Mediterranean Basin Case Study

Hesham El-Askary, Wenzhao Li

Key messages

- Droughts are defined as natural phenomena caused by a deficiency in water resources (e.g. precipitation, groundwater etc.), which represents a certain anomalous situation with respect to the long-term average over a certain period of time and specific area.
- The Mediterranean basin is characterized by water scarcity, recurrent droughts and impending desertification, which threaten not only the economic viability of the region, but also its geopolitical stability.
- Mediterranean basin is also one of the regions that are most vulnerable to climate changes, as well as one of the most impacted because of high human water demand [1]. The key environmental challenges for the region are water management, waste and pollution management, loss of biodiversity, preservation of coastal areas, and desertification.
- Cascading impacts of droughts include dust storms, water-borne infectious diseases, hydrologic alterations, degraded water quality and so on.
- In the context, the situation requires the actions taken by organizations, institutions, and civil stakeholders involved in drought preparedness and mitigation and/or on water management for designing effective risk-based strategies that mitigate the effects of drought in agriculture, water supply systems, and the environment.

1. Short description of the physical and socio-economic characteristics of the case study

The Mediterranean Basin is the area around the Mediterranean Sea that experiences a Mediterranean type bioclimate. It has a total surface area of 2300000 km^2. It stretches from Cabo Verde in the west to Jordan and Turkey in the east, and from Italy in the north to Tunisia in the south. It also includes parts of Spain, France, the Balkan States, Greece, Turkey, and the nations of North Africa and the Middle East, as well as some 5,000 islands scattered around the Mediterranean Sea [2]. It has an interesting geographical and topographical diversity with high mountains, peninsulas, and one of the largest archipelagos in the world (46000 km) [3].

Mediterranean basin is considered one of the world's major climate change hotspots and highly vulnerable to the negative impacts of global warming [4]. Depending on the extent of climatic disruption, the consequences of climate change are expected to worsen already critical situations present in the region. The Mediterranean will face an increased risk of desertification and soil degradation, sea level rise, an increase in the duration and intensity of droughts, changes in species composition, habitat losses, and agricultural and forests production losses, resulting in an increased risk

of coastal erosion, infrastructure damage and threatened water and food security. The Middle East and North Africa (MENA) region, which already has one of the lowest water availabilities per capita world-wide, is expected to be more severely affected.

Water is perhaps the most important shared natural resource in the Mediterranean basin. All climate model projections agree on the region's future warming and drying with potential huge risks and costs to the region's economy, population center and biodiversity [4]. Further, overpressures on water resources are associated to water scarcity, thereby triggering stress on water quality and ecosystems. Rural areas in the Mediterranean are relatively diverse in their history, culture, natural conditions, population density, settlements, economic structure, and human resources and thus require different policy interventions, but share a potential for the establishment of new bases for economic and social development. Table 1 displays some of the causes, impacts and aggravations due to droughts.

Table 1. Drought causes, aggravations and environmental impacts [5]

<table>
<tr><th>Causes</th><th>Impacts</th><th>Intermediate consequences</th><th>Long term consequences</th></tr>
<tr><td>Reduced precipitation</td><td>❖ Reduced flows in surface waters
❖ Reduced infiltration for ground water recharge</td><td rowspan="4">❖ Reduced water availability
❖ Higher concentration of pollution and toxics
❖ Warming of water bodies
❖ Boost in nutrients in the water bodies
❖ Reduced ground water levels
❖ Salinization of aquifers
❖ Saline intrusion in coastal areas
❖ Stress on (ground) water dependent eco-systems
❖ Spread of invasive species
❖ Loss of sedimentation for deltas and estuaries</td><td rowspan="4">Decline in biodiversity:
❖ Loss of aquatic eco-systems
❖ Severe changes in the coastal eco-systems
❖ Regression of dunes and deltas
❖ Loss of species in flora and fauna
❖ Shift of species with increase of thermophiles</td></tr>
<tr><td colspan="2">Aggravations</td></tr>
<tr><td>Climate change</td><td>❖ Increase in temperature
❖ Reduced precipitation
❖ Increase of extreme weather events</td></tr>
<tr><td>Bad water use planning</td><td>❖ Reduced flows in rivers
❖ Non-compliance with ecological flow regime
❖ Water pollution
❖ Over-exploitation of aquifers</td></tr>
</table>

The larger Mediterranean Basin will have warmer and dryer climate conditions at the end of this century. Desertification in the Mediterranean region is largely due to poor land-use practices and land degradation. Hotter and drier conditions at the end of this century, however, will likely extend the desertification-prone areas northwards in the Mediterranean Basin to encompass areas currently not at risk. In addition, the rate of desertification would increase due to increases in erosion, salinization and forest fire hazard and reductions in soil quality [6].

A high irregularity in temporal and spatial distribution of water resources is observed in Spain, along with many areas affected by water scarcity and droughts [7]. In the

year 2008, Barcelona which is part of the Catalonia region in Mediterranean Spain, was forced to import drinking water from France as the reservoirs were running so low on account of drought. It was also one of the driest years for Spain. Currently, the summers are getting hotter and drier with precipitation in 2017 notably light, which brought Spain its worst drought since 2008. This shift in climate threatens to have a long-term impact on the land [8].

In Southern France near Mediterranean coast, temperature increase has been accompanied with decrease in summer precipitation and an increase in autumn precipitation. The 2003 drought brought an adverse impact on agriculture, hydroelectricity, houses as well as clay soil shrinkage and swelling. Huge costs were also involved in the recovering process [9]. In 2019, more than two thirds of France felt the effects of a major drought with 87 departments affected by water restrictions and 41 of them in “crisis situation”. The drought was attributed to low levels of rain during the winter and spring and extremely hot summer months [10].

Italy is a peninsula in the Mediterranean Sea and is surrounded by seas on all three sides. Despite the availability of many water bodies, Northern Italy experiences some of the highest rates of annual water availability in Europe. The water availability in the catchment becomes characterized by seasonal rainfall patterns because of climate change which changes the quantity and timing of meltwater from the Alps. In the summer of 2002, farmers in southern Italy and Sicily could not irrigate their fields because of the hardest drought in decades. The Italian government had to provide relief funds of 500 million euros [11]. In 2018, Italy suffered from a severe summer drought caused by low rainfall in the first half of 2017 and exceptionally high temperatures for most of the year. Nearly two-thirds of Italian farmland has been negatively affected.

Faced with a water shortage crisis on its hands, the Greek government is currently trying to tackle the problem by importing millions of cubic meters of water to the Greek islands in the Aegean. Climate models also show in Greece a decrease in precipitation and an increase in temperature from 2001 to 2100, resulting in tremendous decrease of flow, soil moisture as well as groundwater reservoir [12].

Historically, frequent droughts in Turkey caused crops losses, animal losses as well as losses to the farmers. For example, the famine and disease epidemics due to drought in 1876 caused deaths of more than 200,000 people. There is a lot of variability in rainfall since Turkey is in the Mediterranean macroclimate region in the sub-tropical zone. This gives rise to frequent regional and widespread droughts [13]. Turkey’s agriculture sector and water resources come under sever constraints from these recurrent droughts [14].

The Syria’s drought in 2007-2010 was the worst in the instrumental record, causing widespread crop failure and a mass migration of almost 1.5 million Syrians to urban centers, like Homs and Damascus. Almost 75 percent of Syria’s farms failed and about 85 percent of livestock died. It is even believed to be a catalyst for the Syrian conflict around 2015 [15], [16]. Water-related conflicts occur in many forms, including disputes over access to water and the control of water systems, the targeting of water infrastructure and systems [17]. During the 2009/10 growing season, Southern, southeastern and northeastern regions all suffered continuing drought conditions and well-below normal rainfall. This is made worse by inaccurate on-the-ground meteorological observations [18].

Israel is bordered by the Mediterranean Sea in the west [19], with its coastal plain runs parallel to the Mediterranean Sea and is composed of a sandy shoreline,

bordered by stretches of fertile farmland extending up to 25 miles inland [20]. Israel has suffered from a chronic water shortage for years. In recent years however, the situation has developed into a crisis. The current cumulative deficit in Israel's renewable water resources amounts to approximately 2 billion cubic meters, an amount equal to the annual consumption of the State. [21]. Israel has also experienced a continuous decline in precipitation, compared to the multi-year average, which has led Israel into a state drought. This shortfall, which has lasted for so long, is a rare phenomenon, the likes of which have not been recorded in Israel since the 1920s. The significant decline in precipitation has been particularly noticeable in the north of the country [22].

With the small exception of its strip of Mediterranean coastline and Narrow strip around the Nile River, the whole of Egypt has an arid desert climate. Egypt receives fewer than eighty millimeters of precipitation annually in most areas. Alexandria has relatively high humidity, but sea breezes help keep the moisture down to a comfortable level. Moving southward, the amount of precipitation decreases suddenly. Some areas will go years without rain and then experience sudden downpours that result in flash floods [23].

The historical climate data of Algeria shows the persistence of drought. The study of rainfall recorded in hundreds of weather stations in northern Algeria (period 1951-1980 and 1961-1990), shows a succession of episodes of excessive and deficient rainfall compared to normal and that show great variability [24]. This natural phenomenon observed for a long time, has led to the process of quantitative and qualitative degradation of the water reserve and linking, these droughts have had a negative impact on meeting the water needs of all socio-economic sectors, particularly agricultural, and preservation of terrestrial and aquatic ecosystems. The climate of Algeria has high variability and resulted drought [25].

2. Highlight the specific drought characteristics of the area and exemplify with a specific case:

The Mediterranean area has emerged as a hotspot for climate change and the issues arising out of it. There have been projections of stronger warming of the regional land-based hot extremes compared to the mean global temperature increase. There has also been a robust increase in the probability of occurrence of extreme droughts at 2 °C vs. 1.5 °C global warming [26]. Drought variability displays significant east-west coherence across the basin on multidecadal to centennial timescales and north-south antiphasing in the eastern Mediterranean, with a tendency for wet anomalies in the Black Sea region (e.g., Greece, Anatolia, and the Balkans) when coastal Libya, the southern Levant, and the Middle East are dry. Recent droughts are centered in the western Mediterranean, Greece, and the Levant. The recent 15 year drought in the Levant (1998–2012) is the driest in the record [27]. Using a resampling approach, uncertainties were estimated where it was found that there is an 89% likelihood of this drought being drier than any comparable period in the last 900 years and a 98% likelihood that it is drier than the last 500 years (Figure 1).

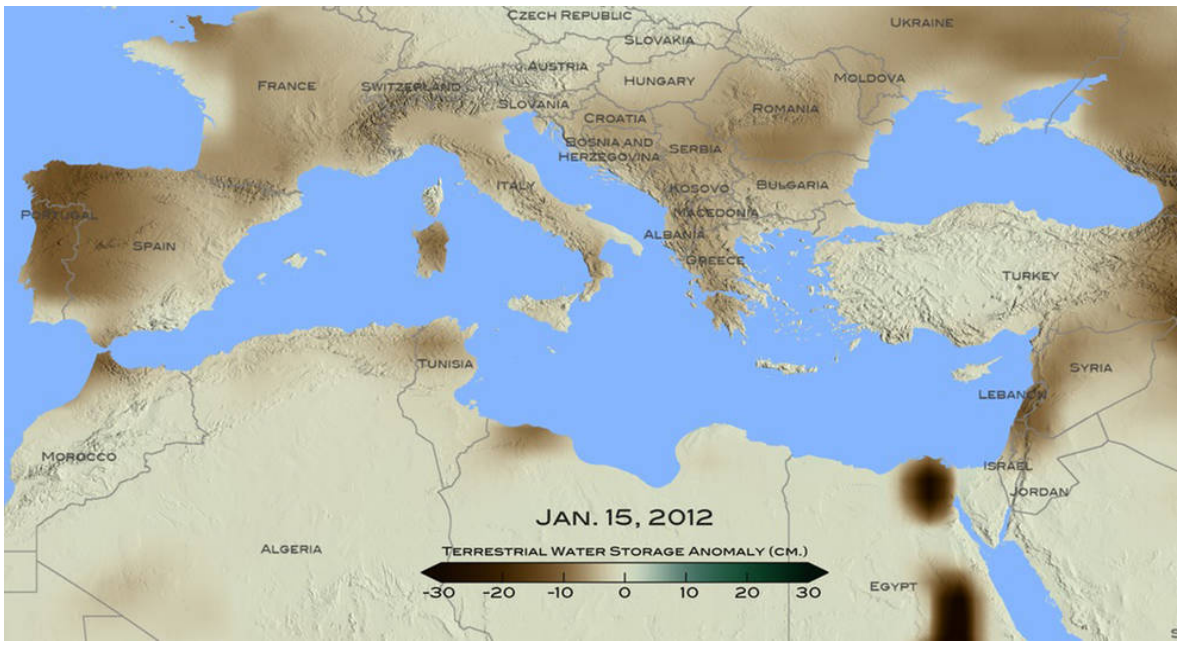

Figure 1. For January 2012, brown shades show the decrease in water storage from the 2002-2015 average in the Mediterranean region. Units in centimeters. The data is from the Gravity Recovery and Climate Experiment satellites, a joint mission of NASA and the German space agency. ***Credits: NASA/ Goddard Scientific Visualization Studio***

a. Frequency and severity of droughts (incl. trends and projections for the area, if available)

With climate change on the rise, there has been warmer days and nights, an increase in heat waves and soil dryness, extreme precipitation while the cold days and nights have decreased. Moreover, most of the climate change models predict that there would be an increase in summer drought, flood frequency and temperature. The Fifth Assessment Report of the IPCC [28] stated that the mean surface air temperature in the region is expected to increase by 2-4 °C by 2081-2100 compared to 1986-2005 and the mean annual precipitation to decrease by 10-20 percent. As a worst-case scenario, the mean temperatures could increase by up to 7.5 °C by the year 2100 and the mean precipitation could decrease by up to 60 percent.

b. **Recorded and expected direct and indirect socio-economic and environmental** (e.g. wetlands, biodiversity, land degradation**) impacts in the region and elsewhere** (e.g. markets)

There has been an observed difference between the northern and the southern/eastern Mediterranean countries with northern countries displaying a prevalence of agricultural and pastoral land abandonment along with reforestation campaigns being effective. In contrast, the southern and eastern countries bearing strong pressures on the ecosystem. In particular, the north African countries have high population pressure on land and water resources apart from urban sprawl, over-exploitation of forests and overgrazing. In addition, desertification processes are exacerbated by climate change, causing increased aridity and extreme events (long periods of drought, devastating floods of land and livestock, large cold spells), with strong socio-economic impacts on farmers. As a result of this, food cooperation is another main issue among the southern

and eastern Mediterranean countries at the backdrop of the existing complementarities between the North and the South [4].

c.Cascading and compound impacts, risk of systemic failures

There have been dramatic modifications due to intensive use by human societies. Human driven alterations like pollution, water abstraction, riparian simplification, bank alteration, straightening of watercourses, dam construction, and species introduction are widespread perturbations in river ecosystems are part of global changes. The simplification of the channel network and the alteration of water fluxes reduce the capacity of fluvial systems to recover from natural disturbances. Hydrologic alterations affect the functional organization of streams and rivers, and lead to a simplification and impoverishment of the biota within these ecosystems. The temperature and rainfall are altered as these effects add to the ongoing climate change. As these effects exasperate, especially in the Mediterranean-type aquatic ecosystems, flow regimes are altered, frequency of floods and droughts increase which affects the distribution and survival of unique biota, and the associated ecosystem functions [29].

Dust storms are sometimes a by-product of drought too. Dust storms are a common meteorological hazard in arid, semi-arid and hyper-arid regions and they can cause significant environmental and economic damage [30]. Dust is termed as a driver and a passive recorder of climate change under different climatic regimes of the Earth's past, present and future [31]. The scattering of SW radiation causes dust cooling effects, which dominates for fine dust and is enhanced over dark surfaces [32]. In contrast, the warming effects dominate for coarse dust and are enhanced over bright surfaces dust, such as MENA region, arise from scattering of LW radiation and absorption of SW and LW radiation [32], [33]. Indeed, an accurate quantification of the dust–climate feedback is hindered by several uncertainties [33]–[36].

The Dust Bowl, a natural disaster which ravaged the Midwest in the United States in the 1930s included episodes of dust storms becoming powerful because of the persisting drought condition [37]. One of the studies conducted for Australia showed a non-linear relationship of increasing dust storms with aridity and stating that both the spatial and temporal occurrences were strongly influenced by drought [38]. Another study pointed out that the spring–summer dust concentrations at Barbados was correlated to rainfall deficits in the sub-Sahara [39]. In a recent study, it was shown increased Saharan dust transport is caused by a combination of enhanced high-pressure systems over the Mediterranean and drier conditions in Northern Africa, along with other atmospheric influences. The study also pointed towards an increased amount of Saharan dust transport in the past century when compared with large occurrences over the past 2000 years [40]. The Mediterranean region, which is rich in mineral dust, the relationship between the atmosphere synoptic-scale circulation, position and strength of pressure systems and dust outbreaks occurrence, uptake and mobility is evident [41], [42].

Water scarcity also results in the occurrence of outbreaks of water-borne infectious diseases at varying degrees depending on the level of water scarcity, density of population, degree of economical development, presence of wild or farmed animals in the area, and so forth. The water-related or water-associated infectious diseases are typically arranged in four classes from the environmental engineering point of view: faecal-oral water-borne diseases, water-washed diseases, water-based diseases and diseases transmitted by water-associated insect vectors. Out of these, the water-washed infections are caused by sharing and reusing for washing hands and face water contaminated with pathogens specific of skin and eyes. The best-known example

is trachoma, an eye infection causing blindness, which is clearly related to water scarcity [43].

In the Mediterranean region with a prevalence of water scarcity and arid climate, water quality for irrigation is of importance too as the salts formed by deposition from irrigation tend to accumulate in the soil profile. Irrigation water may contain up to 1000 g of salt per cubic meter (the general case in Mediterranean region). The application of 100 mm irrigation of high saline waters will introduce one ton of salt to a hectare of irrigated area. Consequently, it is necessary to include leaching and drainage as an integral part of the irrigation program which is, unfortunately, not practiced in several countries in the Mediterranean region. On the other hand, mixing different water resources to decrease salinity is becoming a common practice in countries such as Morocco, Egypt, Tunisia, Jordan and Israel [44].

d. Civil unrest and conflict (if applicable)

The Mediterranean basin encompasses the history and problems that are common to all the neighboring countries in the Mediterranean region. These countries in this region are among the world area which is suffering of water scarcity the most apart from the pollution of the freshwater resources. An estimation puts 30 million Mediterranean people without access to clean drinking water. It is expected that water stress and resulting conflict would be particularly high in Egypt, Israel, Libya, Palestinian Territories, and in the Spanish Mediterranean catchment areas (index at 75% or higher), as well as in Malta, Syria, Tunisia, and in some catchments of Morocco (index between 50 and 75%). There are some cases of nature and culture conflicts and lessons in the Mediterranean wetlands (e.g. Lake Maryut (Egypt), El Hondo Nature Park (South-Eastern Spain) , Grosseto Plain (Maremma, Italy) [45].

Struggles over water resources and infrastructure have played a key role in both the 2003 Iraq war and the recent conflicts ISIS in Iraq and Syria [46]. Water and climatic conditions have played a direct role in the deterioration of Syria’s economic conditions. Various conflicts over water are recorded in these regions because of the natural water scarcity, the early development of irrigated agriculture, and complex religious and ethnic diversity [17]. Jordan is also another country with conflict arising due to water scarcity. Its groundwater has been exhausted to support a growing population. While access to scarce water resources is a common cause of conflict, there is also a competition between sectors over the use of water. This complex interaction is leading to an internal water conflict that is inspiring the need of solutions over water use and availability [47]. In recent years, there has been an increase in incidences of water-related violence around the world at the subnational level attributable to the role that water plays in development disputes and economic activities.

3. Explain existing and/or potential management/mitigation and adaptation options:

Water scarcity is a precarious situation that pushes the governments, institutions as well as the water users competing for a scarce, vulnerable and valuable resource to work towards an effective drought management approach. The agricultural sector, especially in the Mediterranean countries, has been in focus over the last few years for its water governance ability to promote water saving policies and efficiently assign water resources. Considerable efforts and progress have been made at the European Union level in terms of developing policy instruments, research projects, and non-

legally binding technical guidance documents to deal with droughts and water scarcity. The Water Framework Directive (WFD) was adopted in the year 2000 for European water and environmental legislation and one of the purposes of the WFD is the mitigation of drought impacts. Despite this, droughts are only succinctly dealt with within the WFD, and the development of Drought Management Plans (DMPs) is not compulsory. The 2007 EC Communication, "*Addressing the Challenge of Water Scarcity and Droughts in the European Union"* and the publication of the technical guidance, "*Drought Management Plan Report Including Agricultural, Drought Indicators and Climate Change Aspects*" is another key milestone in terms of European drought-risk management.

Drought monitoring is a common element in all cases and is the essential first step for moving from disaster to risk management. Implementation of strategies for Integrated Water Resources Management (IWRM) in water-deficient regions is another essential step. IWRM could achieve sustainable social and economic development combined with the protection of natural ecosystems and the aquatic environment. Implementation of policies aimed towards increasing exploitable potential through improved water and soil conservation as well as to increase the recourse to the artificial replenishment of water tables in arid area is important. Focus must also be given on improving the water demand management. Some actions that can be undertaken in agriculture for potential savings are reutilization of wastewater, reduction of transport losses, and increase in efficiency in irrigation. Similar action for industry is increasing the recycling rate, and for domestic water is reduction of transport losses and leaks. Some practices related to the water treatments are listed in the reference[48]:

- Drinking water treatment
- Wastewater treatment
- Reuse of wastewater
- Reuse of sewage and its treatment
- Reuse of sludge

a. Do drought policies and legislation/ and/or drought management plans exist?

There are several projects/policies related to the drought management. Some of them have been listed below:

- Millennium Development Goals (MDG) – MDG were development goals set by the United Nations. They were put forth by an assembly of the world's heads of state in the year 2000. These goals have put human development - poverty and people and their lives - at the center of the global development agenda for the new millennium, a shift away from growth as the central objective of development. They provided a framework for accountability as well as addressing the development outcomes and inputs from rich countries, thus forming a compact that holds both rich and poor governments accountable for opening markets, giving more aid and debt relief, and transferring technology [49].

- Sustainable Development Goals (SDG) – The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in the year 2015. There are 17 SDG which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go together with strategies that improve health and education, reduce inequality, and spur economic growth - all while

tackling climate change and working to preserve the oceans and forests [50].

- WADI – WADI is an acronym for WAter Demand Integration. The WADI project analyzes the socioeconomic and ecological impacts of water management on natural and artificial water reservoirs in coastal areas around the Mediterranean, which sustain development and the highest level of urbanization. The project focuses on issues, constraints and conflicts regarding the use of fresh water and other natural resources linked to water, as identified through the active participation of key stakeholders. The aim is to increase awareness and collaboration among the actors for the conservation of freshwater resources and their sustainable use for the benefit of the community [51]. Figure 2 displays the WADI approach and the down-top (participatory) flow of communications.

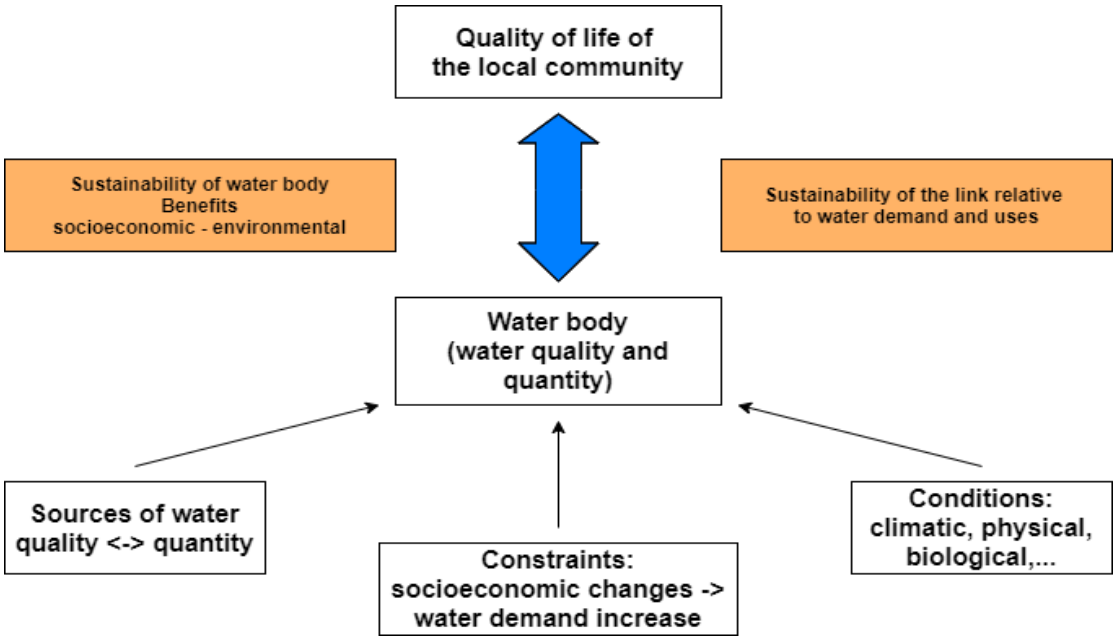

Figure 2. The WADI approach [52]

- European Union Water Initiative (EUWI) – The EUWI was launched with a specific Mediterranean Component (MED EUWI) aiming to: 1) Assist design of better, demand driven and output oriented water related programmes; 2) Facilitate better coordination of water programmes and projects, targeting more effective; 3) Use of existing funds and mobilization of new financial resources and 4) Enhanced cooperation for project's proper implementation, based on peer review and strategic assessment. The main reference for the EU approach to water policy and management is the Water Framework Directive (EC/2000/60), whose principles are brought also to international cooperation efforts such as the MED EUWI.

- Mediterranean Drought Preparedness and Mitigation Planning (MEDROPLAN) – This project was co-funded by the European Union through the Euro-Mediterranean Regional Programme for Local Water Management (MEDA Water) and the Mediterranean Agronomic Institute of Zaragoza - CIHEAM (Spain; Coordinator) and others. The project's main objective is to create guidelines for drought preparedness plans. The guidelines are expected to provide partner countries with an integrated approach for minimizing the impacts of drought on their people and resources. The guidelines are also expected to adapt to the physical and socio-economic environment of the Mediterranean countries and their elaboration following a common methodology. Another

important objective of the project is to provide the framework for the setting up of a Drought Preparedness Network for the Mediterranean countries. Other expected results are: better understanding of drought, its causes, effects and impact on the economy, environment and social conditions; the transfer of know-how and technology; the exchange of information and expertise; the strengthening of institutional capabilities and awareness-raising; the mobilization and promotion of civil commitment [53].

b. If yes, have they been useful

The MDG report published in 2015 showcased mixed results from the goals that were decided. Some of the successes of the MDG project included 91 per cent of the global population used an improved drinking water source in 2015, compared to 76 per cent in 1990. Of the 2.6 billion people that gained access to improved drinking water since 1990, 1.9 billion gained access to piped drinking water on premises. Globally, 147 countries met the drinking water target. One of the goals that needed to be worked more in the future was that the water scarcity still affected 40 percent of people in the world and was projected to increase with poor people suffering the most [54]. The SDG is an ongoing project and the report published in the year 2020 stated that the proportion of the global population using safely managed drinking water services increased from 61 per cent in 2000 to 71 per cent in 2017. Despite this, 2.2 billion people around the world still lacked safely managed drinking water, including 785 million without basic drinking water [55]. This project is promising with some good results and yearly reporting as part of accountability checks.

The WADI project had contributed to enhance local competence for a sustainable use of water bodies and to reduce existing and potential conflicts for water uses between different stakeholders. Throughout the project comparisons of various case-studies over the Mediterranean coastal areas were conducted, at both northern and southern sides, in international co-operation and in collaboration with governmental and local stakeholders of different Mediterranean countries. Data bases on a wide geographical scale (ideally the Mediterranean region, comparing data bases) and time scale (using time series) were produced to enhance the power of the management plans and to assist stakeholders to apply for financial support at the national and international levels [56].

In a report published in 2015, MED EUWI conducted regional and national activities in Jordan, Tunisia and Palestine. At a regional level, with collaboration with EU, funded Sustainable Water Integrated Management-Support Mechanism (SWIM-SM) project. At a national level, it provided an assessment and a diagnostic analysis of the situation on private sector involvement in water services, and a set of recommendations for institutional, legal and structural changes along with an action plan for their implementation. It also conducted national consultation workshops [57].

As part of MEDROPLAN, the Drought Management Guidelines document has been published in 6 languages (Arabic, English, French, Greek, Italian and Spanish) and is followed by examples in English and French of drought management experiences in the 6 countries participating in the MEDROPLAN consortium: Cyprus, Greece, Italy, Morocco, Spain and Tunisia. The technical annex to the document and a website with all the information were generated. In addition to that, the book "Coping with drought risk in agriculture and water supply systems" was published by Springer. This book collected the most relevant scientific contributions obtained through the project [58].

c. Which steps have been taken to mitigate droughts in case of an event?

General mitigation planning is recommended and taken for the Mediterranean countries in a drought event, which include the following [59]:

1. Define the duties and responsibilities of all ministries, departments, and NGOs with respect to drought and provide an organizational structure and delivery system assuring information flow between and within levels of government.
2. Collect and analyze drought-related information and mitigation actions in a timely and systematic manner. Provide a mechanism to ensure timely and accurate assessment of droughts impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other sectors.
3. Identify the most drought-prone areas and vulnerable economic sectors, population groups, or environments and maintain an inventory of government programs previously used and available to respond to drought emergencies.
4. Establish criteria for declaring drought emergencies and triggering various mitigation and response activities an keep decision makers and the public informed of current conditions and mitigation and response actions by providing accurate, timely information.
5. Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives encouraging demand management.
6. Establish a set of procedures to continually evaluate and exercise the drought mitigation plan, with periodic revising so the plan will stay responsive to the needs of the country.

Additionally, Figure 3 lists an example of framework showing steps and tasks for drought mitigation process as a “checklist” that should be considered: [37].

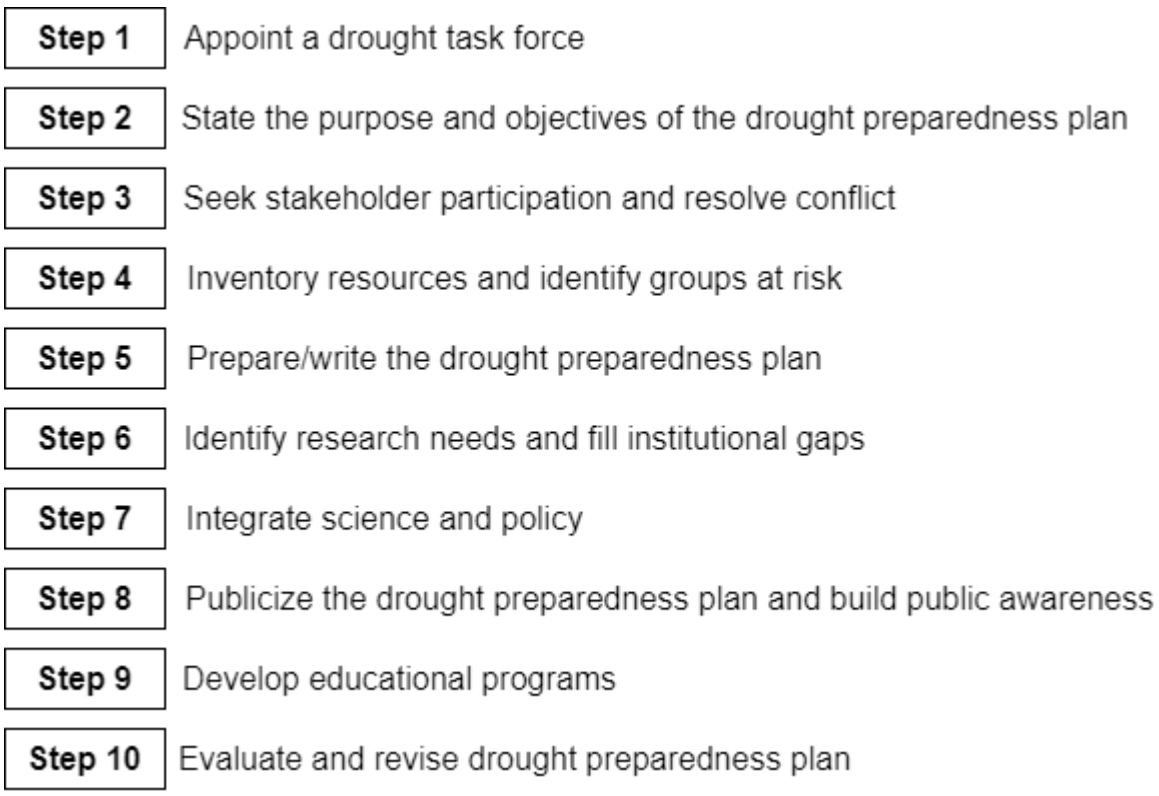

Figure 3. 10-Step Drought Planning Process (Source: National Drought Mitigation Center, University of Nebraska–Lincoln, U.S.A.)

d. Discuss possible options/pathways to increase the resilience and minimize the risk from droughts (now and in the future)

Some options and suggestions are listed to increase the resilience and minimize the risk in case of droughts in the Mediterranean basin:

1. Drought monitoring and early warning systems are key elements of a drought policy and preparedness plan to increase the coping capacity of society in national or regional scale.
2. Building a culture of water saving and efficiency is essential.
3. It is necessary to have the improvement of wastewater treatment (WWT) both quantitatively and qualitatively.
4. The reuse of sewage waters and desalination of the seawater can be considered as an supplemental water source for urban, tourism, and agricultural uses. However, the financial cost and energy consumption should be considered.
5. Adequate protection of aquifers should be taken along with the use of groundwaters since the overexploited groundwater affect available water for surficial aquatic ecosystems and may create problems of subsidence as well as saltwater intrusion.

References

[1] S. Sabater and D. Barceló, *Water scarcity in the Mediterranean: Perspectives under global change*, vol. 8. Springer Science & Business Media, 2010.

[2] “Mediterranean Basin.” https://www.cepf.net/our-work/biodiversity-hotspots/mediterranean-basin.

[3] M. Barbéro, R. Loisel, P. Quézel, D. M. Richardson, and F. Romane, “Pines of the Mediterranean basin,” *Ecology and biogeography of Pinus*, pp. 153–170, 1998.

[4] UNEP/MAP, “Mediterranean strategy for sustainable development 2016-2025,” *Valbonne. Plan Bleu, Regional Activity Centre*, p. 83pp, 2016.

[5] N. Isendahl and G. Schmidt, “Drought in the Mediterranean-WWF policy proposals,” *WWF report, Madrid*, 2006.

[6] T. Ozturk, Z. P. Ceber, M. Türkeş, and M. L. Kurnaz, “Projections of climate change in the Mediterranean Basin by using downscaled global climate model outputs,” *International Journal of Climatology*, vol. 35, no. 14, pp. 4276–4292, 2015.

[7] T. Estrela and E. Vargas, “Drought management plans in the European Union. The case of Spain,” *Water resources management*, vol. 26, no. 6, pp. 1537–1553, 2012.

[8] Kayla Ritter, “A Decade After Barcelona’s Water Emergency, Drought Still Stalks Spain.” https://www.circleofblue.org/2018/europe/a-decade-after-barcelonas-water-emergency-drought-still-stalks-spain/.

[9] “Droughts France,” May 16, 2020. https://www.climatechangepost.com/france/droughts/.

[10] The Local, “Drought in France: One third of the country is now in a ‘crisis situation,’” Aug. 29, 2019. https://www.thelocal.fr/20190829/drought-in-france-one-third-of-the-country-is-now-in-a-crisis-situation.

[11] “Droughts Italy,” May 16, 2020. https://www.climatechangepost.com/italy/droughts/.
[12] A.-E. Vrochidou, I. Tsanis, M. Grillakis, and A. Koutroulis, “The impact of climate change on hydrometeorological droughts at a basin scale,” *Journal of Hydrology*, vol. 476, pp. 290–301, 2013.
[13] “Droughts Turkey,” May 16, 2020. https://www.climatechangepost.com/turkey/droughts/.
[14] F. K. Sönmez, A. U. Koemuescue, A. Erkan, and E. Turgu, “An analysis of spatial and temporal dimension of drought vulnerability in Turkey using the standardized precipitation index,” *Natural Hazards*, vol. 35, no. 2, pp. 243–264, 2005.
[15] C. P. Kelley, S. Mohtadi, M. A. Cane, R. Seager, and Y. Kushnir, “Climate change in the Fertile Crescent and implications of the recent Syrian drought,” *Proc Natl Acad Sci USA*, vol. 112, no. 11, p. 3241, Mar. 2015, doi: 10.1073/pnas.1421533112.
[16] Elaisha Stokes, “The Drought That Preceded Syria’s Civil War Was Likely the Worst in 900 Years,” Mar. 03, 2016.
[17] P. H. Gleick, “Water, Drought, Climate Change, and Conflict in Syria,” *Weather, Climate, and Society*, vol. 6, no. 3, pp. 331–340, Jul. 2014, doi: 10.1175/WCAS-D-13-00059.1.
[18] Wadid Erian, *Drought vulnerability in the arab region*. .
[19] Russell A. Stone, Eliahu Elath, William L. Ochsenwald, and William L. Ochsenwald, “Israel.” Encyclopædia Britannica, inc., Jul. 01, 2020, [Online]. Available: https://www.britannica.com/place/Israel.
[20] “THE LAND: Geography and Climate.” https://mfa.gov.il/mfa/aboutisrael/land/pages/the%20land-%20geography%20and%20climate.aspx.
[21] “Israel’s Chronic Water Problem.” https://mfa.gov.il/MFA/IsraelExperience/AboutIsrael/Spotlight/Pages/Israel-s%20Chronic%20Water%20Problem.aspx.
[22] “The Drought in Israel and the National Plan to Save the Water Sector.” https://www.mekorot.co.il/Eng/newsite/Solutions/SustainableDevelopment/Pages/Drought.aspx.
[23] Tamer A.Nada, “Drought condition and management strategies in Egypt,” Oct. 2014.
[24] N. Hassini, A. Belaid, and D. Abdelmajid, 2011 “Trends of Precipitation and Drought on the Algerian Litoral: Impact on the Water Reserves,” *International Journal of Water Resources and Arid Environments*, vol. 1, pp. 271–276,
[25] “Drought management strategy in Algeria,” Nov. 2014.
[26] Hoegh-Guldberg, O. *et al.*, “Impacts of 1.5 ◦C Global Warming on Natural and Human Systems,” Intergovernmental Panel on Climate Change (IPPC), Geneva, Switzerland, 2018.
[27] B. I. Cook, K. J. Anchukaitis, R. Touchan, D. M. Meko, and E. R. Cook, “Spatiotemporal drought variability in the Mediterranean over the last 900 years,” *Journal of Geophysical Research: Atmospheres*, vol. 121, no. 5, pp. 2060–2074, 2016.
[28] “IPCC Fifth Assessment Report.” https://www.ipcc.ch/assessment-report/ar5/.
[29] S. Sabater and K. Tockner, “Effects of hydrologic alterations on the ecological quality of river ecosystems,” in *Water scarcity in the Mediterranean*, Springer, 2009, pp. 15–39.
[30] I. D. Al Ameri, R. M. Briant, and S. Engels, “Drought severity and increased dust storm frequency in the Middle East: a case study from the Tigris–Euphrates alluvial plain, central Iraq,” *Weather*, vol. 74, no. 12, pp. 416–426, 2019.

[31] J. F. Kok, D. S. Ward, N. M. Mahowald, and A. T. Evan, “Global and regional importance of the direct dust-climate feedback,” *Nature communications*, vol. 9, no. 1, pp. 1–11, 2018.
[32] H. Liao and J. Seinfeld, “Radiative forcing by mineral dust aerosols: sensitivity to key variables,” *Journal of Geophysical Research: Atmospheres*, vol. 103, no. D24, pp. 31637–31645, 1998.
[33] J. F. Kok *et al.*, “Smaller desert dust cooling effect estimated from analysis of dust size and abundance,” *Nature Geoscience*, vol. 10, no. 4, pp. 274–278, 2017.
[34] A. T. Evan, C. Flamant, M. Gaetani, and F. Guichard, “The past, present and future of African dust,” *Nature*, vol. 531, no. 7595, pp. 493–495, 2016.
[35] Q. Fu and S. Feng, “Responses of terrestrial aridity to global warming,” *Journal of Geophysical Research: Atmospheres*, vol. 119, no. 13, pp. 7863–7875, 2014.
[36] N. M. Mahowald, “Anthropocene changes in desert area: Sensitivity to climate model predictions,” *Geophysical Research Letters*, vol. 34, no. 18, 2007.
[37] Kimberly Amadeo, 2020“The Dust Bowl, Its Causes, Impact, With a Timeline and Map.” https://www.thebalance.com/what-was-the-dust-bowl-causes-and-effects-3305689.
[38] G. H. McTainsh, R. Burgess, and J. R. Pitblado, “Aridity, drought and dust storms in Australia (1960–84),” *Journal of Arid Environments*, vol. 16, no. 1, pp. 11–22, Jan. 1989, doi: 10.1016/S0140-1963(18)31042-5.
[39] J. M. Prospero and R. T. Nees, “Impact of the North African drought and El Niño on mineral dust in the Barbados trade winds,” *Nature*, vol. 320, no. 6064, pp. 735–738, Apr. 1986, doi: 10.1038/320735a0.
[40] H. M. Clifford *et al.*, “A 2000 Year Saharan Dust Event Proxy Record from an Ice Core in the European Alps,” *Journal of Geophysical Research: Atmospheres*, vol. 124, no. 23, pp. 12882–12900, 2019.
[41] D. Meloni, A. Di Sarra, F. Monteleone, G. Pace, S. Piacentino, and D. Sferlazzo, “Seasonal transport patterns of intense Saharan dust events at the Mediterranean island of Lampedusa,” *Atmospheric Research*, vol. 88, no. 2, pp. 134–148, 2008.
[42] G. Varga, G. Újvári, and J. Kovács, “Spatiotemporal patterns of Saharan dust outbreaks in the Mediterranean Basin,” *Aeolian Research*, vol. 15, pp. 151–160, 2014.
[43] J. Jofre, A. R. Blanch, and F. Lucena, “Water-borne infectious disease outbreaks associated with water scarcity and rainfall events,” in *Water scarcity in the mediterranean*, Springer, 2009, pp. 147–159.
[44] F. Chenini, “Implications of water quality on irrigation practices under water scarcity,” in *Water scarcity in the Mediterranean*, Springer, 2009, pp. 161–172.
[45] F. Scapini and G. Ciampi, *Coastal water bodies: nature and culture conflicts in the Mediterranean*. Springer Science & Business Media, 2010.
[46] “Weaponization of water.” http://waterandconflict.web.unc.edu/weaponization-of-water/.
[47] M. Shatanawi, M. Shammout, and S. Naber, “Water conflicts among sectors and environmental uses in Jordan,” 2008, vol. 83, pp. 159–172.
[48] D. Barceló and M. Petrovic, *Waste water treatment and reuse in the mediterranean region*, vol. 14. Springer, 2011.
[49] S. Fukuda-Parr, “Millennium Development Goals: why they matter,” *Global Governance: A Review of Multilateralism and International Organizations*, vol. 10, no. 4, pp. 395–402, 2004.
[50] “THE 17 GOALS.” https://sdgs.un.org/goals.
[51] F. Scapini, J.-M. Boffa, L. F. Cassar, E. Conrad, and M. Nardi, “Sustainable management of Mediterranean coastal fresh and transitional water bodies: a

socio-economic and environmental analysis of changes and trends to enhance and sustain stakeholder benefits," 2009.
[52] "Why WADI? - Background history." https://www.bio.unifi.it/p395.html.
[53] "Mediterranean Drought Preparedness and Mitigation Planning." http://www.emwis.org/initiatives/medaeau/fol719001/fol033012.
[54] C. Way, *The millennium development goals report 2015*. UN, 2015.
[55] "Ensure availability and sustainable management of water and sanitation for all." https://unstats.un.org/sdgs/report/2020/goal-06/.
[56] "Presentation." https://www.bio.unifi.it/p394.html.
[57] "2015 EUWI Annual Report." https://europa.eu/capacity4dev/euwi-community-space/comment/518.
[58] D. Gabiña, A. Iglesias, and A. López-Francos, "The Medroplan project: Process and key lessons," *Drought management guidelines technical annex*, pp. 9–12, 2007.
[59] D. A. Wilhite, "Drought monitoring as a component of drought preparedness planning," in *Coping with drought risk in agriculture and water supply systems*, Springer, 2009, pp. 3–19.