral". In the Southern Mediterranean in particular, it is dependent on access to common lands and forested pastures.

Other fertile areas, typical of the Mediterranean region, include oasis and lagoon systems.

Finally, specific peri-urban agricultural models have developed in the Mediterranean region.

Agroecosystems provide a variety of ecosystem services in the Mediterranean region, including services to other sectors (tourism, industry, etc.).

In the fertile areas, the most significant type of ecosystem services rendered are the supply of food, fuel (timber) and fibre (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 value 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 favourable 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 urban sprawl in rural areas prevents water infiltration and increases greenhouse gas emissions (increase in transport consumption, etc.);
  - fire prevention by grazing activities, which decrease woody vegetation density;
  - water regulation through specific agrarian and forestry practices; and

- pollination by maintaining larger floral diversity communities; urban effluents recycling; habitat creation and protecting agricultural biodiversity.

In "disadvantaged/marginal" zones, the main services provided by agroecosystems include:

- supplying water for downstream users (essential "water tower" role 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 water infiltration, which can contribute to a positive hydrology and the storage and reorganization of carbon, but also protecting biodiversity; and
- cultural services rendered by 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.

In the last several decades, most of the agricultural areas with a Mediterranean climate have been affected by various pressures, including climate change, depleting water resources, water and soil salinization, soil degradation, and rapid urban sprawl.

In NMCs, agriculture in marginal mountainous areas is being progressively abandoned, leaving ground for forest expansion. This trend raises risks associated with forest fires and threatens unique biodiversity components associated with Mediterranean grasslands.

In SEMCs, agricultural systems in marginal mountainous areas continue to sustain small family farms. While these agro-pastoral systems have strong potential for ecological integration and sustainability, they have low labor productivity and incomes due to poor access to land and water (Alary et al. 2017). Families in these systems progressively diversify their resources towards more diverse income sources. Over-grazing continues to degrade forested areas, triggering erosion issues, and threatening downstream irrigation systems. Marginal and mountainous environments will continue to be critical to the future

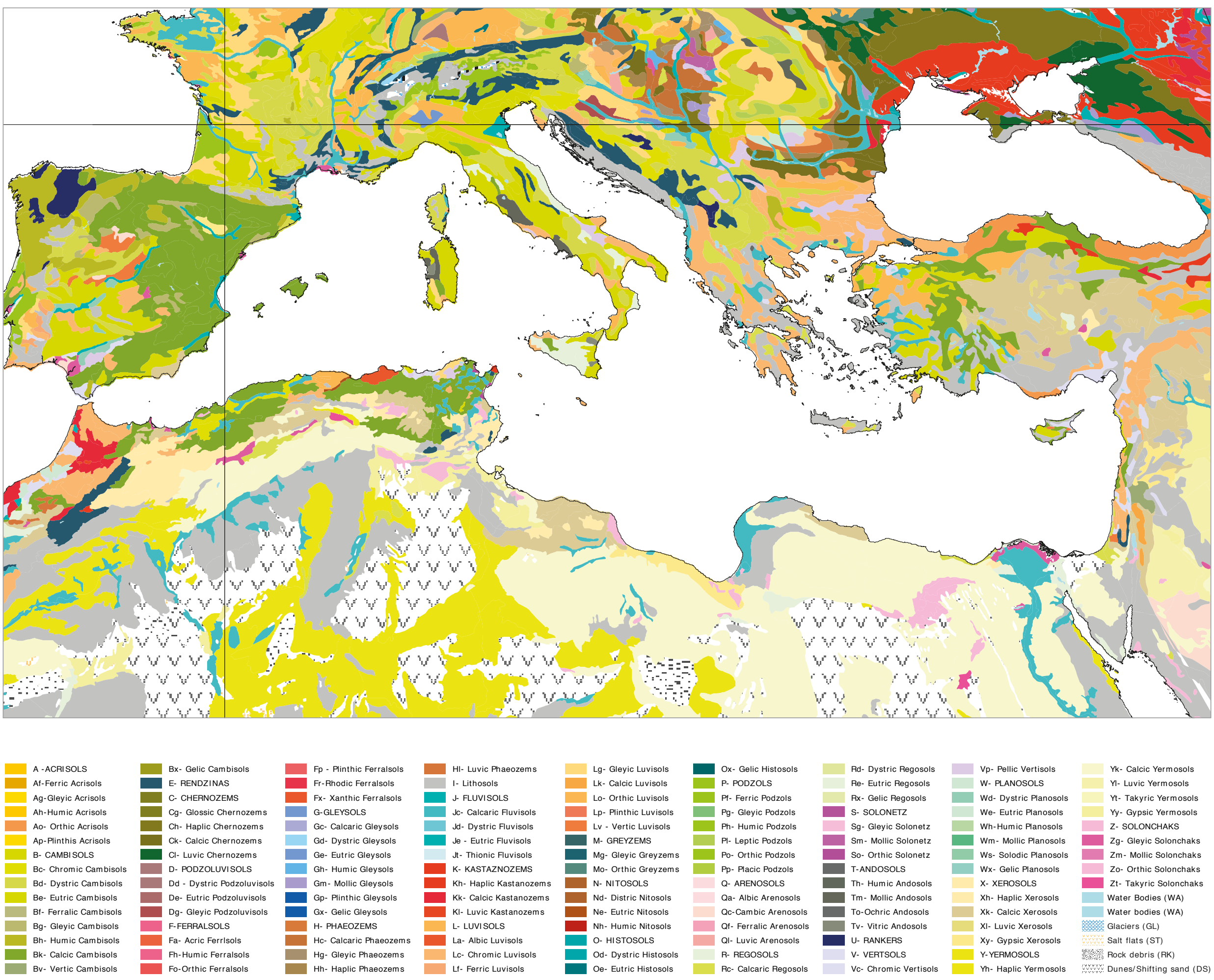


Figure 168 - Main soil types in the Mediterranean region
(Source: FAO-UNESCO, 2020))

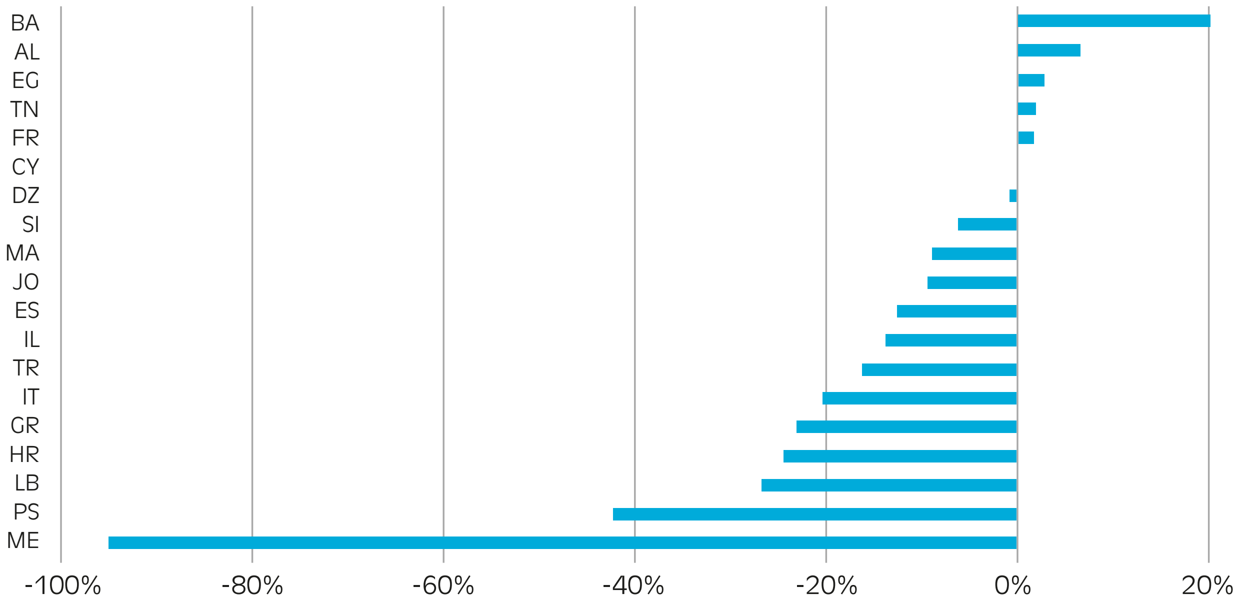


Figure 169 - Arable land area changes between 1995 and 2015, difference in %

(Source: World Bank, 2019) Note: In Montenegro, data collection for agricultural land statistics have followed a new method since 2013, which explains the unrepresentative change in arable land surface

of the Mediterranean basin as a source of livelihood for rural families and water "towers" for downstream activities. Recent research recommends *"taking advantage of the spatial mobility abilities of livestock farming in the Mediterranean to reinforce crop-livestock integration at a regional level, promoting collective actions allowing a wider range of livestock farmers in hinterlands to participate, thereby limiting loss of efficiency and reinforcing sustainability for the most vulnerable livestock farmers"* (Alary et al. 2017).

Other more localized farming systems in the Mediterranean are undergoing profound transformations.

Oasis agriculture, a fragile, complex, and highly productive ancestral system, is threatened by climate change and groundwater over-extraction.

Vast areas in the Nile Delta previously based on rice production are progressively converting to aquaculture as waters become increasingly brackish (Kara et al. 2016). This attests to the capacity of systems to adapt to profound changes if relevant solutions/innovations and policy support are in place.

6.3.2 Soil

Soil is one of the main contributors to agroecosystem functions and food security, and it is as precious as water throughout the Mediterranean. In Mediterranean history, the disappearance of some civilizations can be linked to a decline in food production due to a significant increase in 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 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 168)*, 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.

Soils are shaped by 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, and surface stability. They also host biodiversity, have an aesthetic and spiritual value, and provide an archive of geological and archaeological heritage (FAO & ITPS, 2015). These services are supported by a myriad of organisms, many of which are invisible to the naked eye but are 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. Scientific literature for the Mediterranean basin currently lacks a comprehensive synthesis of the state and trends of Mediterranean soil.

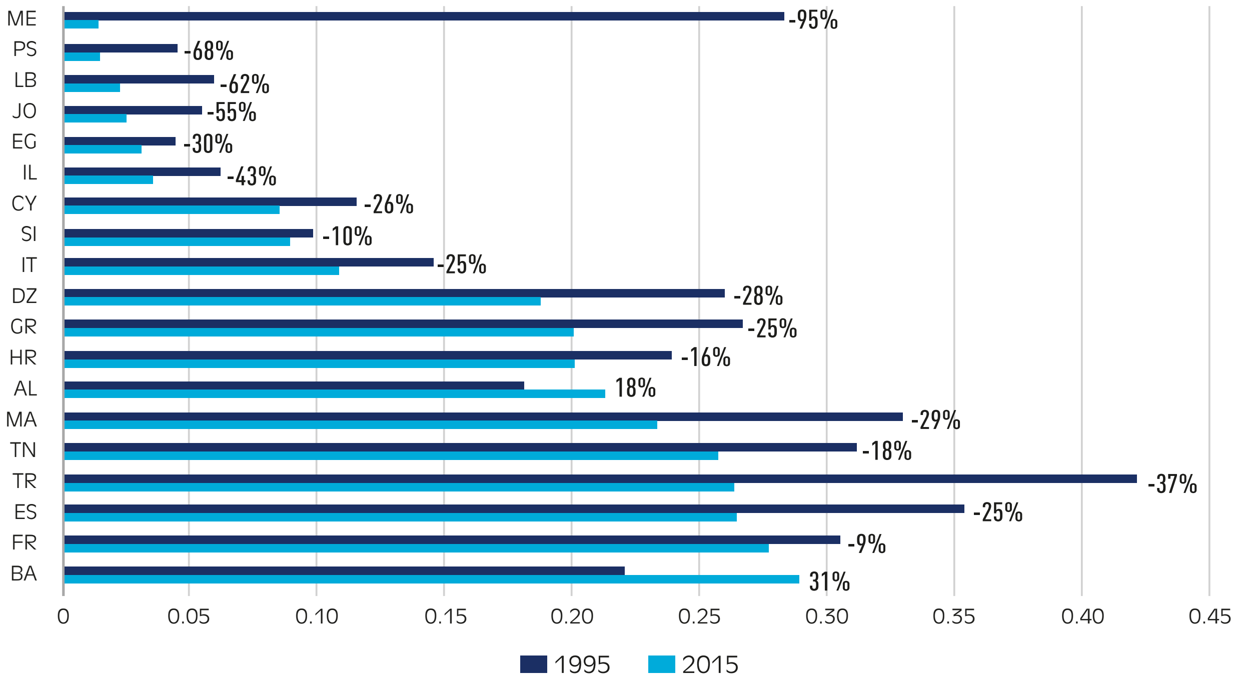


Figure 170 - Number of hectares of arable land per capita in 1995 and 2015 and changes between these dates
(Source: World Bank, 2019) Note: In Montenegro, data collection for agricultural land statistics have followed a new method since 2013, which explains the unrepresentative change in arable land surface.

The area of arable land decreased by an average of 13% from 1995 to 2015. In SEMCs, this decline is particularly notable in the State of Palestine (-42%), Lebanon (-27%), Turkey (-16%) and Israel (- 14%). In NMCs, 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 total number of hectares of arable land decreased by an average of 10% in the Balkan countries between 1995 and 2016.

The area of arable land per capita *(Figure 170)* fell by an average of 41% over the same period, more than double the loss 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%), and Lebanon (-62%).

Arable land is also unequally distributed across the Mediterranean, with over 46% of arable land in the North and only 31% in the South (FAOSTAT, 2019). 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 NMCs.

Factors influencing soil health and functions

The Mediterranean region combines factors that are conducive to soil degradation: often sparse vegetation cover, high annual climatic variability alternating wet and (very) dry years and frequent high intensity rainfall and wind, easily erodible rocks, a rugged relief where 45% of the area has 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 continuous agricultural and livestock raising activities dating back to the Neolithic period (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. These include population growth (particularly in the Southern Mediterranean), and access to subsidies (in countries under the 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), intensive coastal development and urban sprawl, and construction of transport infrastructure. The soil degradation processes include water and wind erosion, salinization and sodification, sealing and compaction, loss of organic matter and permanent loss of vegetation cover. Soil degradation is included in SDG indicator 15.3.1 "Proportion of land that is degraded over total land area", with the aim of monitoring progress towards the goal to "by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world".

In addition to intensification, many inland areas of European Mediterranean countries are experiencing increasing rural land abandonment and associated depopulation and economic marginalization. Land abandonment brings about aging and depopulation of rural areas, and migration to urban areas. When rainfall conditions are favourable, a woody encroachment of former agricultural

BOX 74 State of soil erosion

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

Reported erosion rates show high 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, a rill and interrill erosion rate of 1.3 t/ha/year for the Mediterranean area of Europe was estimated (Cerdan et al. 2010). This accounts for 21.5% of total Pan-European soil losses. Measured erosion is strongly influenced by land use *(Table 27)*. A similar study confirms the key role of land use as a determinant factor in erosion rates in the Mediterranean (Maetens, 2013). The mean annual rate for bare plots and plots where crops have been cultivated ranges from 1 to 20 t/ha/year while plots with permanent cover have erosion rates lower than 1 t/ha/year.

The erosion rates are lower for bare and cultivated areas than in wetter parts of Europe. However, areas covered by (semi-)natural vegetation showed higher rates than in the rest of Europe (yet lower than 1 t/ha/year). These counterintuitive low soil erosion values obtained for the Mediterranean region are explained by the large fraction of rock fragments on the topsoil and other significant erosion mechanisms such as gully erosion, landslides and riverbank erosion that are not well-represented at a plot scale.

Land use	Erosion rate (t/ha/year) measured at plot scale	
	Cerdan et al. 2010	Maetens, 2013
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 the 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.

Table 27 - Estimated average erosion rates by land use in the Mediterranean region

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

Countries	Estimated soil loss rate (t/ha/yr)		% of the total soil loss in EU
	Overall mean	Mean in arable land	
Cyprus	2.89	1.85	0.25
Spain	3.94	4.27	19.61
France	2.25	1.99	11.85
Greece	4.13	2.77	5.31
Croatia	3.16	1.67	1.74
Italy	8.46	8.38	24.13
Malta	6.02	15.93	0.01
Portugal	2.31	2.94	2.01

Table 28 - Average soil loss rate per EU-Mediterranean country (all land, arable lands) and share of EU soil loss
(Source: Panagos et al. 2015)

lands follows land abandonment. This secondary process results in higher biomass, which can provide habitats for various species (though it is unfavourable for grassland specific species, which are often rich components of local biodiversity), but also create an increased fire risk.

Soil erosion is a natural process, but it becomes an issue when erosion rate is higher than the soil formation rate. Natural erosion in a balanced ecosystem has a tolerable level of annual surface horizon loss (5 tonnes/ha). This loss can be accelerated by human activities to rates higher than 50 tonnes/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 soil, and changes of other soil properties (e.g. coarsening soil texture). Erosion also affects the capacity of soil to store and regulate carbon, eventually making it a net contributor to greenhouse gas emissions. Studies in semiarid parts of Spain have shown 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 diffuse pollution and eutrophication of downstream water bodies caused by eroded sediments being transported along with and the nutrients and pesticide attached to them, higher risks of flash floods transporting high loads of sediments, and reservoir siltation. The reduction of reservoir capacity is a serious issue in North African and Eastern Mediterranean countries where water availability for irrigation and drinking relies mainly on surface water storage (Ayadi et al. 2010).

Soil salinization is one of the most widespread soil degradation phenomena that not only affects soil fertility, productivity and resilience against stressful environmental factors, but also reduces land use options (crop selection, land suitability) to accommodate market conditions and demand. Salinization 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) negatively affect soil fertility and productivity. High soil osmosis and head potentially restrict water availability to plants, which negatively affect plant growth and reduce crop production. Conditions causing low biological activity such as low surface organic matter content after fires, weak microbial activity caused by salinity or pollution, 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 have a specific impact on soil functions and are associated with an increasing risk of desertification, i.e. the process of land degradation in arid, semi-arid and dry sub-humid areas. It is considered that approximately 10% of the European territory is affected by varying degrees of desertification (Rubio & Recatala, 2006). Soil is the main actor in desertification processes. It is a living environment with enormous biological activity that is highly sensitive to the availability of water and climate variation. In Mediterranean terrestrial ecosystems, the short-term effects of a drier climate on decomposition lead to a reduction in soil microbial biomass (Curiel-Yuste et al. 2011), reduced soil respiration (Asensio et al. 2007; De Dato et al. 2010; Emmett et al. 2004) and reduced soil enzyme activities (Hueso, Hernández & García, 2011; Sardans & Peñuelas, 2005). The medium-term (i.e. a few decades) effects impact litter quality by reducing nutrient content (Sardans et al. 2008; Wessel et al. 2004) or by increasing recalcitrant compounds (molecules resisting microbial decomposition) (Hernandez, Alegre & Munné-Bosch, 2004; Munné-Bosch & Alegre, 2000), and altering the composition of decomposer communities via feedback processes.

Soil degradation, in turn, affects important climate regulation factors 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 from 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 and major socioeconomic consequences (water scarcity, food insecurity, forest fires, forced displacement).

6.3.3 Food security

The four pillars of food security are availability, access, utilization 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 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 stability, partially from internal production, but especially from trade and reliable international markets. The price volatility of agricultural commodities can harm 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 commodity markets and price volatility. This volatility came at a time of prevailing difficulties for international agricultural commodity markets, 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 SEMCs 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 agro-climatic 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: production imbalance between the Northern and Southern Mediterranean regions and increased dependence of Southern countries on basic food commodities

Trends in food production

The demand for livestock products is expected to grow in the coming decades, but there are significant challenges for livestock systems under changing climate and social conditions (Herrero et al. 2013). In 2014, animal food and feed imports represented around 32% of total food imports (Weindl et al. 2015). The impacts of climate change on local production potential, combined with the growing demand for animal products due to demographic growth and changing consumption habits will increase the food dependence of the Southern Mediterranean countries in the coming decades (estimated at around 50% of 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; Fernando et al. 2016; Fitzgerald et al. 2016). Pests and diseases, as well as mycotoxins could also present a serious threat under unfavourable climate conditions (Bernués 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, could impose additional constraints on agricultural land (Herrero & Thornton, 2013).

Yields for many winter and spring crops are expected to decrease due to climate change, especially in the South. It is estimated that by 2050, Egypt will see a 40% reduction in legume production, with a 12% reduction for sunflowers and 14% reduction for tuber crops in Southern Europe. Warming will also affect olive production by increasing irrigation needs (Tanasijevic et al. 2014), the risk of heat stress around flowering and the lack of chilling accumulation (Gabaldón-Leal et al. 2017), and by altering fly infestation risks (Ponti et al. 2014). Although the impact is not projected to be significant for aggregated productions, local and regional disparities will emerge (Ponti et al. 2014). Changes in the phenological cycle towards shorter durations and early flowering are projected for grapevines, with associated increased exposure to extreme events and water stress (Fraga et al. 2016). These conditions could also affect quality. Early blooming and insufficient 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 factor limiting yields (Arbex de Castro Vilas Boas et al. 2017), although water-saving strategies to enhance quality and nutritional aspects while maintaining satisfactory yield levels could be developed (Barbagallo et al. 2013). For some crops, yields may increase due to CO_2-fertilization effects which could improve water use efficiency and biomass productivity (Deryng et al. 2016; Fraga et al. 2016), although significant uncertainties exist due to complex interactions among the various factors and current knowledge gaps (Fitzgerald et al. 2016; Link, Kominek & Scheffran, 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 an important role in the future. Mediterranean countries import more fish products than they export as a result of 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 on 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 fishing sector. By 2040-2059, compared to 1991-2010, more than 20% of fish and invertebrates currently fished in the Eastern Mediterranean are projected to become locally extinct under the most pessimistic scenario (RCP 8.5) (Cheung et al. 2016; Jones & Cheung, 2015). By 2070-2099, forty-five species are expected to qualify for the IUCN Red List and fourteen 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 with respect to the 1990s under RCP 8.5 (Cheung et al. 2016). In the face of climate change, the expected migration of species to cooler areas as the ocean warms (Poloczanska et al. 2016) may be limited to enclosed seas and the Mediterranean Sea has been described as a 'sans issue' (no exit) for endemic fish, including commercial species (Ben Rais Lasram et al. 2010).

BOX 75 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 significant 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 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, major uncertainties and significant 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 to their productive, environmental and social functions (Bernués et al. 2012; Herrero & Thornton, 2013). Currently, the Mediterranean region is characterized by a mixed production system in the North and some Southern regions, while grazing systems dominate the Southern regions (Herrero et al. 2013b). The number of agricultural holdings with grazing livestock is on the decline but the number of animals per farm is increasing (Bernues et al. 2011). The abandonment of marginal land threatens the future of these pasture-based systems. Transition to mixed crop-livestock systems 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 increased by 25% from 1993 to 2013.

Overall, expected climate and socioeconomic changes pose threats for food security in the Mediterranean region. These pressures will not be consistent across the region and different production sectors, creating further regional imbalances. Sustainable food production is an issue under unfavourable climate and socioeconomic conditions.

Trade: Imports are crucial to cover food needs

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 agro-climatic 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), making it the leading vegetable 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) dominate 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[114], 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[115].
The main Mediterranean players in the world agricultural trade are Northern countries (Spain, France, Italy and Greece), three North 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.
Although France is one of the main exporters of cereals and dairy products, all Mediterranean countries, except Croatia and Turkey, register a net cereal deficit and a high cereal dependency ratio (see *Figure 170* and *Figure 171*).

The climate regime and natural resources limit cereal production[116]

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 less than 7% of global cereal supply in recent years (FAOSTAT, 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 Mediterranean Agricultural Market Information Network (MED-Amin) coordinated by the International Center for Advanced Mediterranean Agronomic Studies (CIHEAM) was launched in 2014 in 13 countries to process information on cereal markets in the Mediterranean. The first Policy Brief (MED-Amin, 2016) summarized the cereal situation in the region as highly imbalanced as the region is facing strong constraints and is exposed to cereal market reversals.

Figure 171 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 from the Mediterranean region was higher in the West than in the East for 2011-2013.

[114] 5th most traded fruit in the world after citrus fruits, bananas, mangos and pineapples.
[115] Turkey is the largest global exporter of dried apricots. It is also the world's second producer and leading exporter of raisins (FAOSTAT, 2017).
[116] This paragraph specifically mentions cereals given the importance of these crops in Southern and Eastern Mediterranean countries (SEMCs).

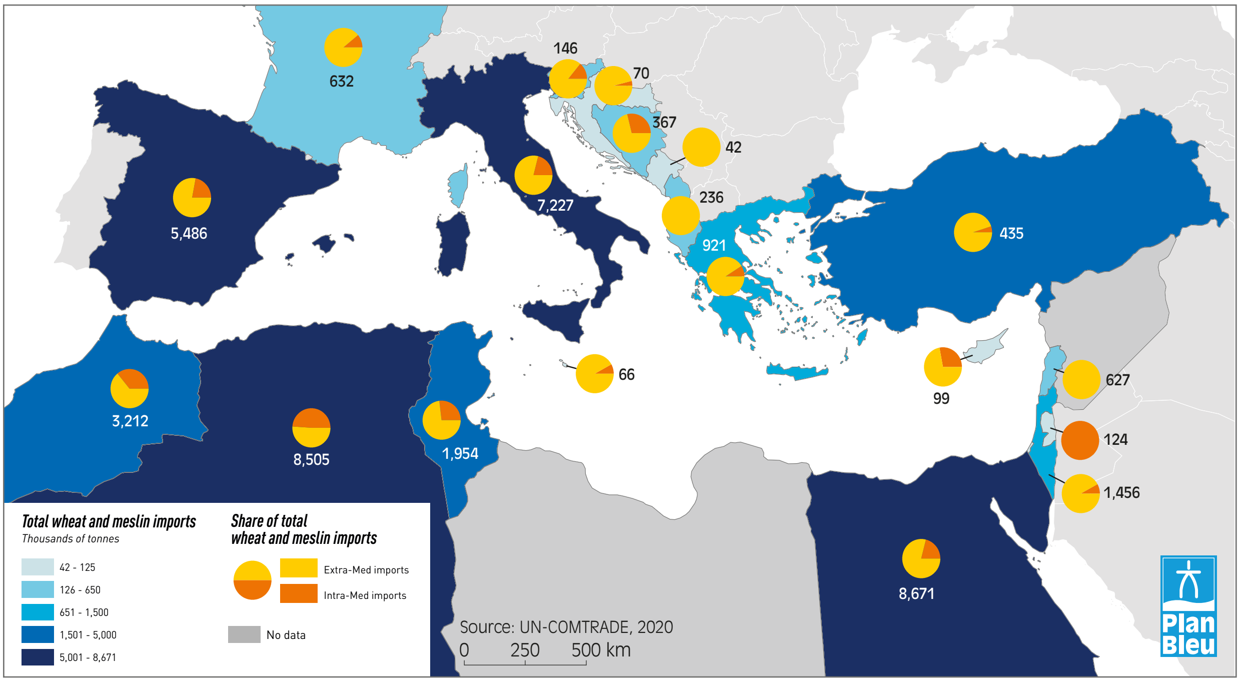


Figure 171 - Wheat and meslin[117] imports in Mediterranean countries, 2015
(Source: UN-COMTRADE, 2020)

The agricultural production deficit is primarily due to agro-climatic conditions and the scarcity of arable land (see above) and water resources[118]. Average rainfall is another agricultural difficulty facing Mediterranean agriculture, particularly in Southern countries *(Table 29)*.

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 salinization due to lack of drainage.

In addition to these characteristics, Southern Mediterranean 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 30*.

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

The only Mediterranean countries with a positive agricultural trade balance are France (+ USD 3.4 billion) and Spain (+ USD 13.1 billion). Turkey registered a positive trade balance of over USD 5.7 billion in 2016 (FAOSTAT, 2019), but a negative balance (- USD 99 million) in 2017 (WTO, 2017).
In 2017, food import expenditure per capita varied by country. It was especially high in countries like Malta (USD 1,198 per capita), Montenegro (USD 820 per capita), Cyprus (USD 738 per capita), Israel (USD 547 per capita) and Lebanon (USD 461 per capita). It is low in Tunisia (USD 92 per capita), Croatia (USD 78 per capita), Turkey (USD 12 per capita) and Morocco (USD 5 per capita).

[117] The FAO defines meslin as a mixture of wheat and rye.
[118] 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, 2019).

Countries	Arable land (ha) 2016	Hectares/ person	Average precipitation mm/year 2014	Cereals (ha) 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 and Herzegovina	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	
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	
State of Palestine	64,000	0.01	402	24,497	10.6	
Slovenia	184,050	0.09	1,162	99,435	9.1	0.5
Spain	12,338,000	0.27	636	6,265,086	24.7	17.6
Syrian Arab Republic (2007)	4,662,000	0.25	252	2,244,751	25.4	9.4
Tunisia (2016)	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	1,500,000,000	0.19	-	718,123,234	11.0	

Table 29 - Land availability, rainfall and cereal crops in the Mediterranean in 2017
(Source: World Bank, 2019)

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.

Mediterranean countries received one third of global cereal imports (Abis, 2015). 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 USD 10 billion on wheat (3.5 times the 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 31*.

UN forecasts to 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, 2018b). 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

Countries	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 and Herzegovina	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
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	6¬1	1,167	2,479	1,323,	1,774	3,861	-1,382
State of Palestine							
Slovenia	231	421	1,201	559	931	1,883	-682
Spain	10,984	20,468	37,399	8,620	14,180	21,337	16,062
Syrian Arab Republic	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

Table 30 - Exports and imports, balance of agricultural trade (106 USD)
(Source: FAO, 2018a; FAOSTAT, 2019)

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.

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 et al. 2018).

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

One of the main factors contributing to 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 subsistence and standards of living. In the Mediterranean region, the situation is different between the North (EU) and the SEMCs. 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 vulnerable 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 urbanization in the region, there is still a large rural population. Major territorial divides are forming between rural and marginalized 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

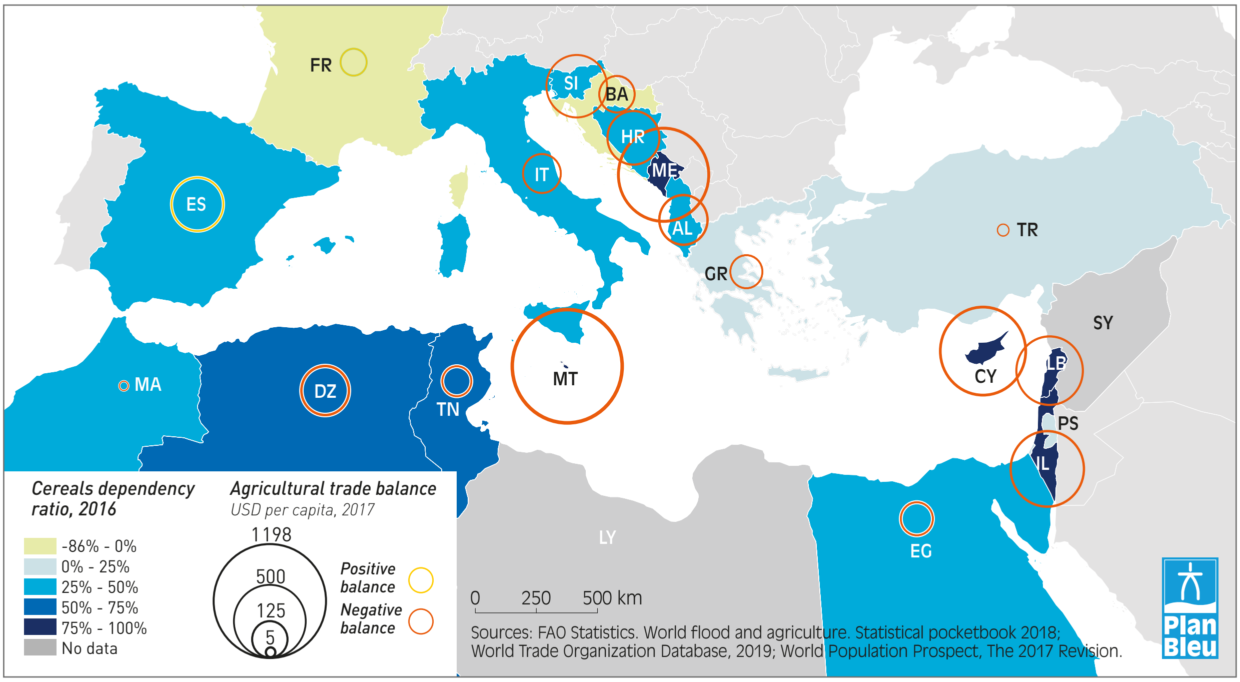


Figure 172 - Agriculture balance and cereal dependency ratio for Mediterranean countries
(Source: FAOSTAT, 2019; WTO, 2017)

Countries	Cereal import dependency ratio (%) in 2016
Albania	40.2
Algeria	72.2
Bosnia and Herzegovina	37.0
Croatia	-11.6
Cyprus	100
Egypt	42.1
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
Spain	31.8
Syrian Arab Republic	N/A
Tunisia	59.7
Turkey	4.0

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

Table 31 - Cereal Import Dependency Ratio in the Mediterranean
(Source: FAO 2018a; FAOSTAT, 2019)

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 forcing 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 (AFD & CIHEAM, 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

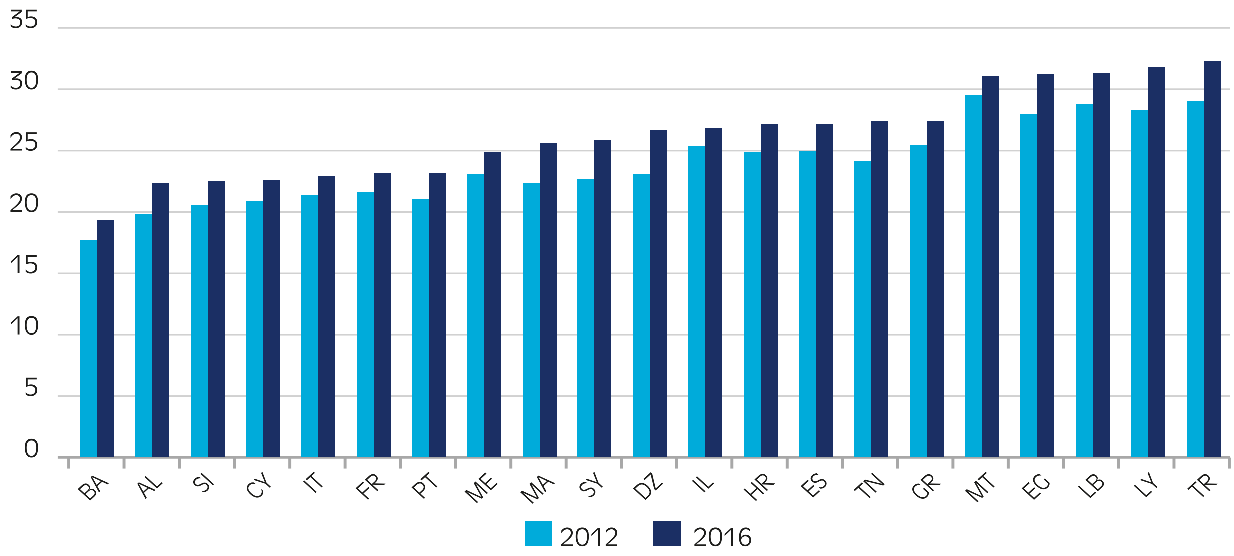


Figure 173 - Prevalence of obesity in adults (18 and over) in %
(Source: FAO et al. 2018)

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 agrifood 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 SEMCs) or social safety nets help to mitigate food price increases and improve purchasing power to a certain extent. 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).

6.3.3.3 Nutrition, quality and food use: 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 exists 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 degree of 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. 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 urbanization, changes to food distribution, the globalization 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 (SEMCs).

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

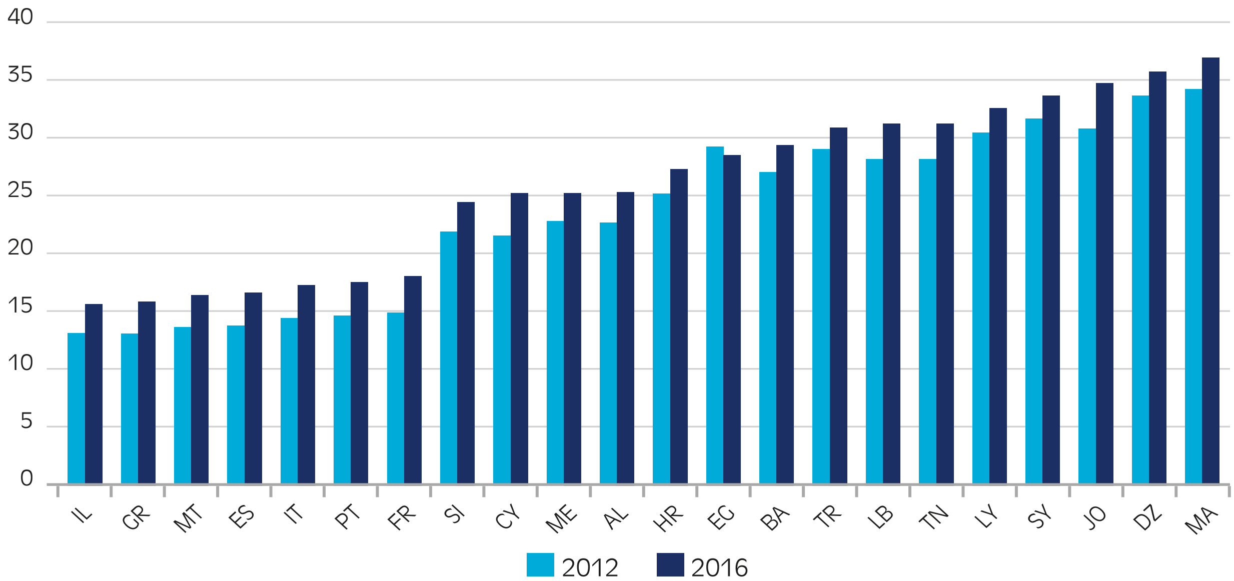


Figure 174 - Prevalence of anaemia in women of childbearing age (15-49 years)
(Source: FAO et al. 2018)

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 et al. 2018) shows a worrying increase in the number of people who are overweight or obese between 2012 and 2016 in all Mediterranean countries *(Figure 173)*. 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 and 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.

In 2017, about 21 million Mediterranean people lived below the level of food requirements, representing 4% of the total population (Blinda, 2018). This undernourished population is unevenly distributed with 74% living in SEMCs and 26% in NMCs (Blinda, 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 174)*, and exceeds 30% in Algeria, Lebanon, Libya, Morocco, Syrian Arab Republic, Tunisia and Turkey.

Although food safety has generally improved in recent decades with the rise of globalization and major retailers, nutritional quality is somewhat lacking, with less food diversity, reduced consumption of local and seasonal products, and the loss of traditional recipes and know-how for conservation. However, since the 1990s, citizens' movements have promoted short supply chains 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).

6.3.3.4 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 consistent 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, with several world record years in cereal production, 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 (OECD/FAO, 2018). 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 power.

The second factor to take into account in 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 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 (FAO, 2017). That is six times higher than the number of undernourished people in countries not affected by conflicts (4.6% on average). For example, the prevalence of undernourishment in Libya or the 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 localized 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 insecurity. Despite international food assistance, Syrian refugees are putting a strain on host communities in neighbouring countries (Lebanon and 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 drop dramatically due to a global increase in temperatures, prolonged periods of drought and extreme climate events. According to the World Bank report (World Bank Group, 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

The status and trends of water and food security in the Mediterranean region described above show that among Mediterranean people and countries, there is an increasing risk of resource depletion (water, soil), diminished resource quality, uneven access to resources, and instability. Specific management responses to ensure food and water security include:

- Integrated Water Resources Management, Water Demand Management and Good Water Governance;
- Increased monitoring;
- Wastewater treatment, recycling and reuse;
- Clean production techniques;
- Ecohydrological conservation and restoration techniques such as aquifer recharge, soil and water conservation practices;
- Rainwater and stormwater capture and use;
- Desalination;
- Agro-ecology and sustainable land management;
- Rural development and support to smallholder farming.

6.4.1 Integrated Water Resources Management

As presented throughout this chapter, water security entails ecosystem and human health issues, tackles water quantity and quality issues, and questions water governance arrangements. Water security is not yet a ready-made operational concept. A first step in fully introducing this concept 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). Integrated frameworks have been developed in line with this definition to address water resources and demand relationships and their evolution under climatic and anthropogenic changes, and promote dynamic water resources and demand management. These modelling tools first evaluate the hydro-climatic conditions of catchment areas and then water demands to finally assess water stress or water allocation rates under climate 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. Subregional decision support systems were then developed. These include the WEAP model (Yates et al. 2005), REALM model (Perera et al. 2005), Aquatool model (Andreu, Capilla & Sanchis, 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 site relationships, dam operating systems or even local institutional instruments. They therefore provide better insights on local water issues and on the effectiveness of adaptation policies and techniques. They are also useful to identify the regions that are most vulnerable to climate and/or anthropogenic pressures as well as sectors and seasons during which water shortage might occur.

The development of integrated approaches for water resources reflects the spatial diversity of pressures and availability. It also provides local support for deciding which sustainable development strategy to adopt based on the specific geographical and anthropogenic issues of the area.

6.4.1.1 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 actions and organizational systems intended to increase the technical, social, economic, environmental and institutional efficiency in the different sectors of water use (intra-sectoral efficiency), and to better allocate water between different uses (inter-sectoral efficiency). This concept of WDM was developed in the 1990s in response to water supply development policies, particularly in the agricultural sector.

It is based on the implementation of a combination of legislative, institutional, technical, economic and other actions and tools, such as reducing leaks, using water-saving equipment, establishing progressive water pricing, environmental taxes, quotas, water rights or payments for environmental services.

Economic valuation also suggests that WDM measures are often cost-effective and enable better allocation of scarce financial resources, when compared to, for example, dam construction, water transfers or desalination in areas facing water scarcity problems. 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 decision-making tools.

6.4.2 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 realized that in a traditional fragmented approach, attempting to achieve security in one of these sectors without addressing trade-offs with the other two sectors will endanger their sustainability and security. Overall results can be achieved by creating intelligent synergies and fair trade-offs among them, while providing opportunities for innovation and learning to minimize 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. The goal is to reconcile their interests and resolve 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

BOX 76

Examples of progress made in water efficiency and sensible management of demand in Mediterranean countries

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 are no large scale examples in the Mediterranean, but they exist elsewhere. In Ethiopia, for example, the water table had previously fallen to a 30 m depth and has been recovered to less than 3 meters in just 20 years. Poverty has been halved simply by better managing all vegetation, soil and water.

dialogue, governance improvements, mobilization of financing, replicable applications, collaboration and coordination.

In order to fully capitalize on the benefits and synergies under a Nexus approach, the development and management choices in the water-energy-food sectors require enhanced integration in terms of knowledge, policy, legislation and institutional 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 into separate groups, with limited interaction.

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. Integration is also being achieved when it comes to action planning and implementation, even though some ministries or sectoral institutions often have stronger leverage and decision-making power.
At the institutional level, *Table 32* presents a mapping of the nexus-related competencies of the relevant Ministries in all Mediterranean countries.

<table>
<tr><th>Countries</th><th>Environment</th><th>Energy</th><th>Water</th><th>Agriculture</th><th>Nexus Integration of Ministerial competencies</th></tr>
<tr><td>Spain</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>France</td><td colspan="2">Ministry for the Ecological and Inclusive Transition</td><td>Cross-ministerial</td><td>Ministry of Agriculture and Food</td><td>Environment & Energy (and partially water)</td></tr>
<tr><td>Italy</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>Slovenia</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>Croatia</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>Bosnia and Herzegovina</td><td>Ministry of Environment and Tourism (FBiH) / Ministry of Spatial Planning, Construction and Ecology (RS)</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>Montenegro</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>Albania</td><td>Ministry of Tourism and Environment</td><td>Ministry of Infrastructure & Energy</td><td>Water Resources Management Agency</td><td>Ministry of Agriculture and Rural Development</td><td>-</td></tr>
<tr><td>Greece</td><td colspan="3">Ministry of Environment and Energy</td><td>Ministry of Agriculture</td><td>Environment, Energy, Water</td></tr>
<tr><td>Malta</td><td>Ministry of Environment, Sustainable Development, and Climate Change</td><td colspan="2">Ministry for Energy and Water Management</td><td>Ministry for Agriculture, Fisheries and Animal Rights</td><td>Energy & Water</td></tr>
<tr><td>Cyprus</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>Turkey</td><td>Ministry of Environment and Urbanism</td><td>Ministry of Energy and Natural Resources</td><td colspan="2">Ministry of Agriculture and Forestry</td><td>Agriculture & Water</td></tr>
<tr><td>Lebanon</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>
<tr><td>Israel</td><td>Ministry of Environmental Protection</td><td colspan="2">Ministry of National Infrastructure, Energy and Water Resources</td><td>Ministry of Agriculture and Rural Development</td><td>Energy & Water</td></tr>
<tr><td>State of Palestine</td><td>Environmental Quality Authority</td><td>Palestinian Energy and Natural Resources Authority</td><td>Palestinian Water Authority</td><td>Ministry of Agriculture</td><td>-</td></tr>
<tr><td>Egypt</td><td>Ministry of Environment</td><td>Ministry of Electricity and Renewable Energy</td><td>Ministry of Water Resources and Irrigation</td><td>Ministry of Agriculture and Land Reclamation</td><td>-</td></tr>
<tr><td>Libya</td><td>Ministry of Health & Environment</td><td>Ministry of Electricity & Renewable Energy</td><td>Ministry of Water Resources</td><td>Ministry of Agriculture, Animal and Marine Wealth</td><td>-</td></tr>
<tr><td>Tunisia</td><td>Ministry of Local Affairs and Environment</td><td>Ministry of Energy, Mines and renewable Energies</td><td colspan="2">Ministry of Agriculture, Hydraulic Resources and Fisheries</td><td>Agriculture & Water</td></tr>
<tr><td>Algeria</td><td>Ministry of Environment and Renewable Energies</td><td>Ministry of Energy</td><td>Ministry of Water Resources</td><td>Ministry of Agriculture, Rural Development and Fishing</td><td>Environment & Energy (only regarding renewables)</td></tr>
<tr><td>Morocco</td><td colspan="2">Ministry of Energy, Mines and Sustainable Development</td><td>Ministry of Public Works, Transportation, Logistics and Water</td><td>Ministry of Agriculture, Maritime fisheries, Rural Development, Water and Forests</td><td>Environment & Energy</td></tr>
</table>

Table 32 - Mapping of Nexus-related Ministerial Competencies in the Mediterranean
(Source: GWP-Med, 2018)

BOX 77

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) aimed to contribute to the quality of the Euro-Mediterranean research area, with a special focus on bi-regional Euro-Mediterranean scientific and technological cooperation, research and innovation, 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 framework 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 addressing the Nexus:

1. Integrating the Nexus concept in all relevant policies, laws and regulations by:
   - Promoting participatory policymaking 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, in a system-wide manner is challenging because of continued limited knowledge on 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.

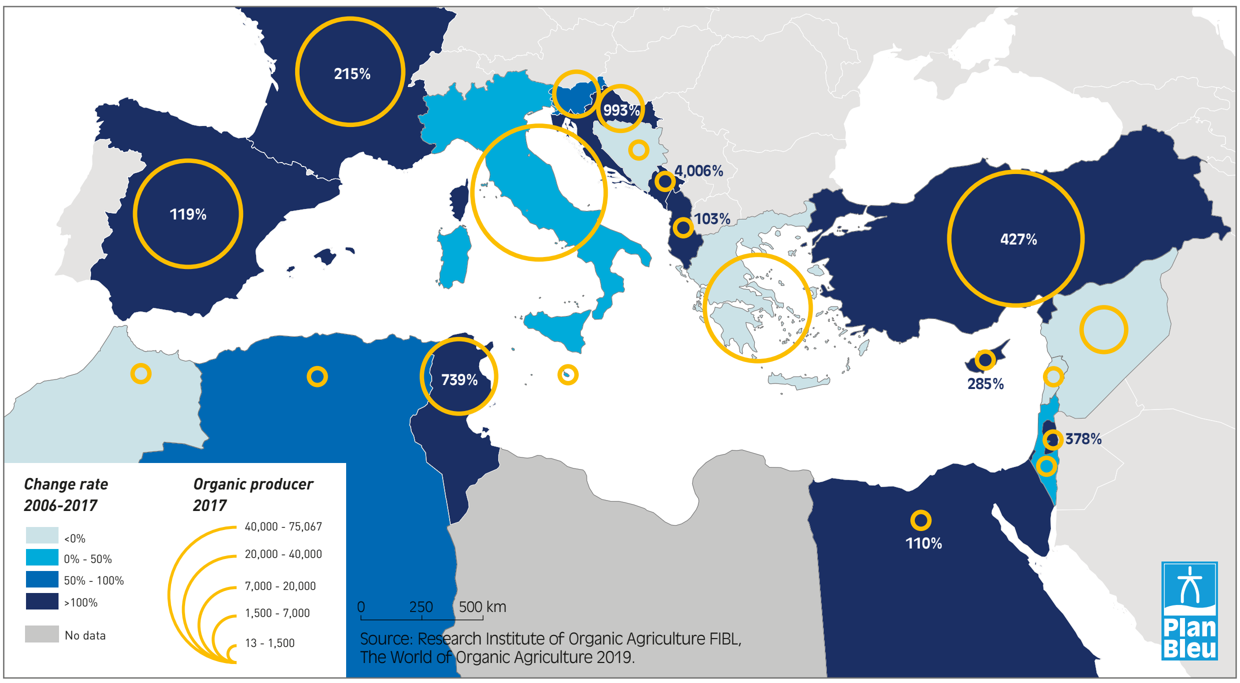


Figure 175 - Change in the number of organic farms in Mediterranean countries

6.4.3 Agro-ecological transition and sustainable agriculture

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

SDG Target 2.4 calls for the development of sustainable food production systems and implementation of resilient agricultural practices that increase 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

BOX 78 Chrichira case study - The principle of energy economy and recovery of energy lost in water pumping

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

In all drinking water systems, considerable energy is spent on pumping, to fill water towers and reservoirs at height. 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 distribution system. For that purpose, SONEDE devised a preliminary plan for optimizing the piping layout to improve system efficiency and installing 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 proposed SONEDE project from both the technical and financial perspectives and assist in the preparation of technical specifications to initiate the call for tenders. 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 centre 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 distribution network of around 226 km of pipes of different diameters, allowing the production and distribution of nearly 1000 l/s (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 pipe network.

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 three years. Based on assessment outcomes, installing hydroelectric micro turbines in water distribution systems with favourable technical conditions may present a very promising energy resource within the water-energy nexus. Based on the Chrichira case study, conclusions and general recommendations are to be drawn for other drinking water network projects:

Figure 176 - Water pressure dissipation using a load breaker

- There is no standard solution, they need to be adapted to each context and each situation.
- First look for energy savings on pumping, by identifying 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 technical solution, followed by thorough optimization in dialogue with the equipment suppliers, (e.g. fixed flow, variable flow, or combination of two turbines or Pump-as-Turbine (PaT)).
- After having chosen a turbine or pump according to the data of the studied site (height and flow), do not hesitate to **conduct a second optimization phase** according to the available equipment (adaptation of the flow of water to a specific pump, achieve optimum operation if possible).
- **In the choice of equipment, take into account the human dimension and corporate culture** (for operation and maintenance know-how, capacity-building and training needs). For example, PaTs are well adapted to the case of SONEDE, which already manages a large number of pumps.

on the proportion of agricultural area under productive and sustainable agriculture, considering the environmental, economic and social dimensions of sustainability. Between 2006 and 2017, the number of organic farms has highly increased in Croatia, Egypt, France, Slovenia, Spain, Tunisia and Turkey *(Figure 176)*. Better soil management would result in their enrichment in organic matter, through agro-ecology, irrigation and land protection.

6.4.4 Rural development and smallholder farming

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, radicalization and conflicts. Collective organizations (rural markets, farmer organizations, local value chains, infrastructure, distribution, new services) need to be developed with new citizen-based initiatives.

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. Capitalizing 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 preserve biodiversity and conserve 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 recognized, and improving agricultural practices and production can help improve the nutrition of family members, including children, the causal link is

BOX 79 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 which need to be taken in the face of climate change.

For the water sector, the challenges are relatively prevalent and affect the whole country. They include 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 depending on the region and remains subject to uncertainties which need to be addressed.

Recommended solutions concern the efficiency in the use of available resources, the equitable share of water between users, greater solidarity, waste reduction and the development of more sustainable uses of water that are less vulnerable to hazards. The plans also call for preserving or restoring the proper functioning of aquatic, wetland and coastal 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 being carried out within the framework of *Schémas Directeurs de la Gestion des Eaux (SDAGE)*, i.e. water management guidelines, to recover the good status of water bodies and habitats. Climate change adds urgency and increasing efforts in their implementation. Given the widespread vulnerability of territories to water availability, the question is no longer whether or not to act, but rather to identify where and on what priority issues to invest efforts. To scale up this effort, the Rhône-Méditerranée (2014) and Corsica (2018) basin adaptation 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 avoid poor adaptation.

Initiatives are being multiplied to act locally on what makes a territory or economic sector vulnerable. Water managers provide a diagnosis in order to identify the different sectors, structures and natural environments that would be highly vulnerable to climate change phenomena. This work may include, for example, drinking water supply schemes, irrigated agricultural sectors or remarkable natural environments. This way, investment priorities are identified to act faster and more effectively in the face of climate change.

not currently systematic (Dury, Alpha & Bichard, 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 women's organizations, in their dual function as 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's 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.**

6.4.5 Climate change adaptation

MENA countries have acceded to international conventions and created institutions dedicated to climate change management. Various water saving measures have been planned and demonstrated, such as dam construction, adaptation of itineraries, introduction of new techniques and non-conventional water resources such as reuse of treated wastewater, systems of production conversion, combating desertification and drought, river basin management, activity diversification in rural areas, forest area management and development of insurance against climate risks. Another proposed measure is to mobilize civil society to contribute to environmental management. In priority 4 of its strategic guidelines, 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 are also no systems for monitoring or evaluating these measures.
At the regional level, research programmes are in place, but there is insufficient exchange and 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 used to serve 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.
Several recommendations can already be made:

- Structural reforms are needed to support family/ smallholder farming.
- The gradual withdrawal of certain crops and practices should be organized due to their growing unsuitability to the bioclimatic environment.
- 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 establish non-agricultural activities in rural areas and / or to organize progress.
- Investment in human capital will provide a dignified living environment for rural populations.
- Agriculture and food production are highly globalized and interlinked sectors, and main sources of income for a vast

part of the Mediterranean population. Resources must be dedicated to secure and stabilize food systems by means of climate-change adaptation.

6.4.6 Knowledge and data gaps

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 is not always consistent. Data is lacking on coastal areas or coastal watersheds despite the fact that they could be the most relevant scales of analysis in the context of the Barcelona Convention.

Monitoring the impact of tourism on water resources is one of the key areas where data is lacking. Only cities are covered by systems which monitor the impact of tourism on water resources and their seasonal variations. There is no general data on this topic in the Mediterranean.

An eco-systemic 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, flooding and flood prevention, and coastal protection.

The major knowledge gaps highlighted throughout this chapter include:

- no recent data available at the catchment scale for the entire Mediterranean region, e.g. water availability and demand;
- low proportion of water bodies with functioning monitoring systems, e.g. gauging stations, water quality measurements;
- lack of integrated data on water quality, regional platform for gathering water quality data, selected list of parameters to focus on;
- no comprehensive synthesis of the status and trends of Mediterranean soils;
- limited quantification of soil erosion;
- high uncertainties concerning the potential influence of climate change on crop yield, including seafood production;
- statistics and typologies on small-scale family farming, are not broken down by gender to determine women's place in agriculture and their contribution.

6.4.7 Priorities for actions

This review of water and food security components, including aspects of availability, demand, quality and resource stability, points to the following priorities for action:

- plan for and manage sustainability transitions using preventive, integrative and inclusive approaches and coordinated responses across the Water-Energy-Food sectors, taking into account the increasing scarcity of available water resources;
- sustainably use water resources including rational water abstractions from rivers and aquifers, and consideration and implementation of environmental flows for the protection of freshwater ecosystems and the services they provide to humans;
- plan and implement water allocation to find a balance between different water users; find the "potential of compatibility" described above, thinking long-term, beyond immediate water supplies to ensure sustainable provision of services for all;
- upgrade non-conventional water source systems e.g. reuse of treated wastewater and desalination, partly to increase access to water supply and sanitation services;
- promote the emancipation of rural youth (and particularly women) through suitable training, job creation and innovation. To improve the attractiveness of agricultural work among young people, the following should be considered, (i) improving legislation relating to the protection of rights and social security (social protection against occupational accidents, sick leave, settlement of disputes and retirement pensions to ensure equality with labour laws used in other sectors), and ii) the institutional recognition of women's work in agriculture, which is sometimes not even paid. On the other hand, local collective actions for the creation of decent jobs, training adapted to the labour market, innovations and micro-businesses for rural youth would make it possible to diversify the rural economy and enable them to become independent without resorting to exodus.
- support the local collective organization of agricultural production and the use of natural resources involving all stakeholders, with particular emphasis on i) building and/or strengthening collective management tools for production and marketing (cooperatives, producer groups, etc.) with the aim of enabling better control by producers of value chains, and ii) improved public policies for monitoring and controlling the use of resources, particularly in regions with fragile ecosystems (oases, steppes, dry plains, irrigated perimeters, etc.) because of the risks associated with climate change that farmers are currently facing in Northern and Southern Mediterranean countries.